UNEP

E-WASTE
VOLUME II

E-waste Management Manual

UNITED NATIONS ENVIRONMENT PROGRAMME

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E-waste

Volume II: E-waste Management Manual

Compiled by

United Nations Environmental Programme
Division of Technology, Industry and Economics
International Environmental Technology Centre
Osaka/Shiga

Preface

Waste Electrical and Electronic Equipment (WEEE) or E-waste is one of the fastest growing waste streams in the world. In developed countries, it equals 1% of total solid waste on an average. The increasing “market penetration” in developing countries, “replacement market” in developed countries and “high obsolescence rate” make WEEE/E-waste one of the fastest waste streams. There is a pressing need to address e-waste management particularly in developing countries. The presence of valuable recyclable components attracts informal and unorganised sector. The unsafe and environmentally risky practices adopted by them poses great risks to health and environment.

For effective WEEE/E-waste management, we need to quantify and characterize this waste stream, identify major waste generators, and assess the risks involved. A scientific, safe and environmentally sound management system, including policies and technologies, needs to be developed and implemented.

International Environmental Technology Centre (IETC) of Division of Technology, Industry and Technology (DTIE) of UNEP is assisting member countries on ISWM. IETC is also focusing on WEEE/E-waste management as a part of ISWM. As an initial step, to build the capacity, IETC has produced two manuals on WEEE/E-waste to assist the member countries and their cities to develop the inventories and WEEE/E-waste management system.

The first manual was prepared as a guidelines document to support WEEE/E-waste inventorisation and assessment of risks involved. This second manual has been prepared as a guidance document to develop and implement WEEE/ E-waste management system. This manual should be used in conjunction with the first manual. This manual has been prepared based on data from secondary sources including publications from scientific journals, reports and web sites. A case study based approach has been adopted to provide examples of live situations so that it can be easily adapted to local conditions.

The manual was developed as a part of Norwegian Assistance on Integrated Solid Waste Management and in close cooperation with Secretariat of Basel Convention (SBC) and Sustainable Consumption and Production (SCP) branch of DTIE-UNEP. Mr. Amit Jain, an expert on WEEE/E-waste assisted IETC to prepare this manual.

This manual is aimed as a living document and practitioners and policy makers are highly encouraged to provide their feedback, which will be incorporated into next edition.

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Executive Summary

Recognizing the rapidly emerging and serious issue of Waste Electrical and Electronic Equipment (WEEE) or E-waste management, this manual on WEEE/ E-waste has been prepared as a guidance document to support development and implementation of WEEE/ E-waste management system. This manual has been prepared based on data from secondary sources including publications from scientific journals, reports and web sites.

The “perspective” of WEEE/E-waste and the mechanism of WEEE/E-waste trade varies across the continents and countries. These different perspectives and mechanisms along with a material flow model have been discussed to provide conceptual understanding of WEEE/E-waste. Components of WEEE/E-waste management and major stakeholders have discussed.

Review of current practices of WEEE/ E-waste in different countries provides an understanding of policies/ laws/ regulations and institutional framework for WEEE/ E-waste management. Institutional mechanisms for collection system and role of National Registry are aspects which will be useful in developing a roadmap for setting up institutions and policy/laws/regulations for WEEE/E-waste management chain. WEEE/E-waste management chain covers collection transportation and treatment including material recovery and disposal.

Technologies or technical interventions are vital for WEEE/E-waste management chain to maximize material recovery and minimize the risks. Technical interventions for collection and transportation of WEEE/E-waste are commonly known as treatment channels and infrastructure. Technical interventions for treatment of WEEE/E-waste are generally knows as treatment technologies. Environmental impacts of treatment technologies are vital to be addressed during design and operation of these technologies. Guidance notes will be useful for technical personnel as well as for the responsible agencies/organizations and other stakeholders to identify appropriate technical options for collection, transportation, treatment and disposal of WEEE/E-waste in order to comply with policy/ laws/ regulations.

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

A case study from a developing country provides an example of the field application of WEEE/E-waste management system, including techno-economic feasibility of a treatment facility, in a real life situation. This example can assist practitioners to design and implement WEEE/E-waste management system.

Acronyms

ADB	Asian Development Bank
AEHA	Association for Electrical Home Appliances
APME	Association of Plastic Manufacturers in Europe
ARF	Advance Recycling Fee
ASEM	Advisory Services in Environmental Management
B2B	Business to Business
B2C	Business to Consumer
B&W	Black and White
BATRRT	Best Available Treatment, Recovery and Recycling Techniques
BPO	Business Process Organization
BCRC	Basel Convention Regional Centre
CPU	Central Processing Unit
CRT	Cathode Ray Tube
CFC / HCFC / HFC / HC	Chlorofluorocarbon / Hydrochlorofluorocarbons / Hydrofluorocarbons / Hydrocarbons
CTV	Color Television
DCF	Designated Collection Facility
DEFRA	Department of Environment, Food and Rural Affairs
DfR	Design for Recycling
DTIE	Division of Technology, Industry, and Economics
EEA	European Environment Agency
EEE	Electrical and Electrical Equipment
EH&S	Environmental Health and Safety
EIC	Environmental Information Centre
EMPA	Swiss Federal Laboratories for Material Testing and Research
EPR	Extended Producer Responsibility
ESM	Environmentally Sound Management
EST	Environmentally Sound Technologies
EU	European Union
FR	Flame Retardant
GDP	Gross Domestic Product
IC	Integrated Circuit
ICT	Information and Communication Technology
IETC	International Environmental Technology Centre
IRGSSA	IRG Systems South Asia Pvt. Ltd.
ISWM	Integrated Solid Waste Management
IT	Information Technology
Kg	Kilogram
LCD	Liquid Crystal Display
L/D	Length/ Diameter
MCIT	Ministry of Communication and Information Technology, India
MFA	Material Flow Analysis
MIT	Massachusetts Institute of Technology
MNC	Multi National Companies
MOU	Memorandum of Understanding
MoEF	Ministry of Environment and Forest, Government of India
MPPI	Mobile Phone Partnership Initiative
MSWI	Municipal Solid Waste Incineration
MT	Metric Tonnes

NCR	National Capital Region
NGO	Non Governmental Organization
ODS	Ozone Depleting Substance
PC	Personal Computer
PCB	Printed Circuit Board
PCB-capacitors	Poly chlorinated biphenyl - capacitor
PRO	Producer Responsibility Organizations
PVC	Poly Vinyl Chloride
PWB	Printed Wire Boards
ROHS	Restriction on Hazardous Substance
RPM	Revolutions Per Minute
SAEFL	Swiss Federal Agency for Environmental, Forests and Landscapes
SBC	Secretariat for Basel Convention
StEP	Solving the E-waste Problem
TV	Television
UNCTAD	UN Conference on Trade and Development
UNEP	United Nations Environment Program
USA	United States of America
Vs	Versus
WEEE	Waste Electrical and Electronic Equipment

Chapter 1: Introduction

1.0 Introduction

The United Nations Environmental Programme (UNEP) through International Environmental Technology Centre (IETC), Division of Technology, Industry, and Economics (DTIE) is implementing Integrated Solid Waste Management (ISWM) based on 3R (reduce, reuse and recycle) in urban areas of Asia -Pacific and Africa. This project aims to promote identification and implementation of environmentally sound technologies (ESTs) for the elements of ISWM including collection, segregation, transportation, treatment, disposal, and recovery and recycle. ISWM covers all types of wastes in an integrative manner from all the waste sources including WEEE/E-waste from domestic/municipal and industrial sources. As a part of Integrated Solid Waste Management Project, UNEP DTIE - IETC is also focusing on electronic waste (WEEE/ E-waste) management. This work will compliment the work being done, globally and regionally, on WEEE/E-waste by UNEP and secretariats of multilateral environmental agreements, in particular the Secretariat of the Basel Convention (SBC). In this context, two manuals, (1) WEEE/ E-waste Assessment Manual and (2) WEEE/ E-waste Management Manual, are being prepared. The second manual has been developed as a guidance document to implement WEEE/ E-waste management and presented in the following chapters. In this chapter, the following sections describe objectives, scope and format of first manual. It is important to note that the aspects related to WEEE/E-waste life cycle and material flow have been elaborated in manual 1; therefore the second manual should be read in conjunction to manual 1.Though, the overall manual is intended to assist all the stakeholders, eg. policy makers, technical personnel, implementation agencies, other stakeholders involved in WEEE/E-waste management, different stakeholders may find one or more chapters more relevant and useful. Therefore, an attempt has been made to cover broad and diverse target audience.

1.1 Objectives

The major objective of second manual is to build capacity of practitioners and decision makers to guide and handhold them to plan, design and implement WEEE/ E-waste management including policy, collection, transportation and treatment in a city/ geographical area and country.

1.2 Scope

The preparation of this manual has involved 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 manual should be usable in all the countries, where WEEE/E-waste projects have been initiated.

1.3 Format

The manual has been prepared in six chapters. Chapter 1 gives introduction and background. Chapters 2 to 5 provide background information supported by examples from different countries followed by guidance notes. Chapter 2 describes the ‘perspective of WEEE/E-waste Management”. It provides a conceptual understanding of WEEE/E-waste management followed by guidance notes to assist policy makers/ other stakeholders to

conceptualize and plan for WEEE/E-waste management project in a geographical region/ country. 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. Chapter 3 describes Current practices of WEEE/ E-waste management to provide an understanding of policy/ laws/ regulations and institutional framework (collection/ transportation/ treatment) related to WEEE/ E-waste management in developed countries and the status in developing countries. Guidance notes provide a broad road map to assist policy makers/ other stakeholders in 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 describes technical intervention at each step i.e. collection, transportation, treatment and disposal of WEEE/E-waste management. Collection and transportation is described in terms of collection channels and infrastructure required to support it, while treatment systems have been described in terms of treatment technologies at three levels. Environmental impacts of the entire WEEE/E-waste treatment system have been described with respect to six environmental attributes. Guidance notes provide a broad framework to assist in design and development of technical specifications for WEEE/ 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 in order to meet regulatory/ compliance.

Chapter 5 describes the sustainability of WEEE/E-waste management by presenting the financial viability of WEEE/E-waste collection, transportation, treatment and disposal. The financial viability is in turn described in terms of regulatory system in place, which defines the standards, financial instruments like recycling fee/ waste tax or other instrument and institutional mechanism for WEEE/E-waste management. At first financial mechanism in developed countries has been described followed by financial mechanism in developing countries and a comparative analysis to identify the drivers for establishing WEEE/E-waste financial model. Further, guidance notes provide a broad framework to assist in assessment of financial viability and development of financial model for WEEE/ E-waste management system.

Chapter 6 presents a case study from a developing country, which describes each aspect of WEEE/E-waste management including techno-economic feasibility of establishing WEEE/E-waste treatment facility.

Chapter 2: Perspectives of WEEE/E-waste Management

2.0 Introduction

WEEE/E-waste is a complex mixture of hazardous and non-hazardous waste, which consists of items of economic value. Therefore, it requires specialized segregation, collection, transportation, treatment and disposal. The following sections attempt a conceptual understanding of WEEE/ E-waste management based on existing management systems in developed countries. At first the mechanisms of WEEE/E-waste trade, WEEE/E-waste life cycle and material flow have been described followed by a description of components of WEEE/E-waste management. Further, generic status of WEEE/E-waste management in developing countries and stakeholders has been described followed by guidance notes.

2.1 Mechanism of WEEE/ E-waste Trade

Mechanism of WEEE/ E-waste trade can be explained in terms of three elements. These elements are given below.

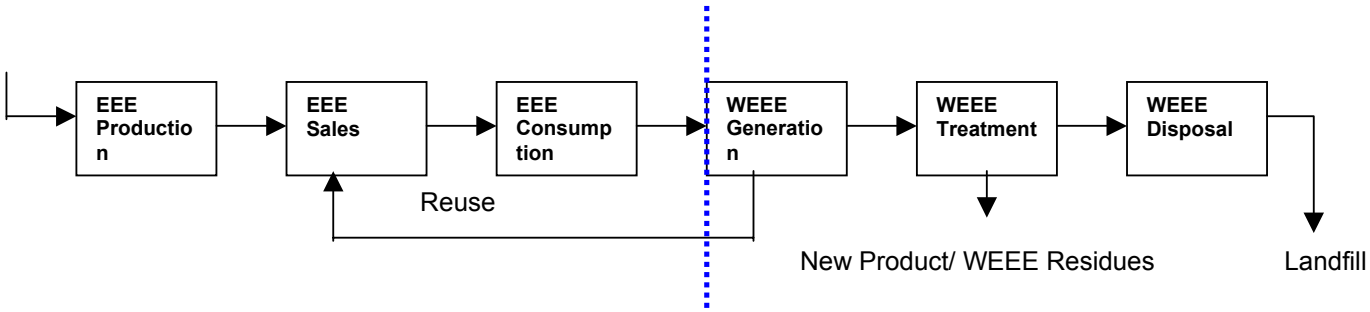
1. Material Flow
2. Life Cycle
3. Geographical Boundary

"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. The following sections provide a conceptual understanding of WEEE/E-waste management starting from WEEE/E-waste generation followed by its transformation into new material.

2.2 WEEE/E-waste Life Cycle

Conceptual life cycle of electrical and electronic equipment is shown in figure 2.1.

Figure 2.1: Conceptual Life Cycle of Electrical and Electronic Equipment



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" eg. 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.

WEEE/E-waste quantification (inventory) in a city/ region forms the basis of WEEE/E-waste management and starts from the stage shown by blue line in figure 2.1.

2.3 WEEE/ E-waste Material Flow Model

WEEE/E-waste material flow model describes various phases of its management. The WEEE/ E-waste material flow model developed by "European Topic Centre on Waste" has been described below and shown in Figure 1.2, to develop a conceptual understanding of WEEE/ material flow. The salient features of this model are:

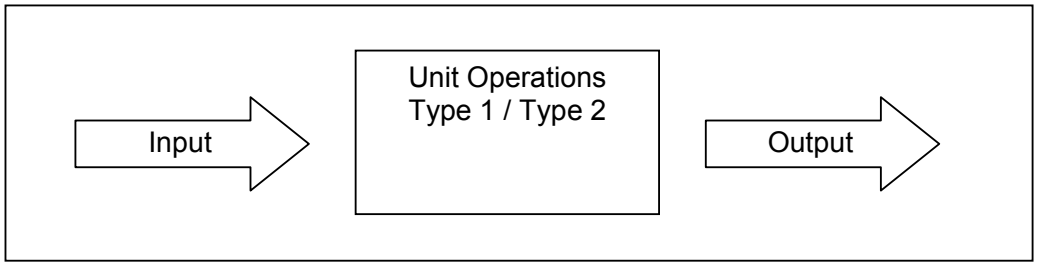
1. The model is based on the 'unit process approach', where a unit process represents processes or activities.

2. The material flow model considers all unit processes and flows within a defined boundary. Arrows indicate the flow of material linking the unit processes.

3. There are two different kinds of unit processes. Type 1 receives material without any alteration, where there are no conversions. Therefore, input is equal to output for instance use and collection of electrical and electronic equipment. In Type 2, a conversion of materials takes place, thus creating new materials (products, waste, etc.) eg. treatment of WEEE/ E-waste including dismantling/ incineration/ smelting etc.

4. The boundary is the interface between the existing system and the external environment or other systems

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 evolution of the 'Four-Phase-Model', where each phase describes respective unit operations and different stakeholders. The four phase model has been shown in figure 2.3.

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 eg. repair, decontaminating, dismantling, shredding, landfill and incineration.

2.4 Components of WEEE/E-waste Management

Phase III and Phase IV of the material flow model define the three major components of WEEE/ E-waste management systems. These are:

1. WEEE/E-waste collection, sorting and transportation system

2. WEEE/E-waste treatment system

3. WEEE/E-waste disposal system.

WEEE/E-waste collection system consists of producer/ retailer take back system, municipal collection system and recycler's/ dismantler's collection system as shown in figure 2.4. Since WEEE/E-waste is hazardous in nature, it is collected, sorted, stored and transported under controlled conditions. Each of the agencies has its own WEEE/E-waste collection and storage centres. The collection means will vary, following distances, rural or urban patterns, and the size of collected appliances. Some categories will require specific collection routes like flatbed collection (for fridges and other reusable household appliances).

An efficient WEEE/ E-waste collection and transportation system will ensure reuse, recycle and adequate WEEE/ E-waste management including avoiding damage or breaking components that contain hazardous substances. The major factors, which determine the efficiency of collection system, are given below.

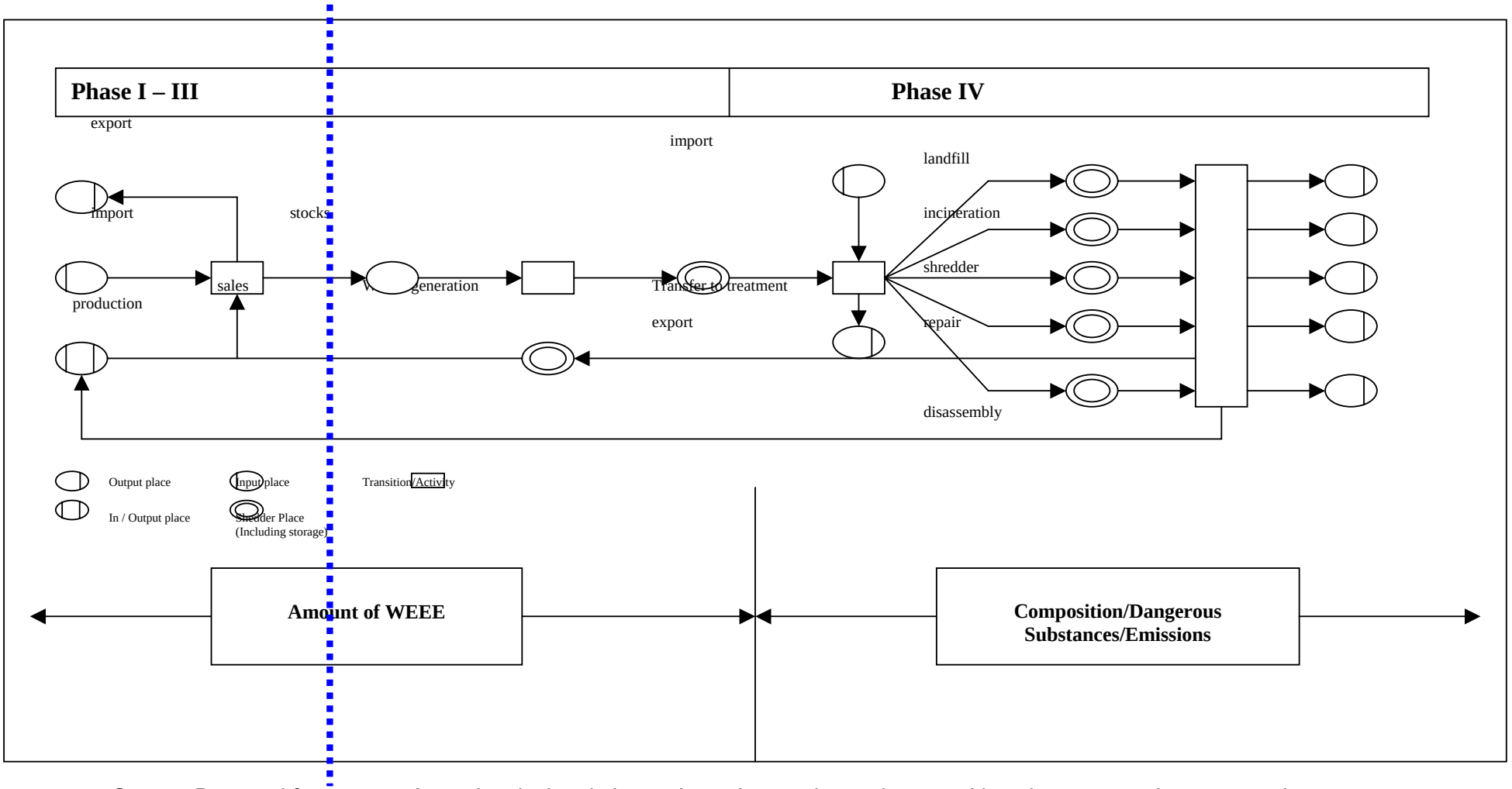
- accessible and efficient collection facilities
- ensure minimal movements of products
- minimize manual handling
- aim to remove hazardous substances
- separate reusable appliances
- adequate and consistent information to the users.

According to available literature, in EU, WEEE/E-waste in general is being sorted/ separated into five groups as given below depending on different material composition and treatment categories. This facilitates efficient collection, recycling and data monitoring for compliance.

1. Refrigeration equipment —Due to ODS usage, this has to be separated from other WEEE/ E-waste
2. Other large household appliances — because of their shredding with end-of-life vehicles and other light iron, they need to be separated from other waste
3. Equipment containing CRTs —the CRTs need to remain intact because of health and safety reasons. Therefore, TVs and computer monitors will have to be collected separately from other waste and handled carefully
4. Lighting (linear and compact fluorescent tubes) — this needs to be deposited in a special container (due to Mercury) to ensure it does not contaminate other waste and that it can be recycled
5. All other WEEE — This equipment can be collected in the same container because there are no recycling or health and safety reasons

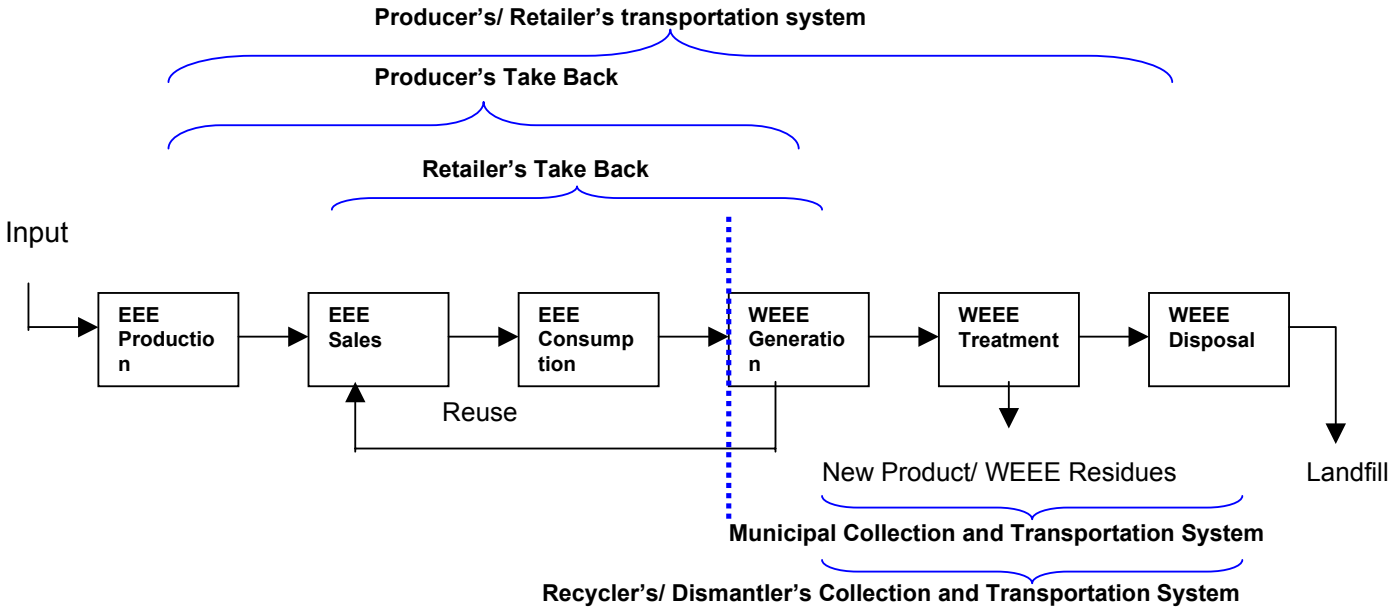
Generic WEEE/ E-waste treatment and disposal system has been described in Phase IV and shown in figure 2.3. The major WEEE/ E-waste treatment techniques are decontamination and disassembly or repair followed by shredding of different fractions. WEEE/E-waste fractions emitted after shredding go for metal recovery. The remaining of WEEE/E-waste fractions are disposed of either in landfills or incinerated.

Figure 2.3: The 'Four-Phase-Model'



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

Figure 2.4: WEEE/ E-waste Collection Systems



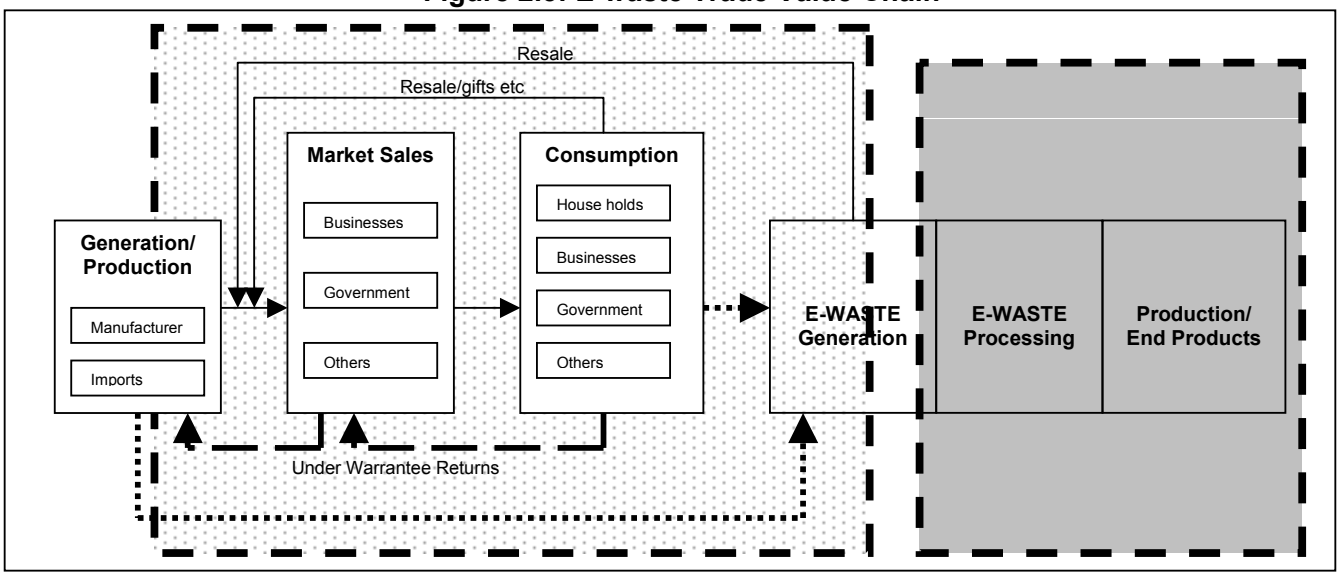
2.5 WEEE/E-waste Management in Developing Countries

The material flow analysis (MFA) described in above section helps to establish WEEE/ E-waste trade value chain. This trade value chain describes unit operations/ processes/ activities carried out by different stakeholders in a geographical region. 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. An example of generic E-waste trade value chain based on MFA in a developing country is shown in figure 2.5. This chain can be further modified or customized with inter or intra linkages depending on the E-waste processing or end production in a particular country.

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 E-waste processing, production/ end products may be present or absent in a country. It has been reported[1] that WEEE/E-waste is locally collected by local recyclers, scavengers, etc. without any legal framework (only recyclable E-waste is well collected) in developing countries like Cambodia, China, Malaysia, Sri Lanka and Thailand.

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

Figure 2.5: E-waste Trade Value Chain



Source: Amit Jain and Rajneesh Sareen ; E-waste assessment methodology and validation in India, Journal of Material Cycles and Waste Management, Volume 8, Number 1 / March, 2006, Springer-Verlag.

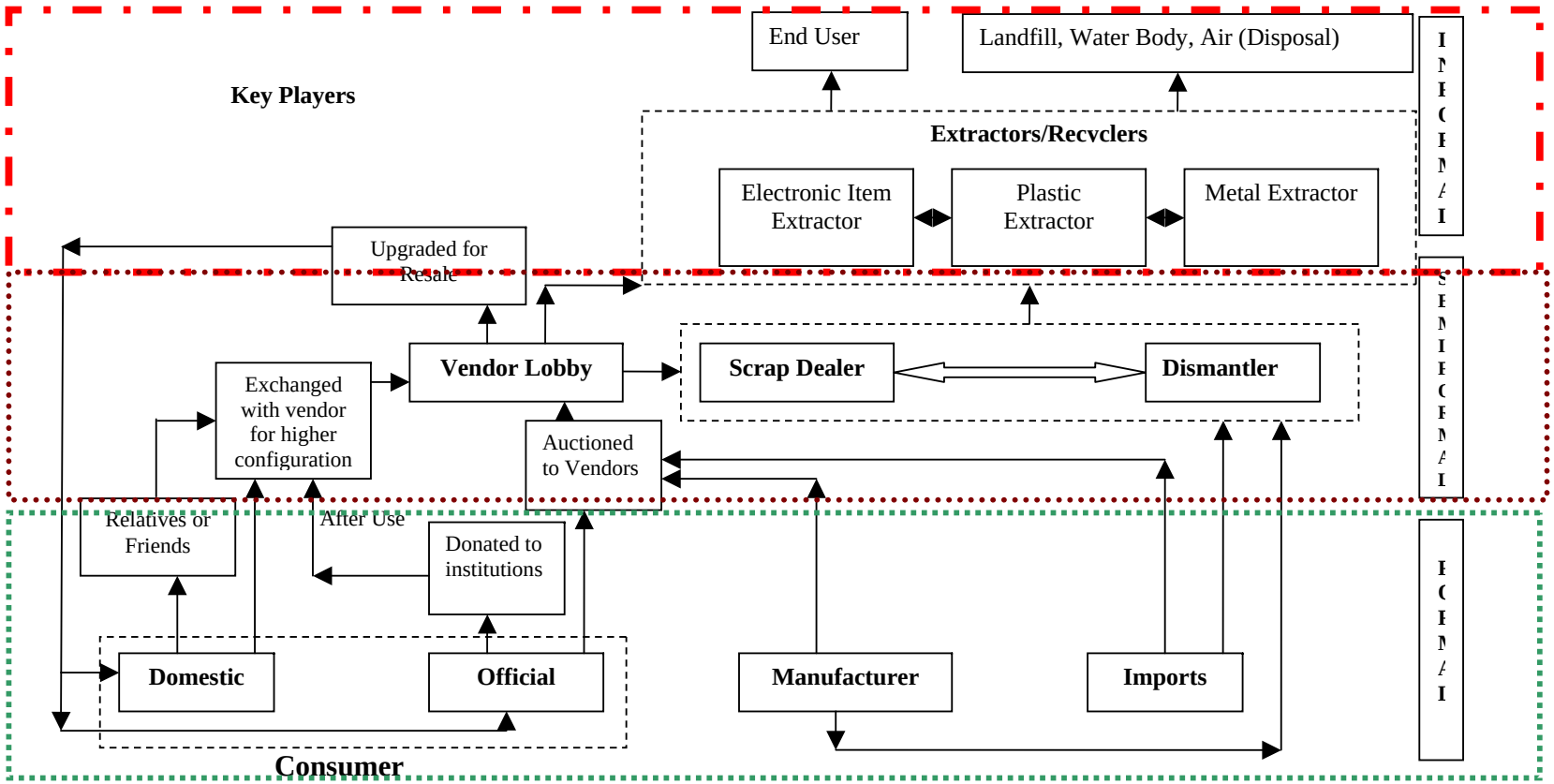
All the WEEE/E-waste stakeholders in developing countries operate at three levels of WEEE/ E-waste generation hierarchy as described below.

1. 1st Level – Preliminary E-waste Generators
2. 2nd Level – Secondary E-waste Generators
3. 3rd Level – Tertiary E-waste Generators.

An example of stakeholder hierarchy in WEEE/ E-waste management in the National Capital Region (NCR) of Delhi, India is given in figure 2.6.

The input to “Preliminary E-waste Generator” comes from formal organized markets like manufacturers, importers, offices and organized markets, where E-waste from domestic consumers comes either in exchange schemes or as a discarded item. Therefore, the major stakeholders are scrap dealers/ dismantlers who purchase E-waste from the first level in bulk quantities. These stakeholders have limited capacity of dismantling and are involved in trading of E-waste with”Secondary E-waste Generators”. The market between first and second level is semi formal i.e. part formal, while the market between second and third level is completely informal. Stakeholders falling under “Secondary E-waste Generators” have limited financial capacity and are involved in item/ component wise dismantling process and segregation eg. dismantling of CRT, PCB, plastic and glass from E-waste. ”Tertiary Level Stakeholders” are the major stakeholders between second and third levels and are metal extractors, plastic extractors and electronic item extractors. They use hazardous extraction processes. Uncontrolled emissions are discharged in air and water during recycling, while the remaining WEEE/ E-waste fractions after recycling are dumped in open dump sites.

Figure 2.6: Stakeholder hierarchy in WEEE/ E-waste management in the National Capital Region (NCR) of Delhi, India



Source: Amit Jain, Perspective of Electronic Waste in South Asia: Current status, Issues and Application of 3Rs, Promoting Reduce, Reuse, and Recycle in South Asia, Sysnthesis Report of 3R South Asia Expert Workshop, Kathmandu, Nepal, 30 August – 1 September 2006, Organized by ADB, IGES,UNEP

2.6 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 and recyclers. At each step in the flow, business transaction defines the movement of the electronic item in the flow. In many developing countries, a majority of stakeholders in this category fall under unorganized/ informal sector. The description of each of these stakeholders in developing country context is given below.

Manufacturers and Retailers

WEEE/E-waste from this sector comprises 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.

Imports

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

Individual Households

Most of the households do not directly sell obsolete WEEE/ E-waste into the scrap market. The preferred practice is to get it exchanged from retailers while purchasing a new computer, or pass it to relatives or friends. In former case, it is the retailer's responsibility to dispose off the computer.

Business/ Government Sector

The business sector (government departments, public or private sector, MNC offices, etc) were the earliest users of IT and IT products; today they account for a sizable amount of total installed ICT equipment. The incompatibility of old systems to cater to present needs and requirements prompts them to pass the obsolete electrical and electronic equipment to dismantlers/ recyclers, who pick up these items based on auction or other standard business practices.

Traders / Scrap dealers / Dissemblers/ Dismantlers

The majority of stakeholders in this category fall under unorganized/ 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. This decision is based on the resale of second hand products. The not-to-be-resold WEEE/ E-waste item/ components find their way to the storehouses for dismantling. During dismantling, each item is dismantled as per building blocks described in section 3.1 of WEEE/E-waste manual 1 and segregated leading to different WEEE/E-waste fractions.

Recyclers

The nature and type of recyclers vary considerably between developed and developing countries. In developed countries the recycling operations may be combined with dismantling operation in integrated facilities or alternatively the scrap dealers may carry out the dismantling operation, segregate the fractions and send them to large scale smelters for material recovery technologies like open roasting, small scale smelting, acid bath, etc. They are spread over different areas in organized/informal sector and one recycler usually deals with one type of metal/ recycling operation. Generally these stakeholders are not concentrated in a single place, but spread over different areas, each handling a different aspect of recycling. The general practices observed in case of recycling in developing countries are open roasting, smelting and acid bath in the unorganized/ informal sector to recover different metals.

In addition to dangerous recycling and disposal practices followed by different stakeholders described above, there is no organized collection, sorting and transportation system in developing countries.

2.7 Guidance Notes

Objective: The major objective of guidance notes on perspective of WEEE/E-waste management is to assist in assessment of existing WEEE/E-waste management in city/ geographical region including identification of problem, its extent and capacity of the existing management system in informal/ unorganized and formal/ organized sectors. This assessment will serve as foundation for planning and implementation of a formalized WEEE/E-waste management system in a city/ geographical region.

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

Step 1: Determine WEEE/E-waste trade value chain in a city/ geographic region using guidance notes described in WEEE/E-waste manual 1. The output of this step will give complete background information on WEEE/E-waste management.

Step 2: Determine existing and future item-wise WEEE/E-waste inventory in a city/ geographic region using guidance notes described in WEEE/E-waste manual 1. The output of this step will give baseline and predicted WEEE/E-waste to be collected, segregated, transported, treated and finally disposed.

Step 3: Determine item-wise content of WEEE/E-waste inventory using guidance notes described in WEEE/E-waste manual 1. The output of this task will give information on quantity and type of hazardous WEEE/E-waste that needs to be collected, segregated, transported, treated and finally disposed.

Step 4: Determine existing item-wise WEEE/E-waste quantities collected and segregated in informal/ unorganized and formal/ organized sectors using the data collected from questionnaire given in WEEE/E-waste manual 1. This information will give an idea of existing capacity of informal/ unorganized and formal/ organized sectors in WEEE/E-waste collection.

Step 5: Determine existing item-wise WEEE/E-waste quantities treated in informal/ unorganized and formal/ organized sectors using the data collected from questionnaire given in WEEE/E-waste manual 1. This information will give an idea of existing capacity of informal/ unorganized and formal/ organized sectors in WEEE/E-waste treatment.

Step 6: Determine recovery (quantities) of items of economic value from existing item-wise WEEE/E-waste quantities treated in informal/ unorganized and formal/ organized sectors using the data collected from questionnaire given in WEEE/E-waste manual 1. This information will give an idea of existing efficiency of WEEE/E-waste treatment processes in the informal/ unorganized and formal/ organized sectors.

Step 7: Determine existing item-wise WEEE/E-waste fraction quantities disposed and disposal procedure using the data collected from questionnaire given in WEEE/E-waste manual 1. This information will give an idea of the extent of pollution, which WEEE/E-waste fractions are creating and should assist in developing a strategy for its abatement and control.

Chapter 3: Current Practices of WEEE/E-waste Management

3.0 Introduction

Current practices of WEEE/ E-waste management provides an understanding of policy/ laws/ regulations and institutional framework related to WEEE/ E-waste management. At first, existing policy/ laws/ regulations and institutional framework related to WEEE/ E-waste management in developed countries is presented. This is followed by an exposition on developing countries and initiatives undertaken by different agencies in addressing the gaps globally. Finally, guidance notes provide a broad road map to assist in developing enabling policy/ laws/ regulations and institutional framework for WEEE/ E-waste management.

3.1 National and Social Policies/ Laws/ Regulations/ Institutional Roles in Developed Countries

Policies/ laws/ regulations related to WEEE/E-waste management provide an institutional framework for their implementation. Countries in Europe and Japan have been the frontrunner in formulating policies/ laws/ regulations for WEEE/E-waste followed by their institutionalization and implementation. The following sections describe policies/ laws/ regulations followed by institutional mechanism in developed countries for WEEE/E-waste management.

3.1.1 Policies/ Laws/ Regulation

“Extended Producer Responsibility” or “Product Take Back” forms the basis of policy framework in developed countries. WEEE directives provide a regulatory basis for collection, recovery and reuse/ recycling targets in EU. The 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 EU directive or more stringent standards based on WEEE/ E-waste management. Majority of countries have regulations similar to WEEE directives. Countries like Japan have regulations focused on “Reuse, Recycling and Recovery”. Other countries like Canada and Australia are developing their systems based on the similar principles of “Extended Producer Responsibility”. The status of WEEE directive transposition into national laws of EU countries and regulatory structure in other developed countries is summarized in table 3.1 and table 3.2, given in appendix 1.

3.1.2 Institutional Mechanism

Institutional mechanism for WEEE/E-waste management system has been described in terms of three elements like 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. Table 3.1 and table 3.2 describe the existing institutional mechanism in terms of these elements in developed countries. 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

3.1.2.1 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 the 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 part of WEEE/ E-waste within national boundaries. This is the general approach in the countries with 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 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 indeed collect WEEE/ E-waste in an equitable manner from collection points throughout the territory.

3.1.2.2 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 ensure 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.

3.1.2.3 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/E-waste 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).

A comparative analysis of table 3.2 shows that Japan has a better functioning WEEE/E-waste management system in comparison to other developed countries. Korea, Canada and Australia are in advanced stage of development of WEEE/E-waste management systems. WEEE/E-waste management systems, which were established earlier in countries like Switzerland, Norway, Belgium, Sweden, and The Netherlands, not only met minimum WEEE/E-waste collection and recycling targets set in EU directives but also performed better. However, harmonization of WEEE/ E-waste national regulations and their implementation in other European countries are major challenges in WEEE/E-waste management across Europe. Their performance in future will provide lessons to other developed and developing countries, which are developing their WEEE/E-waste management framework.

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

Policies/ laws/ regulations and institutional mechanism in developing countries, where some level of WEEE/E-waste awareness exists have been described in table 3.3. An assessment has been carried out on a scale of 1 to 4 based on recent WEEE/ E-waste initiatives in these countries. It may be noted that majority of developing countries are at second stage of development of WEEE/ E-waste management framework. The status of WEEE/E-waste in majority of African and Latin American countries is not available.

Table 3.3: Policies/ Laws/ Regulations/ Institutional Roles for WEEE/E-waste in Developing Countries

LEVEL / PRACTICE	1 LOW	2	3	4	5 HIGH
Legal framework	There is no legal framework, strategy or norms.	There is only plan to develop legal framework.	A legal framework is being prepared and will be issued/enforced in very near future.	Enforcement, but the legal framework is not well conducted.	Full enforcement and model legal framework for other countries.
	Cambodia, Philippines	South Africa, Argentina, Indonesia	Sri Lanka, India	China, Malaysia,Thailand	
Inventory	There is no inventory.	There is the inventory for municipal solid waste, but no designated inventory for E-waste.	E-waste inventory is being prepared.	E-waste inventory is conducted, but lack of information and data.	E-waste inventory is fully conducted and available on website.
		Malaysia, Sri Lanka, South Africa	China, Thailand, Indonesia, Argentina, Philippines	Cambodia	India (national level)
Separate collection	There is no separate collection.	E-waste is locally collected by local recyclers, scavengers, etc. without any legal framework. Only recyclable E-waste is well colleted.	E-waste is well collected by local collection mechanism. Pilot separation and collection systems have been set up.	Collection system for E-waste is operational and includes environmentally sound disposal.	Collection systems are fully operational. Our collection is recognised as a model system by other countries.
	Indonesia, Philippines, Argentina	Cambodia, China, Malaysia, Sri Lanka, Thailand, India	Malaysia, South Africa		
Recycling/reusing technology	There is no recycling/reusing mechanism.	Only recyclable and reusable Ewaste is recycled and reused by local stakeholders.	There is a plan to set up E-waste facility.	There is E-waste recycling facility, but not achieve to full operation for all E-waste in the country.	E-waste recycling facility is fully operated for all E-waste in the country and the model as the statof-the-art recycling facility.
	Cambodia	Sri Lanka, Argentina, Indonesia, Philippines,	Malaysia, South Africa	China, Thailand, India	

Source: Prepared by modifying and updating table 7-1, E-waste matrix,

3.3 Initiatives of Different Agencies

The analysis of table 3.1, table 3.2 and table 3.3 shows that there is a huge gap between developed and developing countries related to WEEE/E-waste policies/ laws/ regulations and institutional mechanisms. Recognizing the urgency to address this gap, a number of agencies have undertaken initiatives at global, regional and country level. A brief description of these initiatives is given below.

3.3.1 Basel Convention

Initiatives undertaken till 2006

A. The Mobile Phone Partnership Initiative (MPPI) Phase 1

The Mobile Phone Partnership Initiative was launched in 2002, during COP 6. This initiative constituted the establishment of a sustainable Public-Private Partnership for the environmentally sound management of used and end-of-life mobile phones. The objectives of the partnership are given below:

(a) Achieve better product stewardship

(b) Influence consumer behavior towards more environmentally friendly actions

(c) Promote the best disposal/recycling/refurbishing options

(d) Mobilize political and institutional support for environmentally sound management

(e) Create an initiative that could be replicated to build new public/private partnerships for the environmentally sound management of hazardous and other waste streams.

Since the start of the initiative, the Mobile Phone Working Group successfully finalized five guidelines that address the refurbishment of used mobile phones, recovery and recycling of end-of-life mobile phones, raising awareness on design considerations, collection and on the transboundary movement of used and end of life mobile phones.

B. Basel Convention Partnership on the ESM of E-waste in Asia Pacific Region

The countries in Asia and the Pacific, which are Parties to the Basel Convention, have identified WEEE/E-waste as a priority. These countries emphasized the need to obtain the latest and relevant information on environmentally sound management of WEEE/E-waste, inclusive of information regarding know-how on cleaner technologies or processes used in the repair, refurbishment, recycling or recovery of used or end-of-life electrical and electronic equipment. In view of these identified needs, this partnership was launched in November 2005.The goal of this partnership is to enhance the capacity of Parties to manage electrical and electronic wastes in an environmentally sound way through the building up of public-private partnerships, and by preventing illegal traffic of hazardous WEEE/E-waste. A number of strategic objectives, which have been identified to achieve the above goal, are given below:

(a) Assessment of the situation through

- Conduct of national inventories
- Establishment of mechanisms for information exchange at the national and regional level

- Monitoring of the impacts on human health and the environment of activities concerning or related to the management of electrical and electronic wastes.

(b) Prevention and minimization

- Establishment of goals, both intermediate and long-term, to reduce the quantity of electrical and electronic wastes ending up in landfills
- Introduction of cleaner production approach to minimize, and where feasible, to eliminate hazardous substances in Electrical and Electronic Equipment (EEE) and consequently their wastes
- Development of economic and regulatory incentives to stimulate best practices.

(c) Management

- Achieving ESM through promotion of best practices and use of sound recycling technologies adapted to the national specificities
- Development of appropriate methods for evaluation, testing, characterization and classification of electrical and electronic wastes
- Development of environmental management systems, Extended Producer Responsibility (EPR), standards and guidelines or principles for environmentally sound management or certification scheme.

(d) Information and training

- Establishment of a regional information collection and dissemination clearing house or network accessible to all concerned stakeholders (e.g. Governments, IGOs, industry, NGOs, municipalities, research institutions)
- Increase of awareness at all levels and public participation on WEEE/E-wastes issues. Development of training curricula for trainers
- Promotion of the transfer, within the region, of expertise, know-how on best practices and technologies.

A number of other activities, which are being undertaken include awareness raising activities; detailed inventories; initiating of pilot schemes on collection and segregation of E-wastes, including take-back schemes; initiate pilot repair, refurbishment and recycling schemes; and training of customs and enforcement officers to control or verify export or import of electrical and electronic wastes and work on the identification of electronic wastes in the Harmonized System of the World Customs Organization. The status of some of the initiatives under this partnership is given in table 3.4.

Table 3.4: Status of WEEE/E-waste initiatives under Asia Pacific Region Partnership

COUNTRY/ BCRC	TITLE OF PROJECT	SCOPE	STATUS
China	Feasibility Analysis to Develop a Centre of Excellence of Information on the ESM of E-waste in BCRC in Beijing, China	Regional	Completed.
SPREP, Samoa	Pilot inventory of E-waste in 10 Pacific Countries	Regional	MOU under finalisation with SPREP
BCRC SEA, Jakarta	Development of	Regional	In progress. Draft

COUNTRY/ BCRC	TITLE OF PROJECT	SCOPE	STATUS
	Guideline Documents on Methodology on Inventory of E-waste and Environmentally Sound Recycling, Reuse, Repair, Refurbishment/Disposal of E-waste		Final Report received on 8 January 2007.
BCRC SEA, Jakarta	Training Workshop on ESM of E-waste	Regional	Planned for 13-15 March 2007 in Cambodia
Sri Lanka	Development of national implementation plan for E-waste management	National	Extended to April 2007
India (NGO)	Facilitating partnerships for ESM of E-waste in India (NGO project): Phase I	National	Extended to May 2007
Indonesia	Preliminary inventory of E-waste	National	On-going. National Workshop was completed in December 2006.
Cambodia, Malaysia, Thailand, Viet Nam	Inventory of E-waste	National	On-going. To be completed by March 2007.

Pilot Project

On 1 November 2006, a Memorandum of Understanding (MOU) for the implementation of the Pilot Project on Trans-boundary Movement of End-of-Life Mobile Phones in South East Asian Countries was signed between the Secretariat of the Basel Convention (SBC), the Basel Convention Regional Centre for South East Asia (SEA) based in Jakarta and the Dowa Eco-System Co., Ltd. Japan. Under this pilot project, Dowa Eco-System Co. Ltd. will contribute 10 million Japanese Yen of seed money to cover the costs of activities for the first stage of the project during the 2006 financial year, which concludes on 31 March 2007. The whole project will be implemented from 1 November 2006 until 31 March 2008. The objective of the pilot project, which would involve initially Malaysia, Thailand and Singapore, is to establish a scheme for the collection and environmentally sound management of end-of-life mobile phones from these three countries. As a first step, an investigation of the current status of end-of-life mobile phones will be conducted and at the second stage a pilot collection scheme for collection and control of the transboundary movement of end-of-life mobile phones to Japan for recovery of precious metals will be carried out in an environmentally sound manner. The project will also provide an opportunity for the practical implementation of the technical guidelines for the environmentally sound management of mobile phones developed under the Basel Convention Mobile Phone Partnership Initiative. If successful, the project would be expanded and implemented in other Asian countries and would include E-wastes such as personal computers and accessories.

C. Other E-waste projects implemented

Argentina

A project on the Inventory of Electronic Wastes in the South American Region was designed, which aimed at assisting the participating countries to prepare, draft and update a national inventory and to establish technical directives to deal with E-waste in order to achieve the international standards on environmental sound management. This project was implemented in 2006 by the Basel Convention Regional Centre for Training and Technology Transfer for the South American Region (BCRC-Argentina) together with the existing regional focal points and competent authorities, and in cooperation with the Secretariat of the Basel Convention.

Planned Initiative 2007-2008 and beyond

A. The Mobile Phone Partnership Initiative (MPPI), Phase 2

The following activities will be carried out:

(a) The MPPI will begin collecting data on the trans-boundary movements of used and end of life mobile phones. The information will assist parties to clarify how used mobile phones should be addressed and reported upon

(b) Implement a pilot in two or more countries on the collection of mobile phones

(c) Implement a pilot in some countries on the recycling of used and end of life mobile phones

(d) Complete the report on the application of the guideline on the refurbishment of mobile phones

(e) Hold workshops in different regions to get the information from the guidelines into the hands of the country representatives in each region.

B. Global Partnership on E-waste

Under this partnership and forum, regional programs will be elaborated or initiated. Environmentally sound management of E-waste has been identified as a priority work program under the Basel Convention strategic plan and under the Basel Convention Declaration on Partnership. The next focus area under this partnership will be the African Region along with the Latin American Region.

C. Global Partnership on computing equipment

The partnership will begin to take form during the first quarter of 2007. The expected initiatives are given below.

(a) Ensuring environmentally sound management (ESM) of end-of-life computing Equipment; and

(b) opening a dialogue with all stakeholders on initiatives that could be carried out in different UN regions and available information that would address issues associated with illegal traffic.

In the partnership's first phase, personal computers (in particular CPUs), CRTs and printers will be addressed. Building upon current information and principles on recycling and refurbishment, the partnership will provide new and innovative information, guidance, and standards for evaluating and/or testing and labeling of collected used products and those that have already been refurbished and recycling at environmentally sound facilities.

D. Activities under the Nairobi Declaration

Decision VIII/2 under the Nairobi Declaration, among others, mandated the Open-ended Working Group to undertake the following activities:

(a) To develop a work plan for the environmentally sound management of WEEE/ E-waste focusing on the needs of developing countries and countries with economies in transition for consideration by COP9

(b) The preparation of technical guidelines for the environmentally sound management of WEEE/E-waste

(c) To monitor developments in the environmentally sound management of WEEE/ E-waste

The Nairobi Declaration also covered the following issues:

(a) Role of the Basel Convention regional centres

(b) Increase in financial support for work on E-waste issues

(c) Development of strategic partnerships targeting E-waste

(d) Encouragement of the development of pilot projects on take-back systems
(e) Collaboration of Parties in the prevention and combating illegal traffic of E-waste

(f) Phasing out of technologies which are not environmentally sound and the promotion of environmentally sound technologies

(g) Life-cycle approach and promotion of clean technology and green design for e-products

(h) In export, prevention of donations of end-of-life e-equipment.

3.3.2 G-8 3Rs Initiative

The Ministerial Conference on 3Rs Initiatives, held in April 2005 in Tokyo, formally launched the 3Rs Initiative agreed upon by the G8 leaders at the Sea Island Summit. During the Conference, participating countries and organizations shared information on 3R-related activities. The Basel Secretarial works closely with 3Rs initiative on E-waste issue.

The Senior Officials Meeting on the 3Rs Initiatives (SOM) was held in Tokyo, Japan on 6 to 8 March 2006 and was hosted by the Ministry of Environment, Japan. Twenty countries participated in the meeting apart from the European Commission, eight international organizations and network, including the Basel Convention Secretariat.

The Asia 3Rs Conference was held in Tokyo, Japan on 30 October to 1 November 2006 and was hosted by the Ministry of Environment, Japan. Twenty Asian countries and six G-8 countries participated in the meeting, which included, eight international organizations and

networks, including the Basel Convention Secretariat. At the Working Group on E-waste Management, the progress of the Asia Pacific E-waste Project was presented by the Basel Secretariat and the Basel Convention Regional Centre for SEA in Jakarta.

3.3.3 StEP - Solving the E-waste Problem

The StEP initiative, developed in 1984 and formally launched in March 2007, is based in the UN University, Bonn, Germany. The StEP initiative is the offspring of UNU, the UN Environment Programme (UNEP) and the UN Conference on Trade and Development (UNCTAD). Other prominent charter partners include the U.S. Environmental Protection Agency, the Massachusetts Institute of Technology (MIT), University of California at Berkeley, the Chinese Academy of Sciences, Technical University Vienna (Austria), French National Institute of Telecommunication (France), Technical University Delft (Netherlands), University of Melbourne (Australia), State Secretary of Economics and EMPA (Switzerland), Regional Environmental Centre (Hungary), the Korea Institute of Geoscience & Mineral Resources, and Umicore Precious Metal Refining (Belgium). The role of SteP is to provide analysis and dialogue from a neutral standpoint in order to find solutions, which reduce environmental risk and enhance development. Its prime objectives are optimizing the life cycle of electric and electronic equipment by:

(a) Improving supply chains;
(b) Closing material loops;
(c) Reducing contamination;
(d) Increasing utilization of resources and reuse of equipment;
(e) Exercising concern about disparities such as the digital divide between the industrializing and industrialized countries;
(f) Increasing public, scientific and business knowledge.

Principles

1. StEP's work is founded on scientific assessments and incorporates a comprehensive view of the social, environmental and economic aspects of E-waste.

2. StEP conducts research on the entire life-cycle of electronic and electrical equipment and their corresponding global supply, process and material flows.

3. StEP's research and pilot projects are meant to contribute to the solution of E-waste problems.

4. StEP condemns all illegal activities related to E-waste including illegal shipments and reuse/ recycling practices that are harmful to the environment and human health.

5. StEP seeks to foster safe and eco/energy-efficient reuse and recycling practices around the globe in a socially responsible manner.

The key-elements of the StEP Initiative's organization are a Steering Committee, a Secretariat and five task forces involving its coordinators, members and observers. The description of each task force and the projects under implementation/ planned are given below.

(i) Task Force 1: Policy & Legislation

1. Research Study: 2008 Review of Directive 2002/96 on Waste Electrical and Electronic Equipment. This project is one of two studies which will support the European Commission in their 2008 review of the WEEE-Directive by presenting and evaluating options for its development.

2. Research Project: Best WEEE Policies: Overall aim is to comparatively evaluate different national policies and legislation on WEEE and, from this, to come up with legal and political recommendations for "best WEEE policies". For this, the task force has already completed a rough inventory on national WEEE legislations and policies.

   Further, under development are the following:
   - A draft Policy White Paper on Lessons from the EU WEEE Directive for North America and An Assessment of In-Place North American Electronics Recycling Systems
   - A list of necessary criteria and indicators to comparatively assess legislation and policies in place.

3. Project: Online database for WEEE Legislation & Policies
4. Research study: Political and legal barriers to reuse
5. Research study: Quantification and qualification of the E-waste problem. The aim of this study is to quantify and qualify global streams of E-waste to provide for a sound basis for future evaluations and concerted recommendations.

(ii) Task Force 2: Redesign

1. Project: DfR Case Studies Library: This study gives an overview on current approaches and case studies in the field of Design for Recycling.
2. Project: EU/Asia E-waste Partnership: Best Practice Partnership for Electronics Waste Management in Urban Areas of South-East Asia. The proposed project is intended to support the development and implementation of new policies, techniques and approaches to govern aspects of E-waste reduction and management in the context of urban environment.
3. Working Paper: Inventory of best practice in DfR – Design for Recycling. This study intends to assess existing approaches in Design for Recycling (DfR) and thus, give an overview on best practices in DfR.
4. White Paper: Electrical and Electronics Product Design Requirements for minimized Global End-of-Life Impacts. The intention of this White Paper is to give a feedback from end-of-life problems on a global scale to product design.

(iii) Task Force 3: Re Use

1. Project: Common Nomenclature. This project intends to find common definitions of reuse, refurbishment, EEE products and other related topics and make them available online.
2. White Paper: Optimal Framework Conditions for Re Use.
3. White Paper: Environmental and business guidelines for equipment and component recovery (B2B and B2C).
4. Conference/ Global Forum: Professional Reuse, Refurbishment, Remarketing and Sustainable Consumption. Aim of this project is to prepare a global TF3 StEP Conference with thematic focus on Professional Reuse, Refurbishment, Remarketing and Sustainable Consumption.
5. Market study Bangladesh.
6. Research Study: International shipments of WEEE and EEE for Reuse.

7. Research Project: Sustainable reuse of EEE and changing consumer behavior.

(iv) Task Force 4: Re Cycle

1. Research project: The Best of Two Worlds. The research project investigates the eco-efficiency of manual dismantling of domestic E-waste in China with control over all environmentally relevant fractions.
2. Research study: Web of metals. This study focuses on the global dynamic "Web of Metals" with the overall aim of mapping the global flow of selected elements contained within electronics through a dynamic system modelling.
3. Project: Global E-waste program. Objective of this programme is to improve local recycling processes in the informal sector, to raise public awareness and clean the E-waste channels.
4. White Paper: Sustainable Material Flows for Secondary Materials from End-of-Life Electronics in the Industrialized and Industrializing World
5. Research study: Future options for CRT glass
6. Research study: The global recycling supply chain. This research study will look into environmental, economic and social constraints and optimisation e.g. export licences, economies of scale and other related topics along the global recycling chain.

(v) Task Force 5: Knowledge Management & Capacity Building

1. Project: Creation and Maintenance of the StEP EduWeb, WorkWeb, InfoWeb & File -Gallery
2. Workshop: International workshop on E-waste management
3. White Paper: Extending the Life of Computers with an Educational Program
4. Manual: How to de-manufacture a computer
5. Training program: Summer/Winter school on sustainable E-waste management
6. Project: Annotated E-waste bibliography

3.3.4 UNEP/ DTIE (IETC)

UNEP through International Environmental Technology Centre (IETC) is implementing "Integrated Solid Waste Management Project" based on 3Rs (reduce, reuse and recycle). ISWM covers all types of wastes in an integrated manner. UNEP DTIE-IETC is also focusing on WEEE/E-waste management and is developing two manuals on WEEE/E-waste assessment and WEEE/E-waste management.
Earlier UNEP DTIE supported a city level WEEE/E-waste assessment study for Mumbai and Pune in India.

3.3.5 GeSI: Global e-Sustainability Initiative

The Secretary to GeSI is located in UNEP/DTIE. It is an industrial organisation for which a membership fee is paid annually to run the Secretariat and handle other administrative matters. GeSI consists of Information and Communications Technology (ICT) service providers and suppliers, with the support of the United Nations Environment Programme and International Telecommunication Union. Their objectives are to share their experience and knowledge, work with stakeholders, manage their own private sector operations in a sustainable way, raise awareness of the contribution ICT can make to society and engage in research and benchmarking.

3.3.6 Swiss State Secretariat for Economic Affairs (SECO)

SECO along with Swiss Federal Laboratories for Materials Testing and Research (EMPA) has designed and implementing the global program "Knowledge Partnerships in E-waste Recycling". EMPA is studying the situation of E-waste recycling in developing and transition countries. The program expects to share knowledge and experience gained through this system and to establish "Knowledge Partnerships in E-waste Recycling". The project is being implemented in India, China, Chile, Columbia and South Africa. The programme is split into two complementary parts: "Knowledge Management" and "Capacity Building".

- Knowledge Management & Information Dissemination**:** This component deals with development of an E-waste knowledge base in the form of the "eWaste Guide", an interactive website freely accessible on the Internet. The guide is being continuously updated and amended based on experiences gained in the capacity building subproject as well as the evaluating and comparing processes.
- Capacity Building: This component analyses the general conditions for E-waste recycling in India, China and South Africa with the aim of implementing an ecologically sustainable and financially viable E-waste recycling system in one of those countries.

3.3.7 GTZ

GTZ is supporting WEEE/E-waste initiatives in different countries. As part of its advisory services, it is supporting Indo-European E-waste Initiative, apart of Indo German Environment Program, known as Advisory Services in Environmental Management (ASEM 2002-2008). It has also supported programme on WEEE/E-waste assessment in Yemen.

3.4 Guidance Notes

Objective: The major objective of guidance notes is to assist policy makers/ other stakeholders to assess whether WEEE/E-waste is addressed in the existing environmental/ related legislation of the country. This assessment will assist them to identify the gaps and the regulations where WEEE/E-waste can be addressed or whether there is a need to address it in a new regulation. Six steps identified in guidance notes for WEEE/ E-waste definition given in WEEE/E-waste manual 1 are being integrated to new steps to provide a broad road map to assist in development of an enabling policy/ laws/ regulations and institutional framework for WEEE/ E-waste management.

Guidance Procedure: Guidance procedure includes completion of following nine 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".

E-waste reference in Indian 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:* Incase 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 tentative content, extent and coverage of WEEE/E-waste definition.

- *Step 7:* 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. 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.

- *Step 8:* Carry out due diligence on WEEE/ E-waste institutional mechanism like collection and transportation system and registry eg. Collective and clearing house system, B2C and B2B model. Identify the gaps with respect to existing collection and transportation system (outputs of step 4 from chapter 1) and recommend tentative collection and transport framework. Organize a workshop of major stakeholders like line ministries/ government agencies (IT/ Electronics/ Consumer Durables/ Electrical/ Industries/ Environment/ Forests, Finance/ Economy & Commerce), industry

associations, retailer's associations, municipalities, formal and informal recyclers, transporters, operators for incinerators/ hazardous waste management facilities and NGOs to arrive at acceptable WEEE/ E-waste institutional mechanism.

- *Step 9:* Design a pilot level WEEE/E-waste collection and transportation system to demonstrate the viability of WEEE/E-waste collection and transportation system.

Chapter 4: Stages and Technologies for WEEE/E-waste Management

4.0 Introduction

WEEE/E-waste management requires technical intervention at each step i.e. collection and transportation, treatment, and disposal. Collection and transportation system has been described in terms of collection channels and infrastructure required to support it. Treatment systems have been described in terms of treatment technologies at three levels. Environmental impacts of the entire WEEE/E-waste treatment system have been described with respect to six environmental attributes. Finally, guidance notes provide a broad framework to assist in design and development of technical specifications for WEEE/ E-waste treatment system.

4.1 Collection systems

WEEE/ E-waste collection systems have been described in terms of WEEE/E-waste collection channels and infrastructure required to make these channels operational. Each of these items followed by examples is described below.

4.1.1 Collection Channels

The three major WEEE / E-waste collection channels, which are being successfully used, are municipal collection sites, retailer take-back, and producer take-back. The collection mechanism used by each collection channel is given below.

4.1.1.1 Retailer Take Back and Storage

In this collection mechanism, consumers can take back WEEE/ E-waste to retail stores that distribute similar products. They may give back the product at the retail store depending upon purchase of a new product, or without any purchase required, and is sometimes done at the point of home delivery and installation of a new item by the retailer/distributor. Where available, this service is usually free to private households.

4.1.1.2 Producer Take Back and Storage

In this collection mechanism, WEEE/ E-waste is taken back directly by producers either directly at their facilities or designing collection centres and then fed into the WEEE/ E-waste system. This usually applies to larger commercial equipment and operates on the principle of “new equipment replacing the old ones”.

4.1.1.3 Municipal Collection and Storage

In this collection mechanism, consumers and/ or businesses can leave WEEE/ E-waste at municipal sites. A number of sorting containers and/or pallets are provided at their collection site according to the product scope and logistical arrangements with recyclers and transporters. This collection mechanism is usually free for household WEEE/ E-waste, although charges sometimes apply for commercial companies.

4.1.1.4 Other Collection Points

Consumers and or businesses can leave/ drop off WEEE/ E-waste at specially created sites/centers. These can be specialized sorting centres controlled by the collective system/ PRO or more commonly third party sites, whose operators may be remunerated for the provision of space. A number of sorting containers and/or pallets are provided according to the product scope and logistical arrangements with recyclers and transporters. This is

usually free for household WEEE/ E-waste, but sometimes charges apply for commercial products.

The majority of schemes in Europe operate around the municipal collection system eg. ICT Milieu, in Denmark and El Kretsen in Sweden use this channel exclusively. Others, such as Recupel, Belgium, NVMP, the Netherlands and El-Retur, Norway encourage retailer participation. Some non EU schemes, such as SWICO, Switzerland achieved much higher levels of collection via the retail chain.

Municipal solid waste collection sites, which are used for WEEE / E-waste collection, have been found to be very cost effective as minimal up-gradation of these facilities are required. Similarly, drop-off and permanent collection point at retail outlets have been found to be very successful. The operation of collection system described above require storage and transportation infrastructure as described below.

4.1.2 Collection Infrastructure

Collection infrastructure requires establishment of WEEE/ E-waste collection points and storage area in a city/ geographical region. The following features mentioned in WEEE EU directive provide guidance on a conceptual approach for establishing collection points and storage areas:

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. Ensure that a rate of separate collection of at least four kilograms on average per inhabitant per year of WEEE/ E-waste from private household is achieved.
5. Private households not to dispose of WEEE/ E-waste as unsorted municipal waste and to collect such WEEE/ E-waste separately.
6. 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.
7. Sites for storage (including temporary storage) of WEEE/E-waste prior to their treatment should have weatherproof covering for appropriate areas.

4.1.3 Guiding principles for design and formulation of technical specifications of WEEE/E-waste collection points

An effort has been made to define principles for designing and formulation of technical specifications of collection points/ storage area by taking recourse to “Code of Practice for Collection of WEEE from Designated Collection Facilities (DCF)”, dti, Government of UK, February 2007, “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.

As per Annex 1 - Designated Collection Facilities of “Code of Practice for Collection of WEEE from Designated Collection Facilities (DCF)”, a DCF should:

1. Enable household WEEE to be collected from the DCF 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
D – Gas discharge lamps
E – All other WEEE

This means being able to **accommodate** if required containers, of a size and type appropriate to the site, for C-E, and hard standing or containers for A and B. Where this is not possible because of the size, policy requirements, layout or accessibility of the site, EITHER fewer streams may be collected, provided that:

- Those streams which are collected should be segregated from each other on site
- Sites able to receive the other streams from the public are within a reasonable distance in the Local Authority area and accessible to all on an equal basis

OR streams may be mixed, so long as C and D remain separate from other streams and each other, and B can be readily identified for uplifting separately.

2. If intended to take household WEEE direct from members of the public:

- be **accessible** to members of the public with household WEEE
- have **signs** to direct members of the public depositing household WEEE to the relevant container or area
- **Accommodate** a minimum volume capacity of 3m^3 for D and1 m^3 for E.

3. Be run using reasonable endeavors to **prevent the mixing** of WEEE with other waste or its contamination by other hazardous material, so as to make it unsafe or disproportionately difficult to treat or to exceed the levels in Annex 2 or otherwise agreed with the producer collecting from that site;

4. Under its operating and collection contracts allow producers to arrange collection of household WEEE from the site and treatment.

As per Annex 2 - contamination with non-WEEE hazardous and non-hazardous material, “Code of Practice for Collection of WEEE from Designated Collection Facilities (DCF)”, a DCF should include:

Part I: Unacceptable levels of contamination

1. The following should be considered as unacceptable levels of contamination of WEEE:

(a) The presence in a container provided to take WEEE of:

(i) 15% or more by weight of material other than that for which the container is designated, whether or not WEEE

(ii) Any of the following prohibited items regardless of weight:

a. Food waste
b. Hazardous waste of a type other than that for which the container is designated
c. Liquid wastes other than water

(b) The presence in, on or with any items of WEEE not containerized, such that they are either not evident when the item is collected or cannot readily be separated from the item for collection, of the material listed in (a)(i) and (ii).

Some recommendations as per "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, are given below.

Impermeable surfaces

The type of impermeable surface required depends on a number of factors. Major factors are given below:

- The type and quantity of WEEE/E-waste being stored including whether the WEEE/ E-waste contain hazardous substances and fluids
- The type and volume of other materials dealt with
- The type and level of activity undertaken on the surface
- The length of time the surface is meant to be in service
- The level of maintenance.

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 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.

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.

Weatherproof covering

The purpose of the weatherproof covering for storage is

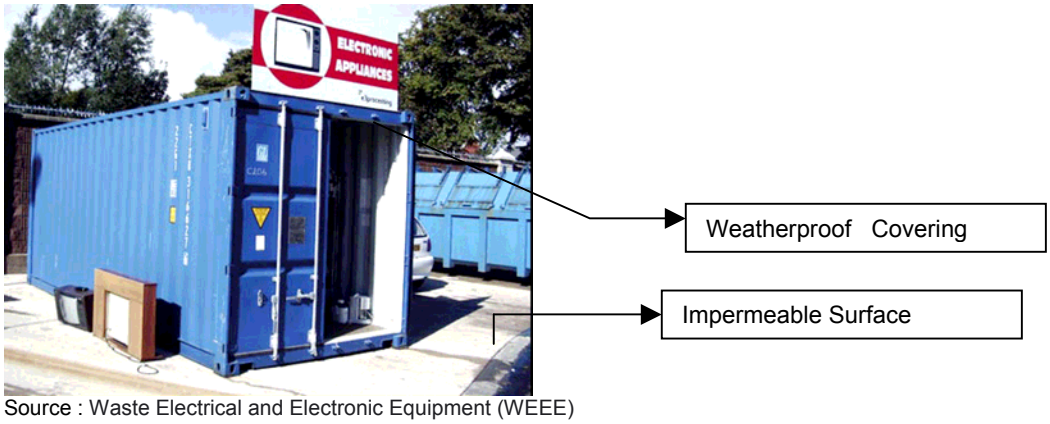
- To minimize the contamination of clean surface and rain waters, to facilitate the reuse of those whole appliances and components intended for reuse

- To assist in the containment of hazardous materials and fluids

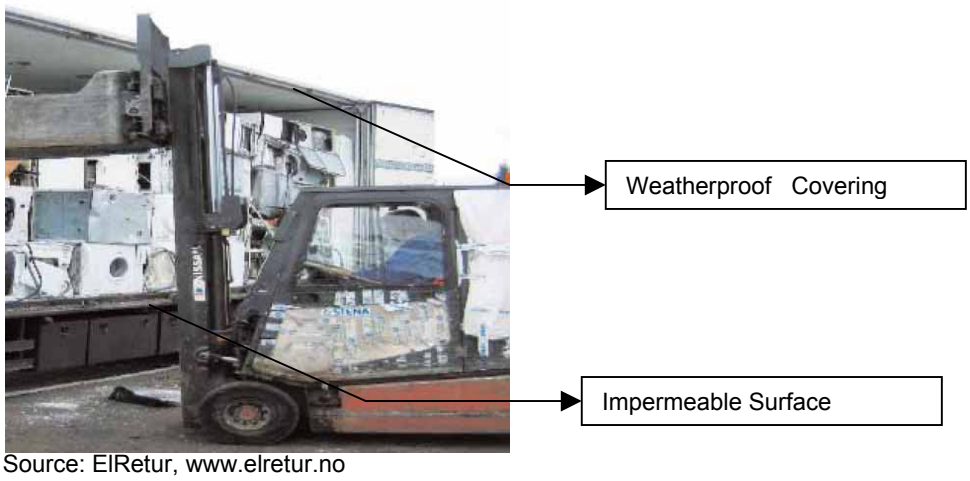
The areas that are likely to require weatherproof covering will therefore include those storing hazardous or fluid containing WEEE/ E-waste or whole appliances or components intended for reuse.

The type of weatherproof covering required will depend of 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 & weatherproof covering) at a collection facility



Source : Waste Electrical and Electronic Equipment (WEEE) Pilot Scheme Report, www.ehsni.gov.uk



Source: ElRetur, www.elretur.no

The following insights have been drawn with respect to specifications from the analysis of code of practice, BATRRT and other sources of literature.

Layout of Collection Point/ Storage Area

1. Collection point/ storage area should be easily accessible i.e the identification of their location is very important
2. Area of the collection point/ storage should be able to accommodate separated/ sorted WEEE/ E-waste with respect to size
3. Collection point/ storage area should have impermeable surface with sealed drainage system
4. Weatherproofing of collection point/ storage area.

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 item based on tonnage captured eg. In Canada, the assumptions taken for 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 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: www.sens.ch

Different Types of Bins used by SENS in Switzerland

Cages

Source : Waste Electrical and Electronic Equipment (WEEE) Pilot Scheme Report, www.ehsni.gov.uk

4. Fix up the area based on container size and numbers.

Number of Collection Point/ Storage Facility

Collection target defines the number of collection points. The number of WEEE/ E-waste collection points will vary from country to country. An example of local collection facilities per population 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[2], 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.

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.

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 point 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 WEEE/E-waste manual 1.
   The literature source[3] cites that in Switzerland, transport distances of 35 to 50 km between WEEEE-waste collection points (according to type of collection point), which is weighted according to actual collection amount of various types of collection point, have been taken for life cycle assessment calculation of WEEE/E-waste collection systems.
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

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

[3] R.Hishier et al. 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

4. Optimize the route and frequency of collection based on accessibility of the collection site.

4.2 WEEE/ E-waste Treatment Systems

The major environmental impacts due to uncontrolled treatment of WEEE/E-waste in unorganized/ informal sector have been described in WEEE/E-waste manual 1. The major options for disposal of WEEE/E-waste in the absence of any treatment option are landfilling and incineration. However, the presence of hazardous elements and compounds in WEEE/ E-waste offers the potential of increasing the intensity of their discharge in environment due to landfilling and incineration. Therefore, 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 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 and followed by mechanical and magnetic separation process.

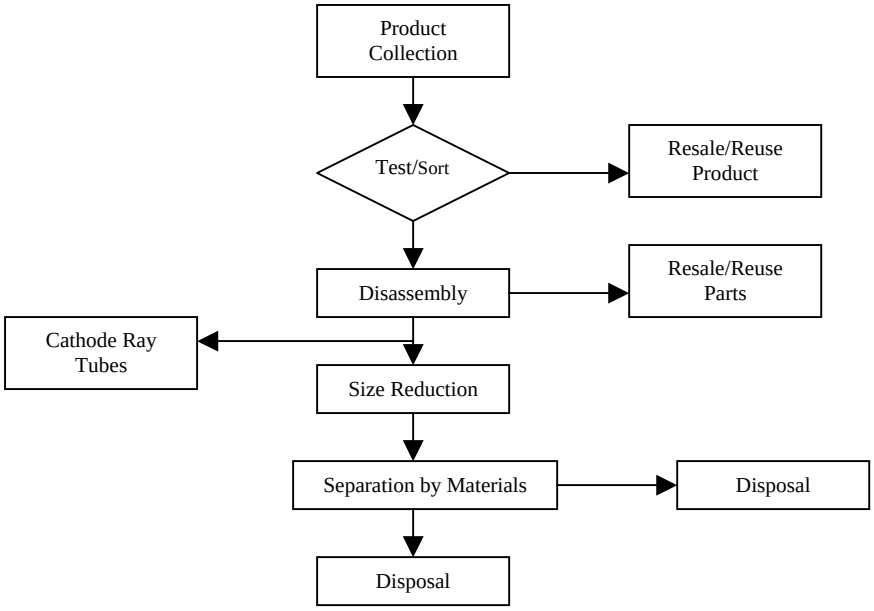
- Recycling/recovery of valuable materials: WEEE/E-waste fractions after segregation consisting of ferrous and non-ferrous metals are further treated. Ferrous metals are smelted in electrical arc furnaces, non-ferrous metals and precious metals are smelted in smelting plants.

- 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.

4.2.1 WEEE/ E-waste Treatment Technology

The simplified flow diagram for WEEE/E-waste treatment is given in figure 4.3. It starts from product collection followed by product testing in order to sort reusable and non-reusable WEEE/E-waste separately. Non-reusable WEEE/E-waste is disassembled and WEEE/E-waste fractions are sorted into reusable and non reusable parts. Non-reusable WEEE/E-waste parts undergo size reduction, separation and recovery of different materials, while the remaining WEEE/E-waste fractions are disposed.

Figure 4.3: Simplified flow diagram for the recycling of WEEE/E-waste



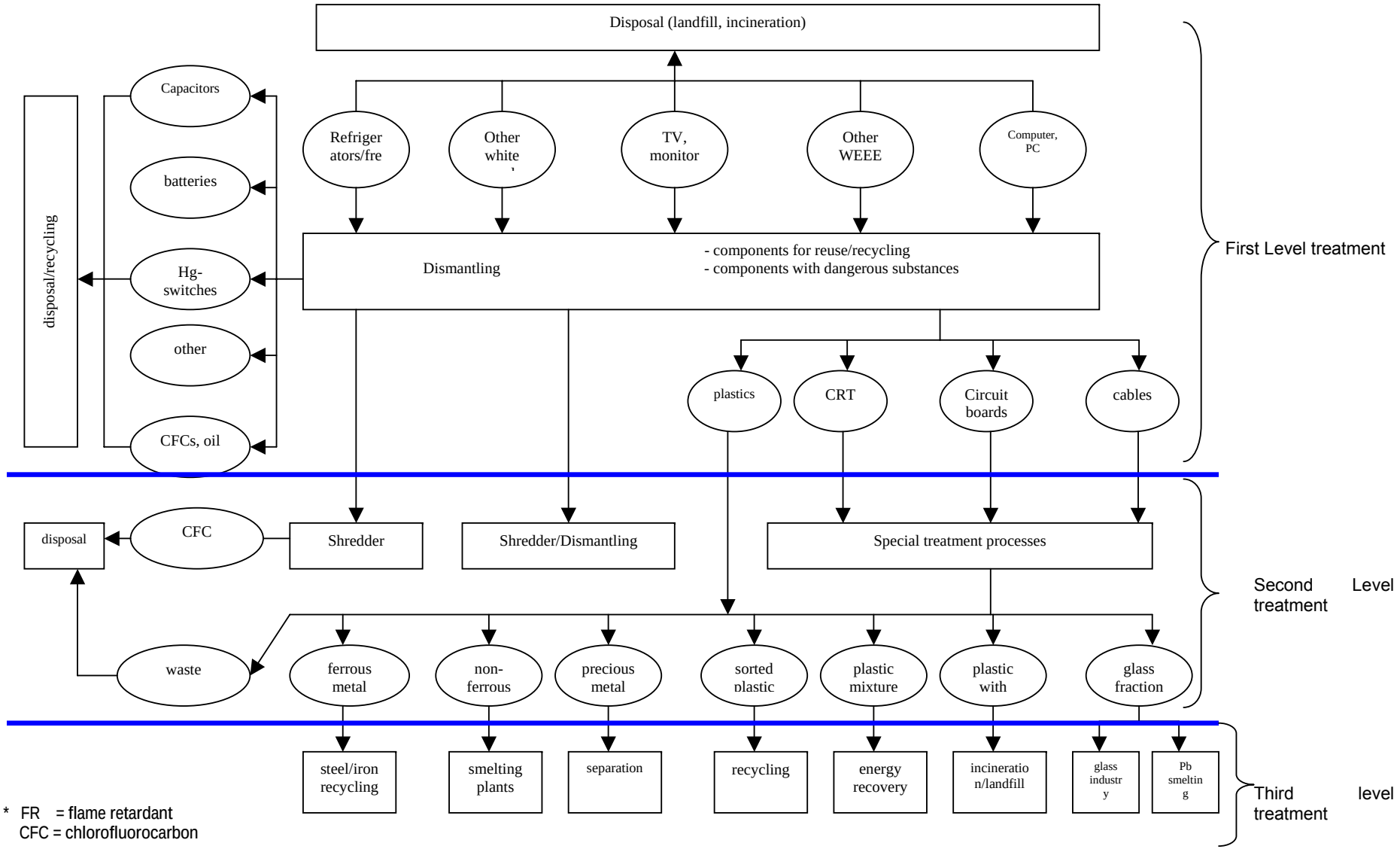
Source: Hai-Yong Kang, Julie M. Schoenung, Electronic wate recycling: A review of U.S. infrastructure and technology options, Resources Conservation & Recycling 45 (2005) 368-400, Elsevier

Detailed WEEE/E-waste treatment system has been shown in figure 4.4. This treatment system is used at three levels:

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

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 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 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.

Figure 4.4: Treatment Schemes for WEEE/ E-waste



Source: Prepared by modifying Figure 6.1 from the report "Waste from electrical and electronic equipment (WEEE) – quantities, dangerous substances and treatment methods", EEA Copenhagen, 2003

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.

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.

The interpretation of these requirements as per "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 is given below.

Weatherproof covering

The purpose of the weatherproof covering for storage at treatment sites 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 and treating 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 and treatment 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.

Impermeable surfaces

The WEEE Directive requires the provision of impermeable surfaces for appropriate areas. "Impermeable surface" means a surface or pavement constructed and maintained to a standard sufficient to prevent the transmission of liquids beyond the pavement surface. 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; and

- except where they may lawfully be discharged, all liquids entering the system are collected in a sealed sump.

The activity of treating WEEE/ E-waste itself carries a risk of pollution that must be managed. All treatment activities must take place within an area provided with an impermeable surface.The type of impermeable surface required is likely to depend on a number of factors, including:

- The type and quantity of WEEE/ E-waste being stored or processed including whether the WEEE/ E-waste contain hazardous substances and fluids
- The type and volume of other materials dealt with
- The type and level of activity undertaken on the surface
- The length of time the surface is meant to be in service
- The level of maintenance.

Whether a surface is in fact impermeable will depend on how it is constructed and the use it is put to. A surface will not be impermeable and therefore will be unacceptable 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.

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.

Equipment for treatment of water

The WEEE/ E-waste Directive require the provision of equipment for the treatment of water, including rainwater, in compliance with health and environmental regulations. However, it should remember that as a matter of best practice, operators of treatment facilities should take appropriate steps to minimize the contamination of clean waters. All liquid runoff from an impermeable pavement used for the storage of hazardous WEEE/ E-waste and hazardous components will be regarded as being contaminated, unless it can be shown otherwise (irrespective of whether there happens to be any activity on the pavement at the time.) On most sites, two systems for the management of water will be necessary, for clean water and for contaminated water. Clean water can be dealt with by surface water drains that should carry only uncontaminated water from roofs to a watercourse or can be soaked away. The treatment of contaminated water to the necessary standard will require a sealed drainage system, as defined above. It may be necessary to obtain consent if water is to be discharged.

Storage for disassembled parts

Treatment sites must provide appropriate storage for disassembled spare parts from WEEE/ E-waste. Some spare parts (e.g. motors and compressors) will contain oil and/or other fluids. Such parts must be appropriately segregated and stored in containers that are secured such that oil and other fluids cannot escape from them. These containers must be stored on an area with an impermeable surface and a sealed drainage system.

Storage for other components and residues

Other components and residues arising from the treatment of WEEE/ E-waste will need to be contained following their removal for disposal or recovery. Where they contain hazardous substances they should be stored on impermeable surfaces and in appropriate containers or bays with weatherproof covering. Containers should be clearly labeled to identify their contents and must be secure so that liquids, including rainwater, cannot enter them. Components should be segregated having regard to their eventual

destinations and the compatibility of the component types. All batteries should be handled and stored having regard to the potential fire risk associated with them.

Balances

WEEE Directive also requires that sites for treatment of WEEE/ E-waste have “balances to measure the weight of the treated waste”. The objective is to ensure that a record of weights can be maintained of WEEE/ E-waste entering a treatment facility and components and materials leaving each site (together with their destinations). The nature of the weighing equipment is likely to depend on the type and quantity of WEEE/ E-waste being processed.

4.2.1.1 First Level WEEE/E-waste Treatment

Input: 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

All the three unit operations are dry processes, which do not require use of water. The first step is to decontaminate 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. Further, 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.

Output:

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

Various steps in the manual dismantling process at a WEEE/E-waste dismantling facility are depicted in figure 4.5. The guiding principles for fixing up the layout of first level WEEE/E-waste treatment facility are given below.

- 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.

Figure 4.5: Manual Decontamination/ Dismantling Process

Step 1 **Step 2** **Step 3** **Step 4**

Step 1: Collected E-waste entering the disassembly line in the dismantling facility

Step 2: Manual dismantling of monitor (removal of plastic back cover and disposal into a plastic bin)

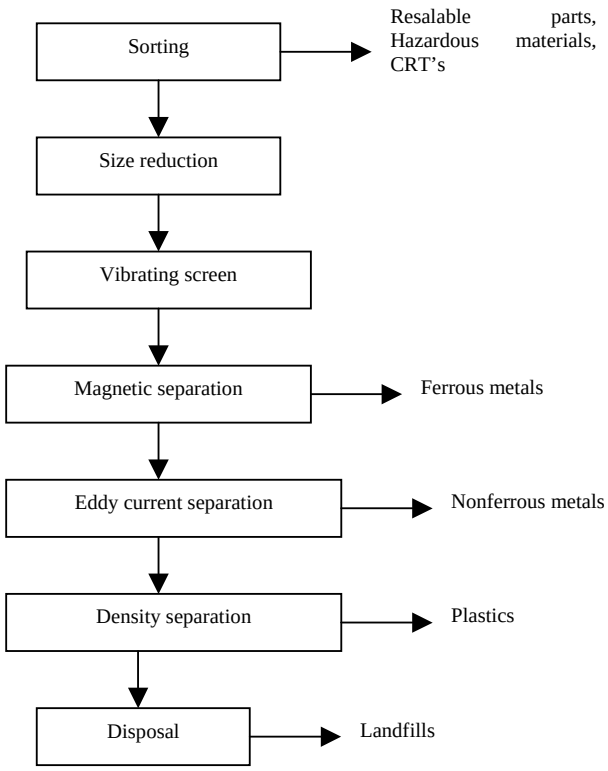
Step 3: Decontamination by manually removing the hazardous items and their collection in bins

Step 4: Complete dismantling and segregation of E-waste fractions

4.2.1.2 Second Level WEEE/ E-waste Treatment

A simplified conceptual flow diagram for second level WEEE/E-waste treatment is given in figure 4.6. Input, unit operations and outputs are described below.

Figure 4.6: 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 & Recycling 45 (2005) 368-400, Elsevier

Input: Decontaminated E-waste consisting segregated non hazardous E-waste like plastic, circuit board and cables.

Unit Operations: There are three unit operations at second level of 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 is given in figure 4.7, while equipments used are given in table 4.2.

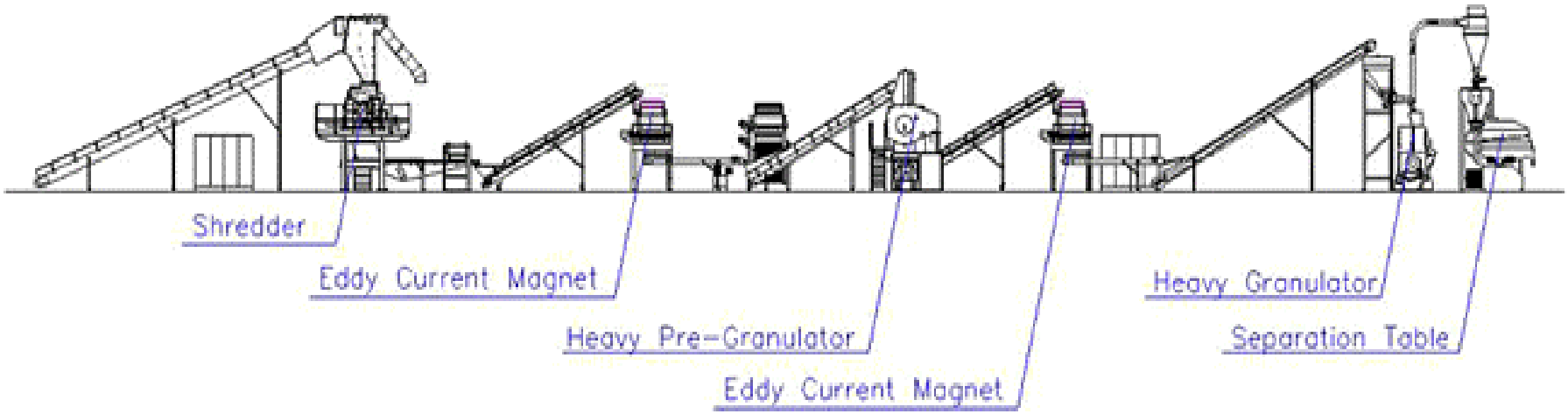
Output: Output from the second level treatment technology is given below.

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

Table 4.2: Equipments used in second level WEEE/E-waste treatment

	Equipments	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.	

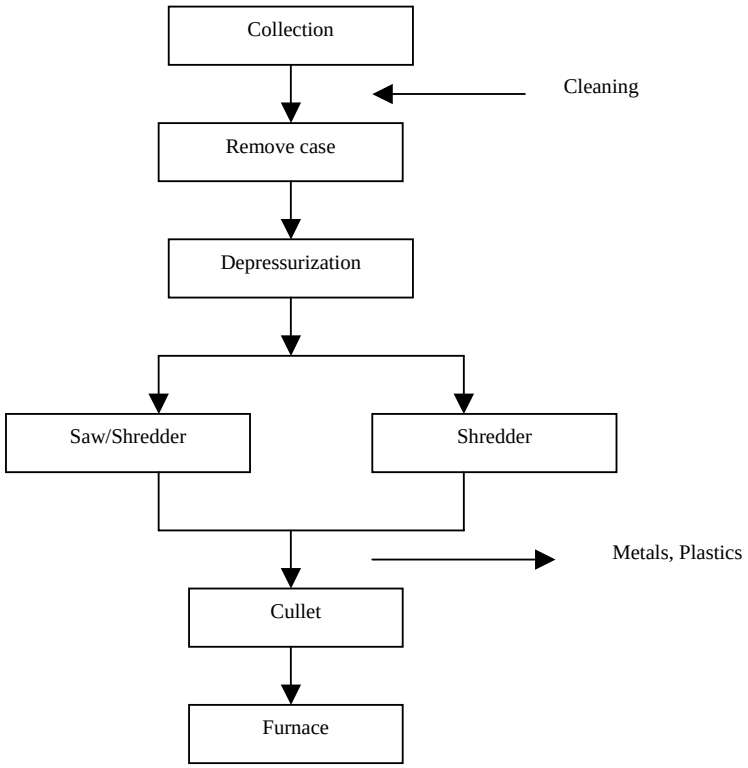
Figure 4.7: Second Level WEEE/ E-waste Unit Operations



4.2.1.2.1 CRT treatment technology

A simplified conceptual flow diagram for CRT treatment is given in figure 4.8. Input, unit operations and outputs are described below.

Figure 4.8: Process flow diagram for recycling of CRTs.



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

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 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 on to the surface of the saw blades as they cut. This is to control temperature and prevent warping.

- Waterjet 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.

4. 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.

5. Shredding

Outputs: Metals, Plastic and Glass Cullet

Cullet glass is reused as a raw material by CRT manufacturers. Recovered CRT glass also goes to the lead smelter, where they act as fluxing agent in the smelting process.

4.2.1.2.2 Available Process Technology

Literature cite examples of existing WEEE/ E-waste treatment technology in Switzerland (Europe) and Japan[4] as shown in figure 4.9, figure 4.10 and figure 4.11. The salient features of these technologies are given below.

1. The process combines manual and machine procedures.

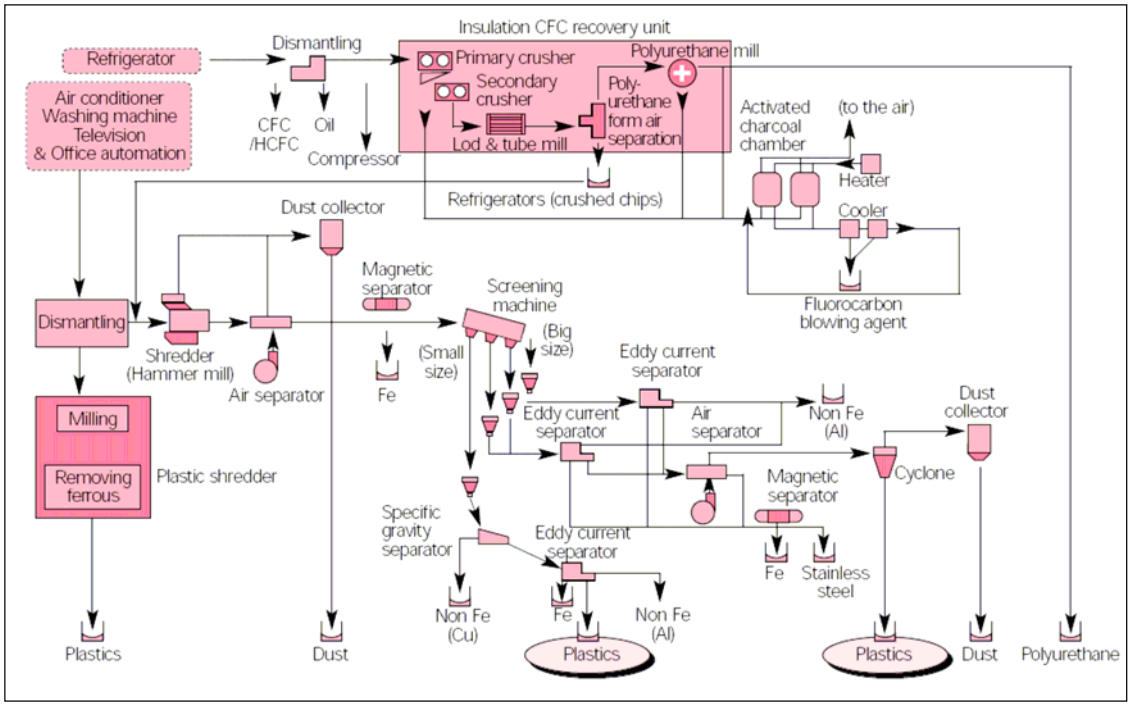
2. WEEE/ E-waste is at first cut, crushed and finally sorted into discreet product

[4] 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

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 4.9: Flow sheet of a WEEE/ E-waste recycling plant in Japan



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

Figure 4.10: Flow sheet of a non CRT WEEE/ E-waste recycling plant in Switzerland

Pre- comminuting for a rough liberation/ Shredding

Separation of Fe & non-Fe (Cu, Al, Au, Ag and other precious metal)

Electro - Magnetic separation of ferrous and nonferrous metals

Separator

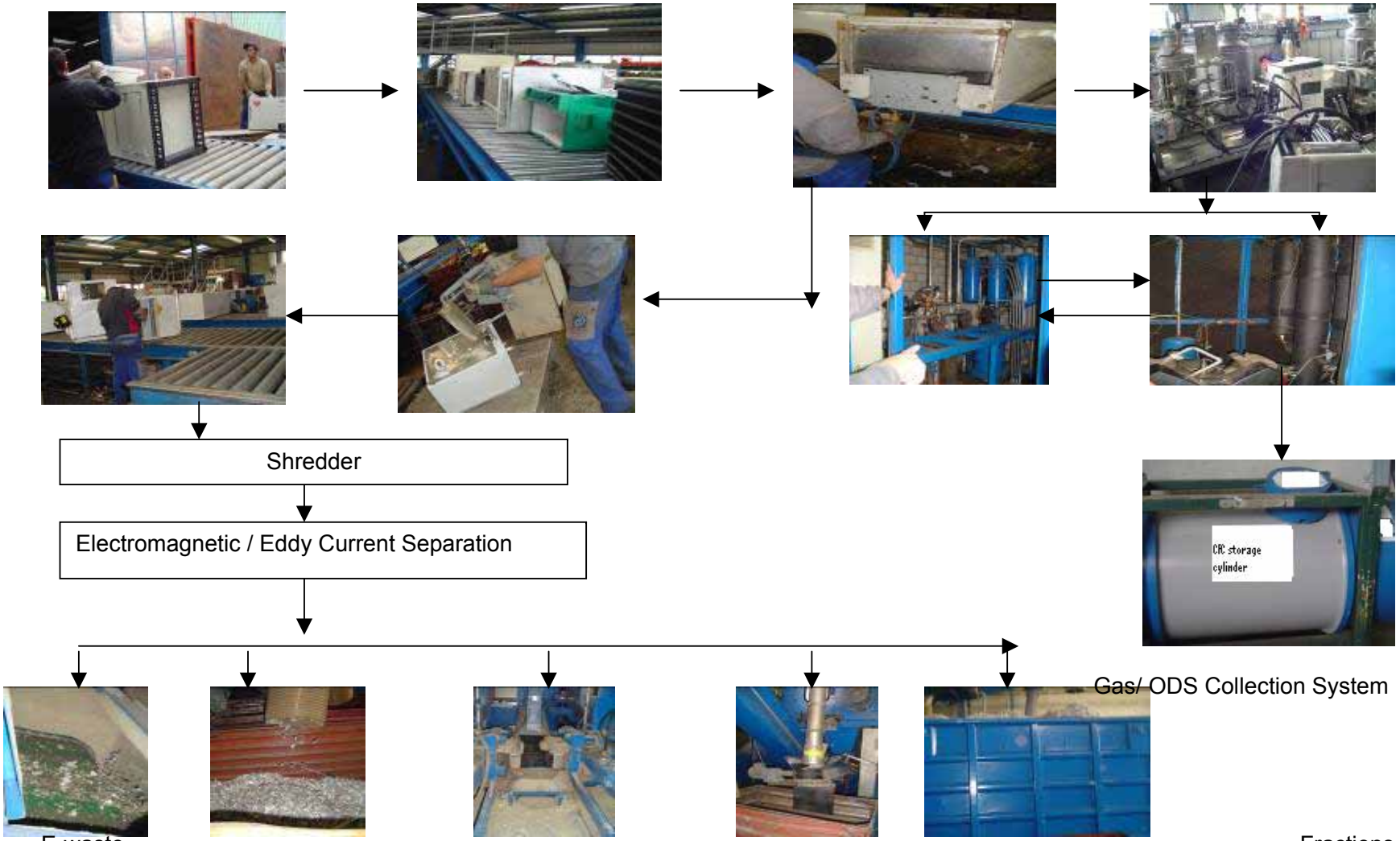
Plastic

Liberation of Non Ferrous Metals

Eddy current separation of coarse metal fraction

Separation of Cu, Al, Au, Ag and other precious metal

Figure 4.11: Flow sheet of WEEE/ E-waste (refrigerator) recycling plant in Switzerland



Guiding principles for 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 dry process using mechanical operations.

2. The pre-comminuting stage includes separation of plastic, CRT and remaining non CRT based WEEE/ E-waste. Equipments 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 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 operative is based on the use of rare earth permanent magnets. When a conductive particle is exposed to an alternating magnetic field, eddy currents will be induced in that object, generating a magnetic field to oppose the alternating magnetic field. The interactions between the magnetic field and the induced eddy currents lead to the appearance of electro dynamic actions upon conductive non-ferrous particles and are responsible for this separation. Materials that can be easily separated by an eddy current separator are given in table 4.3. The main separation criteria for an eddy current, is the ratio of electrical conductivity to density of the material. The material that has a higher ratio can be separated more easily than those with lower ratio eg. aluminum, is the most easily separated material.

Table 4.3: Materials that can be separated by an eddy current separator, and their properties

Materials	**σ (10^{-8} / Ω m)**	**P (10^{3} kg/ m^3)**	**σ/ P (10^{3} m^2/ Ω kg)**
Al	0.35	2.7	13.1
Zn	0.17	7.1	2.4
Ag	0.63	10.5	6.0

Materials	σ (10^{-8} / Ω m)	P (10^{3} kg/ m^3)	σ/ P (10^{3} m^2/ Ω kg)
Cu	0.59	8.9	6.6
Brass	0.14	8.5	1.7
Pb	0.05	11.3	0.4

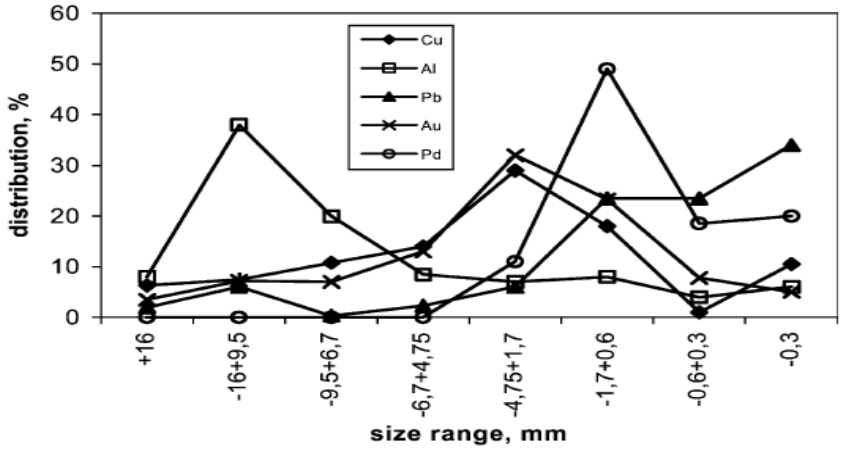
σ - Electrical conductivity; P – Density ; σ / P – Ratio of electrical conductivity to density
Source: Hai-Yong Kang, Julie M. Schoenung, Electronic wate recycling: A review of U.S. infrastructure and technology options, Resources Conservation & Recycling 45 (2005) 368-400, Elsevier

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.

   Figure 4.12 shows the non- ferrous metal distribution (a major factor to establish financial viability of recycling system) as a function of size range for PC scrap. It can be seen that aluminum is mainly distributed in the coarse fractions (+6.7 mm), but other metals are mainly distributed in the fine fractions (−5 mm).

Figure 4.12: non- ferrous metal distribution Vs. size range for PC scrap



Source: Jirang Cui, Eric Forssberg, Mechanical recycling of waste electric and electronic equipment: a review, Journal of Hazardous Materials B99 (2003) 243-263, Elsevier

Table 4.4 describes eddy current separation results of WEEE/ E-waste from TV scrap.

Table 4.4: Eddy Current separation results of TV scrap

Particle Size (mm)	Products	Weight (%)	Metal Content (%)	Recovery (%)
-9.5+6.7	Non-ferrous metals	34	27	77
	Waste	66	4	23
	Total	**100**	**12**	**100**

Source: Jirang Cui, Eric Forssberg, Mechanical recycling of waste electric and electronic equipment: a review, Journal of Hazardous Materials B99 (2003) 243-263, Elsevier

Size properties are essential for choosing an effective separation technique. Therefore, eddy current separator is best for granular non-ferrous materials having size greater than 5mm.

Literature cites that magnetic separation leads to recovery of about 90% to 95% of ferrous metal from WEEE/ E-waste. Magnetic separators, in particular, low-intensity drum separators are widely used for the recovery of ferro-magnetic metals from non-ferrous metals and other non-magnetic wastes. Over the past decade, there have been many advances in the design and operation of high-intensity magnetic separators, mainly as a result of the introduction of rare earth alloy permanent magnets capable of providing very high field strengths and gradients. 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 > 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.

4.2.1.3 3rd Level WEEE/ E-waste Treatment

The input, output and unit operations at third level treatment are described in table 4.5. It may be noted that all the unit operations are geographically distributed.

Table 4.5: Input/ Output and unit operations for third level treatment of 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 FR	Incineration	Energy Recovery
CRT	Breaking/ Recycling	Glass Cullet
Lead Smelting	Secondary Lead Smelter	Lead
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

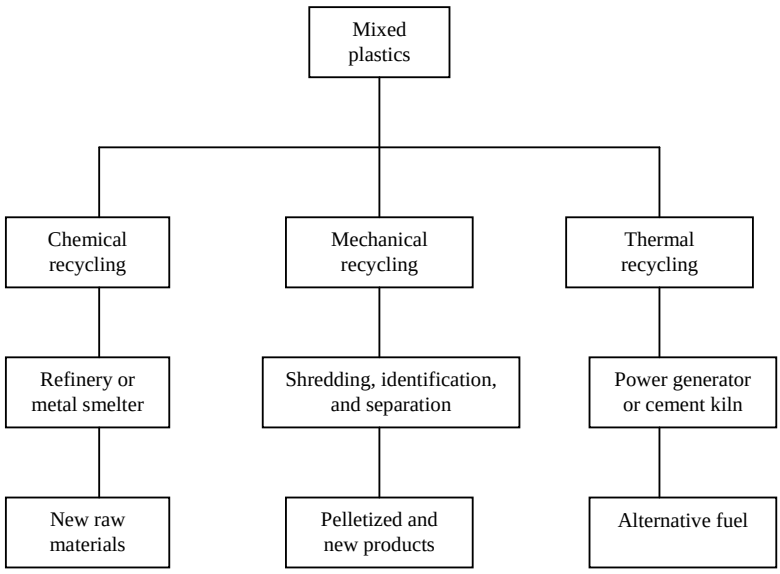
The description of some of the third level WEEE/ E-waste processes are described below.

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 4.13. In chemical recycling process, waste plastics are used as raw materials for petrochemical processes or as reductant 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.

The two major types of plastic resins, which are used in electronics, are “thermosets” and “thermoplastics”. Thermosets are shredded and recycled because they cannot be re-melted and formed into new products, while thermoplastics can be re-melted and formed into new products.

Figure 4.13: Recycling options for managing plastics from end-of-life electronics

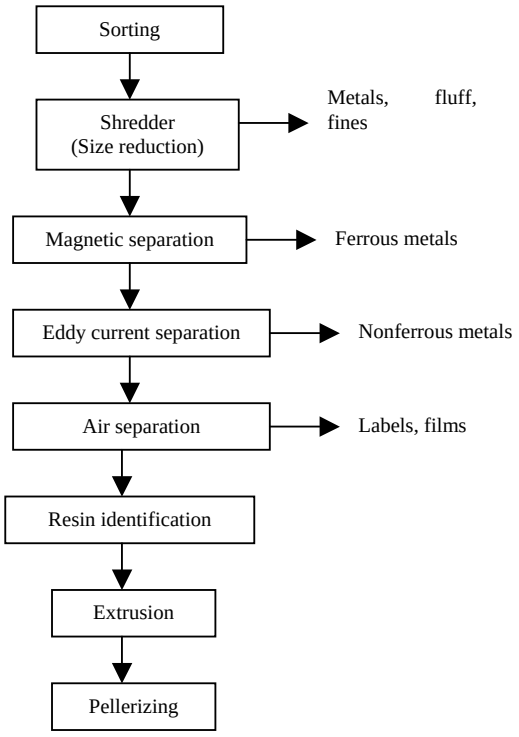


Source: Hai-Yong Kang, Julie M. Schoenung, Electronic wate recycling: A review of U.S. infrastructure and technology options, Resources Conservation & Recycling 45 (2005) 368-400, Elsevier

Mechanical Recycling Process

Mechanical recycling process is shown in figure 4.14.

Figure 4.14: Representative process flow diagram for the mechanical recycling of post consumer plastics



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

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 method is used for removal of paints and coating from waste plastics.

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 separators are used for ferrous metals separation, while eddy current separators are used for non ferrous metals separation. Air separation system is used to separate light fractions such as paper, labels and films.

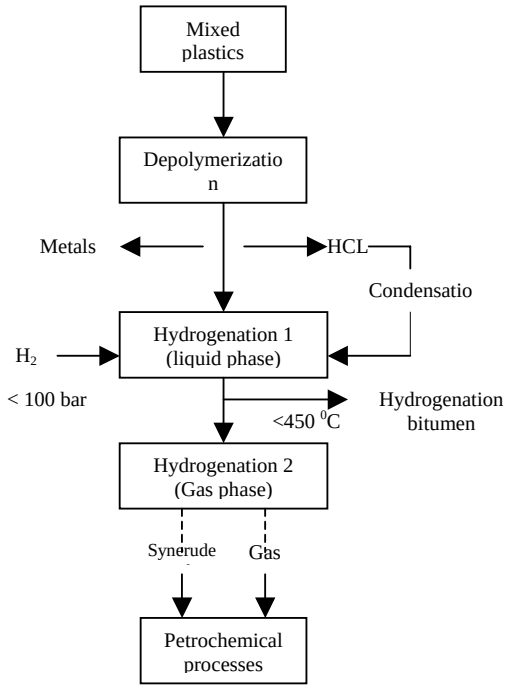
Resin identification can be carried out by using a number of techniques like hydrocyclones, triboelectric separator, high speed accelerator and X-ray fluorescence spectroscopy. In hydrocyclones separation technique, plastic fractions are separated using density separation technique, which is made more 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 negative electrode. This technique has been found to be most effective for materials with a particle size between 2-4 mm. In high 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.

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

- Chemical Recycling Process

Chemical recycling process is shown in figure 4.15. This process was developed by the Association of Plastic Manufacturers in Europe (APME). The different steps in this process are given below:

Figure 4.15: De-polymerization of plastics and conversion processes



Source: Hai-Yong Kang, Julie M. Schoenung, 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.

- 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.

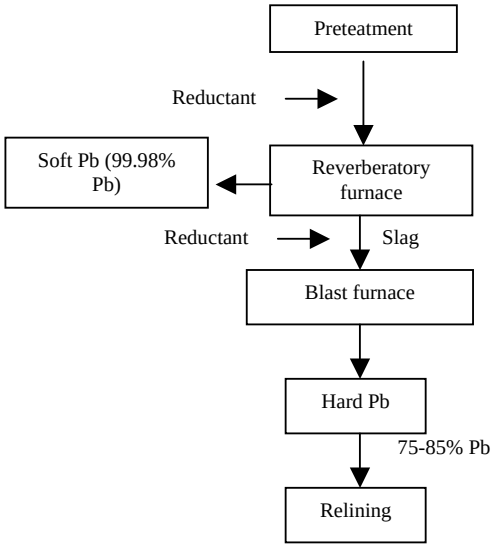
Metals Recycling

Metals recycling has been described below in terms of lead recycling, copper recycling and precious metals recycling. 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 4.16 and involves the following steps.

Figure 4.16: Processes flow for secondary lead recovery



Source: Hai-Yong Kang, Julie M. Schoenung, 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 baghouse and feedback into the furnace to recover lead. Slag from blast furnace is disposed of in hazardous waste landfill sites.

Copper Recycling

The copper recycling process is shown in figure 4.17. It involves the following steps:

1. E-waste fraction containing Cu is fed into a blast furnace, which are 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.

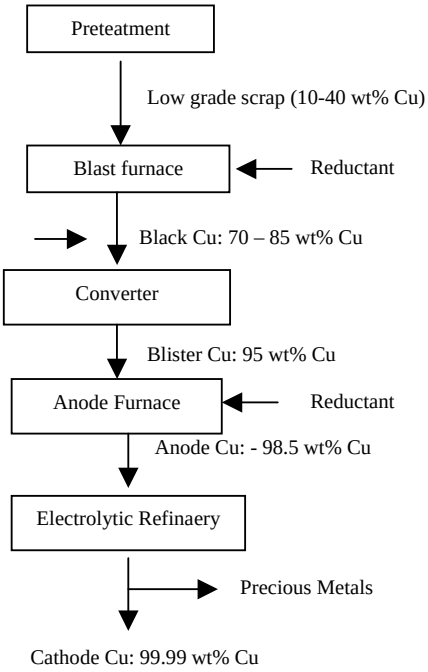
3. Blister copper and scrap Cu are melted and reduced by coke or wood or waste plastic in the anode furnace. Other less noble metals are oxidized and removed from blister copper. Sulfur is also removed from the anode furnace. The following reduction reaction occurs in the anode furnace.

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

4. Recovered anode copper is further purified in electrolytic process where it is dissolved in H_2SO_4 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.

Figure 4.17: Process flow for secondary copper recovery



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

Precious Metals Recovery

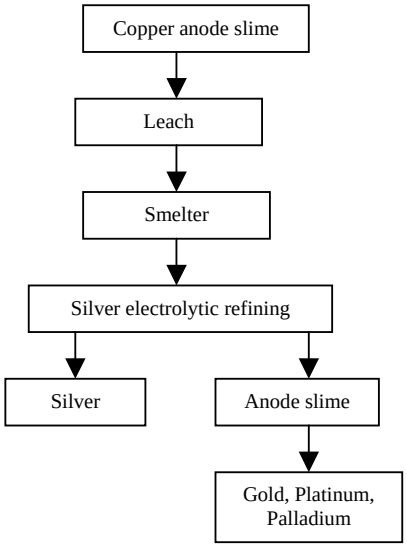
The precious metals recovery process is shown in figure 4.18. It involves the steps shown in the flow chart. The anode slime recovered from copper electrolytic process shown in figure 4.17 is used for precious metal recovery. The process involves the following steps.

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 4.18: Precious metals recovery process

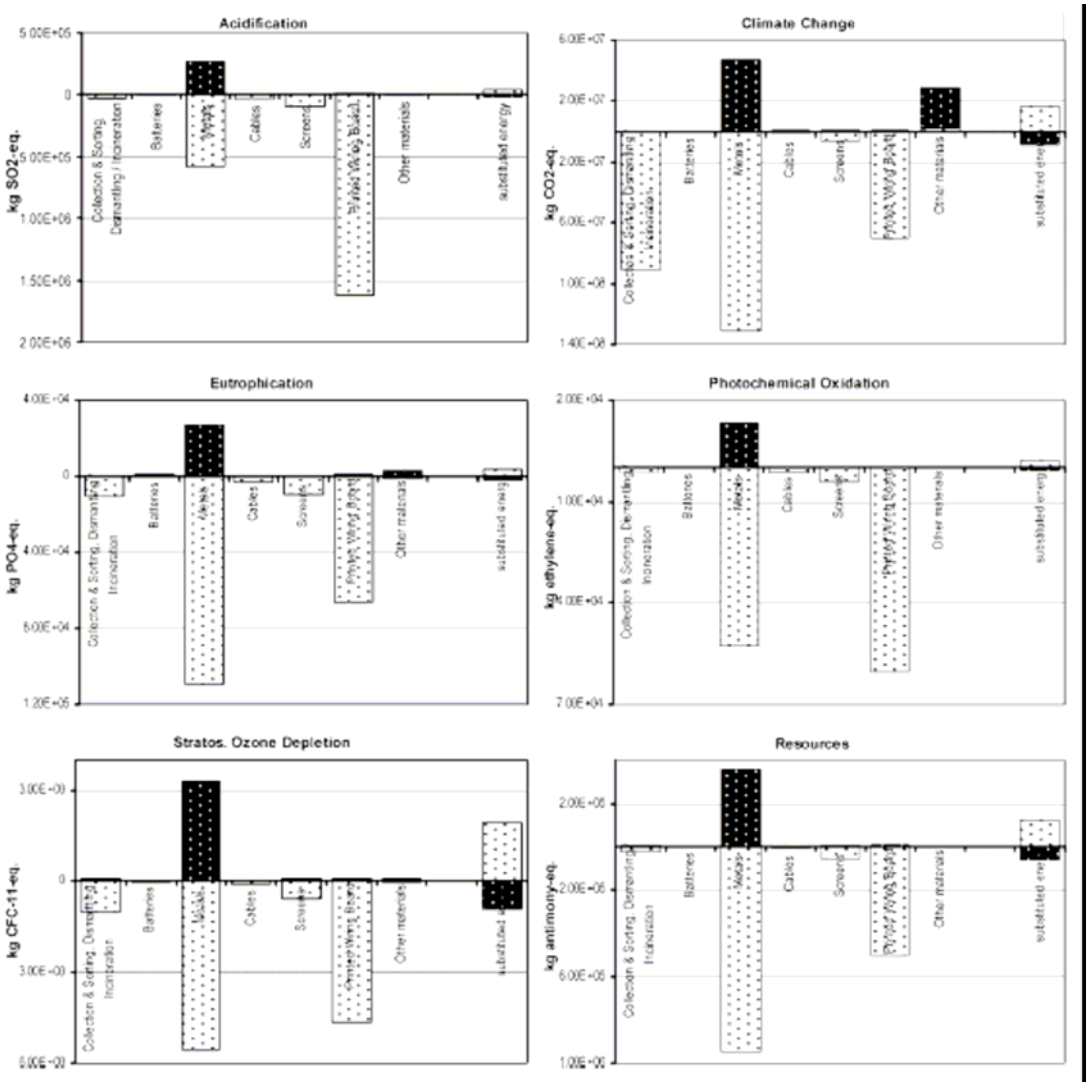


Source: Hai-Yong Kang, Julie M. Schoenung, Electronic wate recycling: A review of U.S. infrastructure and technology options, Resources Conservation & Recycling 45 (2005) 368-400, Elsevier

4.3 Environmental Impacts of the first, second and third level WEEE/E-waste treatment system

Environmental impacts of uncontrolled WEEE/E-waste treatment have been described in WEEE/ E-waste manual 1. However, in order to assess environmental impacts of WEEE/ E-waste treatment, an example of environmental impacts of entire Swiss take back and recycling system[3] has been described by comparing it with a baseline system. Swiss take back recycling system includes take back, collection, sorting, transportation, dismantling and secondary material processing steps. The baseline system includes WEEE/E-waste disposal by incineration in municipal waste incineration plant (MSWI) and primary production of raw material. The impacts have been assessed with respect to environmental attributes like acidification, climate change, eutrophication, photochemical oxidation, ozone and resources depletion. A comparison between the two scenarios has been shown in figure 4.19. The environmental impact of the WEEE/ E-waste recycling system is shown with dark bars on the positive side, while the avoided primary production is shown as bright bars on the negative side of the x-axis. In the first row, the value on the negative side represents the incineration of the complete WEEE/ E-waste in an MSWI plant. In the very last row, the bars are on the reverse side since these bars represent the substitute energy generated by the incineration of organic materials in either of the two systems. It can be inferred that the sum of the burden produced (dark bars) is much lower than the burden avoided (bright bars). The various impact categories are dominated by the primary production of steel and precious metals.

Figure 4.19: Environmental impacts of the WEEE recycling system, i.e. collection, sorting and further treatment (dark bars), compared with the avoided environmental impacts of the WEEE incineration and the primary production of the raw materials (bright bars).



Source: Figure 6, R.Hishier et al. 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

4.4 Guidance Notes

Objective: The major objective of guidance notes is to assist technical personnel/ WEEE/E-waste implementation agencies/ other stakeholders to identify technical options for WEEE/E-waste collection, transportation, treatment and disposal systems in order to meet regulatory/ compliance system described in chapter 3. Further, the assessment of technical options will lead to design and development of technical specifications for WEEE/E-waste management system.

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

Step 1: Determine collection and transportation system as per step 8 and 9 mentioned in chapter 3.

Step 2: Determine up area of collection point/ storage facility. The area of collection point/ storage facility is fixed as per 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 separated WEEE/ E-waste item based on tonnage captured in a given time frame 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 captured WEEE/ E-waste items calculate the bin/ container/ cage/ Gaylord container size (volume and dimensions) and their numbers.

4. Fix up the area based on container size and numbers

Step 3: Determine number of Collection Points/ Storage Facilities. This is fixed as per following guiding steps.

a. Collection target defines the number of collection points
b. Calculate the population served
c. Calculate each of the WEEE/E-waste capture rate per inhabitant per year
d. Calculate the number of collection points required to achieve the target rate
e. Determine the final number of collection points after studying the study area/ land use/ geography after deciding the location.

Step 4: Determine location of collection point/ storage facility and transportation. Guiding steps for this purpose are given below:

1. Study the consumer behaviour for the best used option for collection point i.e. retailer take back collection centre, municipal collection centre or any other option 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 WEEE/E-waste manual 1.

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.

Step 5: Determine layout for first level WEEE/E-waste treatment facility. Different guiding steps for this purpose are given below:

1. Fix up the capacity of the treatment facility per day or per annum
2. Calculate the average productivity of the worker in terms of time taken by each worker to dismantle a WEEE/ E-waste item.
3. Calculate the numbers of workers required to dismantle WEEE/ E-waste per day.
4. Calculate the number of shifts per day based on number of workers.
5. Calculate the number of shifts and total number of workers; calculate the number of dismantling tables and sorting area required for workers.
6. Calculate the area of dismantling hall.
7. Determine storage area for storing WEEE/ E-waste inventory. This inventory is fixed based on transportation frequency of collected WEEE/E-waste from collection points to treatment facility.
8. Determine storage area of dismantled and sorted WEEE/E-waste components based on transportation frequency of dismantled WEEE/E-waste items from first level treatment facility to second level, third level and disposal.
9. Determine total area of first level WEEE/E-waste treatment facility by adding all the three areas mentioned in items 6, 7 & 8.
10. The facility should have balance, weatherproof covering, impermeable surface, spillage collection facility and equipment for treatment of water (if required).

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

1. Determine the capacity of the treatment facility per day or per annum
2. Determine stages of treatment of WEEE/ E-waste based on level of size reduction of WEEE/E-waste item.
3. Determine process based on WEEE/E-waste treatment capacity per day and level of size reduction. This will help to fix up the size of hammer mill/ shredder/ other size reduction machines.
4. The output of hammer mill/ shredder/ other size reduction machines will assist to fix up the magnetic/ eddy current and density separation machines/ equipment.

5. 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).
6. After defining process elements invite technical quotations from equipment suppliers and identify the area required to establish the process.
7. Determine rage area for storing WEEE/ E-waste inventory. This inventory is fixed based on transportation frequency of collected WEEE/E-waste items from first level treatment facility to second level treatment facility.
8. Determine storage area of dismantled and sorted WEEE/E-waste components based on transportation frequency of dismantled WEEE/E-waste items from second level treatment facility to third level treatment facility and disposal.
9. Determine total area of second level WEEE/E-waste treatment facility by adding all the three areas mentioned in items 6, 7 & 8.
10. The facility should have balance, weatherproof covering, impermeable surface, spillage collection facility and equipment for treatment of water (if required).
11. In case, first and second level WEEE/E-waste treatment facilities are integrated, follow the steps described in step 5 and 6.

Step 7: Identify and fix third level WEEE/E-waste treatment options. Different guiding steps to determine options for third level WEEE/ E-waste treatment facility are given below.

1. Identify the capacity of existing ferrous, non-ferrous metal, plastic and glass recyclers in a particular country/ region/ geographical area.
2. Identify the technology used by existing recyclers in recycling process.
3. Select the recyclers, who can use output of second level WEEE/E-waste treatment facility as input raw material into their facilities.
4. Usually, the outputs of second level WEEE/E-waste treatment facility can be sold as raw material in regional/ geographical metal/ commodities/ chemical market.

Step 8: Identify and determine hazardous and non recyclable WEEE/E-waste fractions disposal options. Different guiding steps for this purpose are given below.

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

Step 9: General guidelines for WEEE/E-waste treatment facilities provide guidance for establishing WEEE/E- waste treatment facility.

1. Prepare Environmental Impact Assessment report along with detailed project report of the WEEE/E-waste treatment facility.

2. Regular re-evaluation of environment, health and safety (EH&S) 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:

    - EH&S training of personnel.

    - An up-to-date, written hazardous materials identification and management plan that specifically addresses at least the following: lead, mercury, beryllium, cadmium, batteries, toner, phosphor compounds, PCBs, and brominated flame retardants and other halogenated materials, with particular focus on possible generation of by-product dioxins and furans.

    - 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 EH&S 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.

5. Facilities have an adequate plan for closure. The need for closure plans and financial guarantees is determined by applicable laws and regulations, taking into consideration the level of risk. Closure plans should be updated periodically, and financial guarantees should ensure that the necessary measures are undertaken upon definite cessation of activities to prevent any environmental damage and return the site of operation to a satisfactory state, as required by the applicable laws and regulations.

Chapter 5: Financing Mechanism of WEEE/E-waste Management

5.0 Introduction

The sustainability of WEEE/E-waste management is dependent on financial viability of WEEE/E-waste collection, transportation, treatment and disposal. The financial viability is in turn dependent on regulatory system in place as it will define the standards and institutional mechanism for WEEE/E-waste management. The following section describes the financial mechanism in place in developed countries followed by financial mechanism in developing countries and a comparative analysis of the two to identify the drivers for establishing a WEEE/E-waste financial model. Further, guidance notes provide a broad framework to assist in assessment of financial viability of WEEE/ E-waste management system.

5.1 Financing mechanism of WEEE/E-waste Management in Developed Countries

Financing mechanism of WEEE/E-waste management system in developed countries has evolved after gaining experience over the years of operation. It is a dynamic system as WEEE/E-waste generation pattern changes both in terms of increasing volume and addition of other products into WEEE/E-waste stream. The financing mechanism covers each aspect of WEEE/ E-waste management like collection, transportation and treatment costs of WEEE/ E-waste. The following sections describe the fundamentals of the financing mechanism, which includes financing models, fee structure, funding of WEEE/E-waste supply chain and financial guarantee to ensure compliance and sustainability of the model.

5.1.1 Financing Models

The entire financial model in Europe is based on “Extended Producer Responsibility”, where the producing organizations are responsible for WEEE/E-waste take back and treatment. The financial model is integrated model consisting of WEEE/ E-waste collection, transportation and treatment. Different WEEE/E-waste collection, transportation and treatment schemes have been described in chapter 3 and chapter 4. The conceptual guidance for financing each of these schemes has been provided by EU directive. These guidance features as per EU directive are given below.

1. Producers are responsible for the costs of picking up WEEE/E-waste from collection facilities and for refurbishing waste products for reuse or for recycling and recovery.
2. For “historical” products” (i.e., those put on the market before August 13, 2005), the costs of waste management are to be shared by all producers in existence at the time those costs are incurred. These producers may impose a separate “visible fee” (one that is explicitly designated, perhaps on the price tag) to cover these costs for eight years (ten years for large household appliances).
3. End users other than households may be made partly or totally responsible for financing the management of historical products.
4. For new products (i.e., those put on the market after August 13, 2005), producers have “individual responsibility”, i.e. they must pay the cost of managing their own

products. They can do this through programmes set up by individual companies or through participation in collective schemes.

5. No visible fees are permitted to fund the management of waste from new electrical and electronic products.
6. When producers put a new product on the market, they must provide a financial "guarantee" that waste management of the product will be paid for. Producers can get waiver on this guarantee by participating in a producer responsibility organization (PRO), paying recycling insurance, or setting up a special bank account for this purpose.

ICT sector and brown and white goods sector have different preferred financial models with regard to WEEE/ E-waste management. In Europe, brown and white goods producers are comfortable with the schemes set up to address brown and white goods, while the IT producers are comfortable with those schemes set up to address IT goods. Examples of different types of models are given in table 5.1. The major difference in financial model lies in the method of charging fee/ money for WEEE/E-waste management i.e. visible fee or arrears based on market share of different electrical and electronic equipment (EEE). White Goods firms, and to a lesser extent consumer electronics generally support visible fee schemes e.g. Recupel and NVMP, and are less supportive of arrears-based market share schemes e.g. ICT Milieu. The reverse is true for ICT firms. The difference in charging fee by two models reflects the differing preferences for dealing with "historic" WEEE/E-waste and "orphan" (unbranded/ no claimant) WEEE/E-waste. ICT firms have fewer historic liabilities due to high obsolescence rate of products in comparison to brown and white goods. ICT firms also tend to favour competitive compliance systems, rather than national schemes, as they perceive that costs provided by different compliance systems will be competitive and will be better managed.

5.1.2 Fee Structure

The fee structure consists of different options. These options include actual costs of recycling, projected costs of recycling per category and cross subsidization. Cross subsidization occurs if the fee charged on one category of WEEE/E-waste is higher than its recycling costs. The differential is used to pay for the recycling of another category of WEEE/E-waste, whose recycling costs are higher than the fee charged. The more complex (combination of three items) is the fee structure, the more demanding it is in WEEE/E-waste collection and administration e.g. NVMP and Recupel differ significantly in the number of product fees they charge. Table 5.1 gives an example of fee structure.

Table 5.1: Established European WEEE Schemes (EU/EEA): Flexibility of Cost Models

Scheme	Number of Cost Models	Type of Cost Allocation
Recupel (Belgium)	1	Fixed Fee Model – All categories.
NVMP (The Netherlands)	1	Fixed Fee Model – Certain categories excluded

Scheme	Number of Cost Models	Type of Cost Allocation
ICT Milieu (The Netherlands)	1	Debiting Model – ICT products. Real costs are calculated on a month-by-month basis and divided amongst members on a market share basis, calculated monthly.
EI Retur (Norway)	3	Fixed Fee Model (EE Bransjen) – According to type and volume of product placed on market (Brown Goods). ICT Model (IKT Retur/IT Retur) – Actual Costs are calculated month by month and divided amongst members on a current market share basis. Fixed Fee Customer Model – White Goods (Hvitevareretur). A fee is levied by customs on import and passed to PRO Spell out what it means!
EI Kretsen (Sweden)	3	Debitting Model – Preliminary Cost. A preliminary cost (per unit, per kg or % of sales values) is fixed for the year. These fees are compared against actual costs at year-end and difference settled.. Debitting Model – ICT products. Real costs are calculated on a month-by-month basis and divided amongst members on a market share basis, calculated on the preceeding year. Costs per unit will therefore vary on a month-by-month basis. Other Debitting Model. Special fixed fee debiting models have been developed for specific product groups – e.g. light bulbs (2500 SEK per year).
SWICO (Switzerland)	2	Fixed Fee Models: ICT Products. Fixed fee tariff banded according to sales price. 12 fee bands with no fee for products under 50CHF. Fixed Fee Model: Consumer Electronics/Photographic. Fixed tariff according to product category. 5 fee levels with no fee for price below 50 CHF.

5.1.3 Funding for Supply Chain

The fee charged catalyses financial flow along the WEEE/E-waste supply chain. This financial flow meets the costs of WEEE/E-waste collection, transportation and treatment. Examples of funding of WEEE/E-waste stakeholders along the supply chain in Netherlands, Japan and Switzerland are shown in figure 5.1, figure 5.2 and figure 5.3.

The salient features of Netherlands NVMP supply chain model are given below:

1. Producers/ Importers pay NVMP to manage their WEEE/ E-waste responsibilities under Dutch legislation. A fixed fee is paid to NVMP for each product placed on the market. This fee is passed on to the consumer with no mark up. The scheme covers household WEEE/ E-waste.

2. Households pay a visible fee on the purchase of new EE products. Households pay a local municipal waste tax to fund general waste collection and operation of municipal sites. Households may return WEEE/ E-waste free of charge to municipal collection sites. Municipalities provide some kerbside collection.

Households may also return WEEE/ E-waste to a retailer/distributor free of charge on the basis of 1:1 new for old purchase. Retailers may charge for collection of the old product from household:

3. Retailers are obliged to take back WEEE/ E-waste on a new for old basis from consumers. They may then transfer the WEEE/ E-waste to a municipal waste site, direct to the regional sorting stations (RTS) or pay for collection by NVMP.

4. Municipal collection sites receive WEEE/ E-waste and take responsibility for delivery to regional sorting stations operated by the municipalities and NVMP. Municipalities are not reimbursed.

5. Regional sorting stations receive WEEE/ E-waste free of charge and sort for collection and treatment. NVMP makes a financial contribution to the operation of RTS.

6. Transport contractors are responsible for the collection of WEEE E-waste from the RTS and delivery to treatment plants and recycling firms. Contractor invoices on the basis of weight. Logistics are organized in house by NVMP.

7. Treatment and recycling contractors take receipt of WEEE and process. Contractors invoice NVMP on the basis of actual treatment costs.

The salient features of Japanese supply chain model are given below:

1. Consumers pay an end-of-life fee for product disposal and treatment as opposed to the producer responsibility concept in the WEEE Directive. This fee is paid to the retailer, and passed on to one of two industry consortia who are responsible for the collective management of WEEE/ E-waste in the specified categories.

2. Retailers are obliged to take back goods on a new for old basis. This applies both to replacement products, but also to products from non-identical product categories. It is estimated that 80% of waste is currently collected through the retail stream.

3. The Association for Electric Home Appliances (AEHA) is a trade group responsible for orphan products. Some collection services are also subcontracted to AEHA, who operate in isolated or rural areas not served by retailers.

4. Each Industry Consortium manages approximately 200 consolidation and bulking centres across Japan. These are privately owned and managed, although retailers, local government or another designated organisation is obliged to deliver goods from the retailer.

5. Each consortium operates approximately 12 treatment centres for different project types and groups. Transport from the consolidation to treatment centres is outsourced.

The Swiss system is based on EPR, both legally and operationally i.e. producers and importers are both physically as well as the financially responsible for an environmentally

sound disposal of WEEE/E-waste. The salient features of Swiss WEEE/E-waste supply chain model are given below:

1. The entire operative responsibility is shared with the two PROs–SWICO and S.EN.S, who manage and operate the system on behalf of their member producers.

2. Secured financing of the collection and recycling is ensured by way of the Advance Recycling Fee (ARF) charged on all new appliances. The ARF is used to pay for the collection, the transport and the recycling of the disposed appliances. The ARF can range from a minimum CHF (Swiss franc) 1 on small items, such as hair dryers and electric shavers, to up to CHF 20 for TVs or CHF 40 for refrigerators. Both SWICO and S.EN.S have distinct categories of products according to the approximate cost of recycling them. It is seen that the largest portion of the ARF goes to the recyclers.

3. The Swiss ARF is an intergenerational contract between appliances purchased in the past and those that will be purchased in the future, similar to a pension system. Therefore, it requires accurate estimations of how much waste will be generated and how many new products will be sold.

4. SWICO and S.EN.S have official collection points around Switzerland in addition to the thousands of retail locations which have to take back old equipment free of charge, irrespective of the brand or year of manufacture. It becomes easier for consumers to dispose their WEEE/E-waste at appropriate locations.

5. By having common collection points, the PROs are better able to manage logistics, benefit from economies of scale and provide a consumer friendly, all-inclusive solution instead of a prohibitively expensive brand specific one.

6. Both material and financial flows are controlled at every stage, as shown in figure 5.3. The independent controls not only deter free riders, but also give credibility to the entire system. It also ensures participation of retailers and consumers.

5.1.4 Financial Guarantee

Producers have to provide a financial guarantee for fulfilment of their take back obligation for electrical and electronic products placed on the national market after the effective date of the local legislation (so called “New waste”) by giving evidence of a guarantee (e.g. blocked bank account/insurance) for future WEEE/ E-waste management costs. In most European countries an additional financial guarantee is not needed if the producer is member of a collective scheme.

The financial model, fee structure, funding the supply chain and financial guarantee in EU countries are summarized in table 5.2.

Figure 5.1: Financial Model of Netherlands NVMP – A Collective EU Collective Compliance System

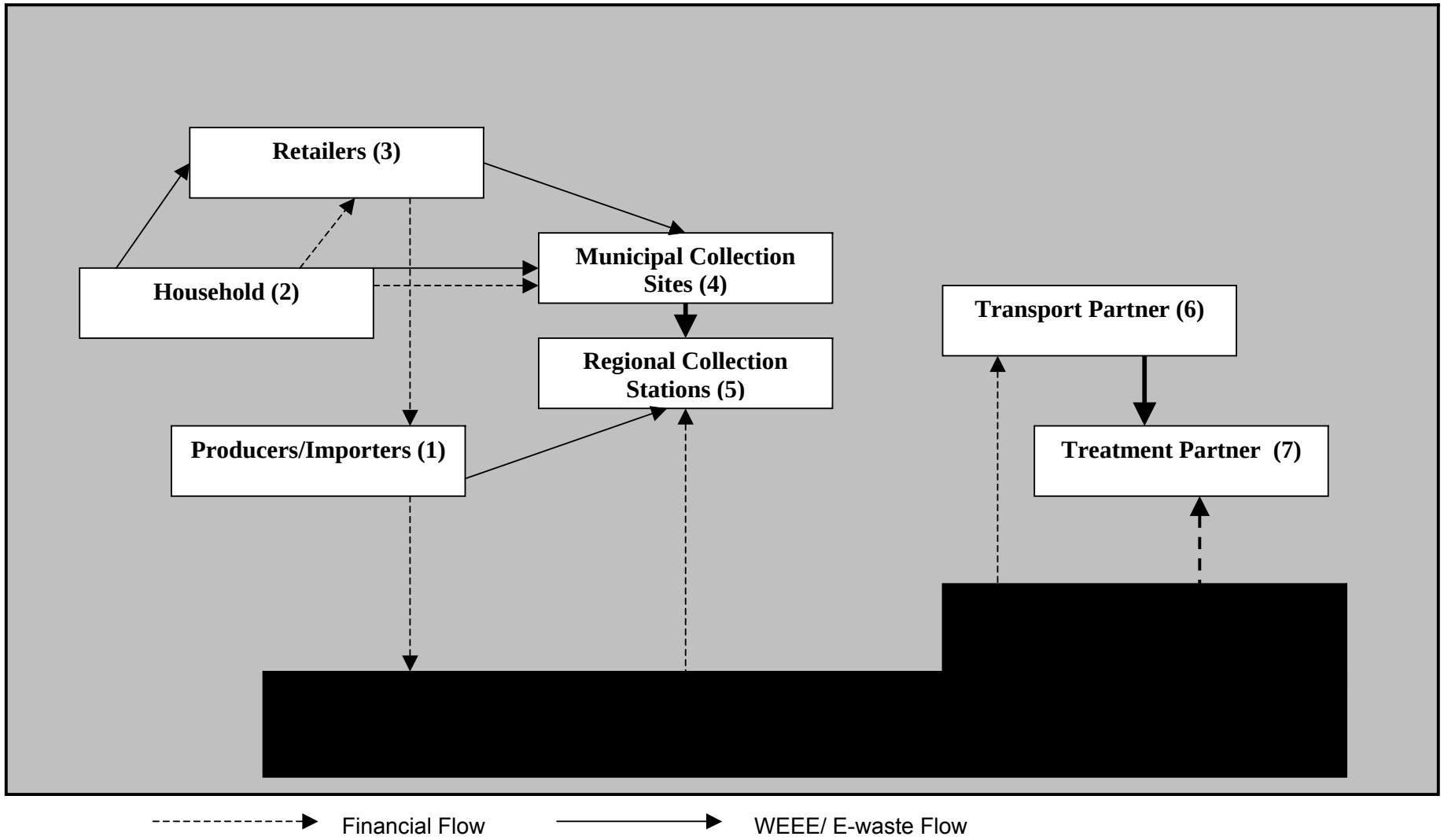


Figure 5.2: Financial Flow Model of Japanese WEEE Take back System – A Consumer/Retailer based system

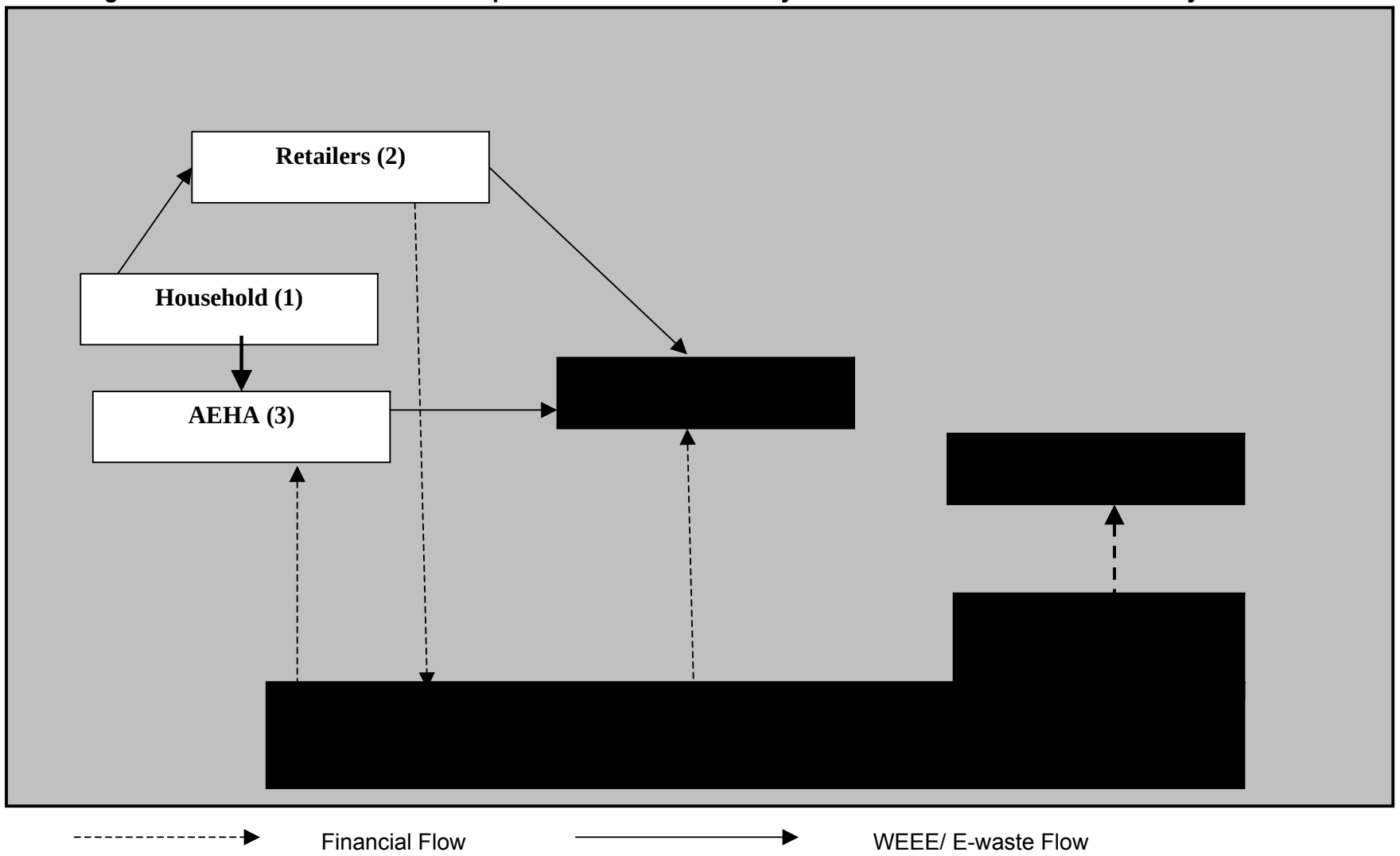
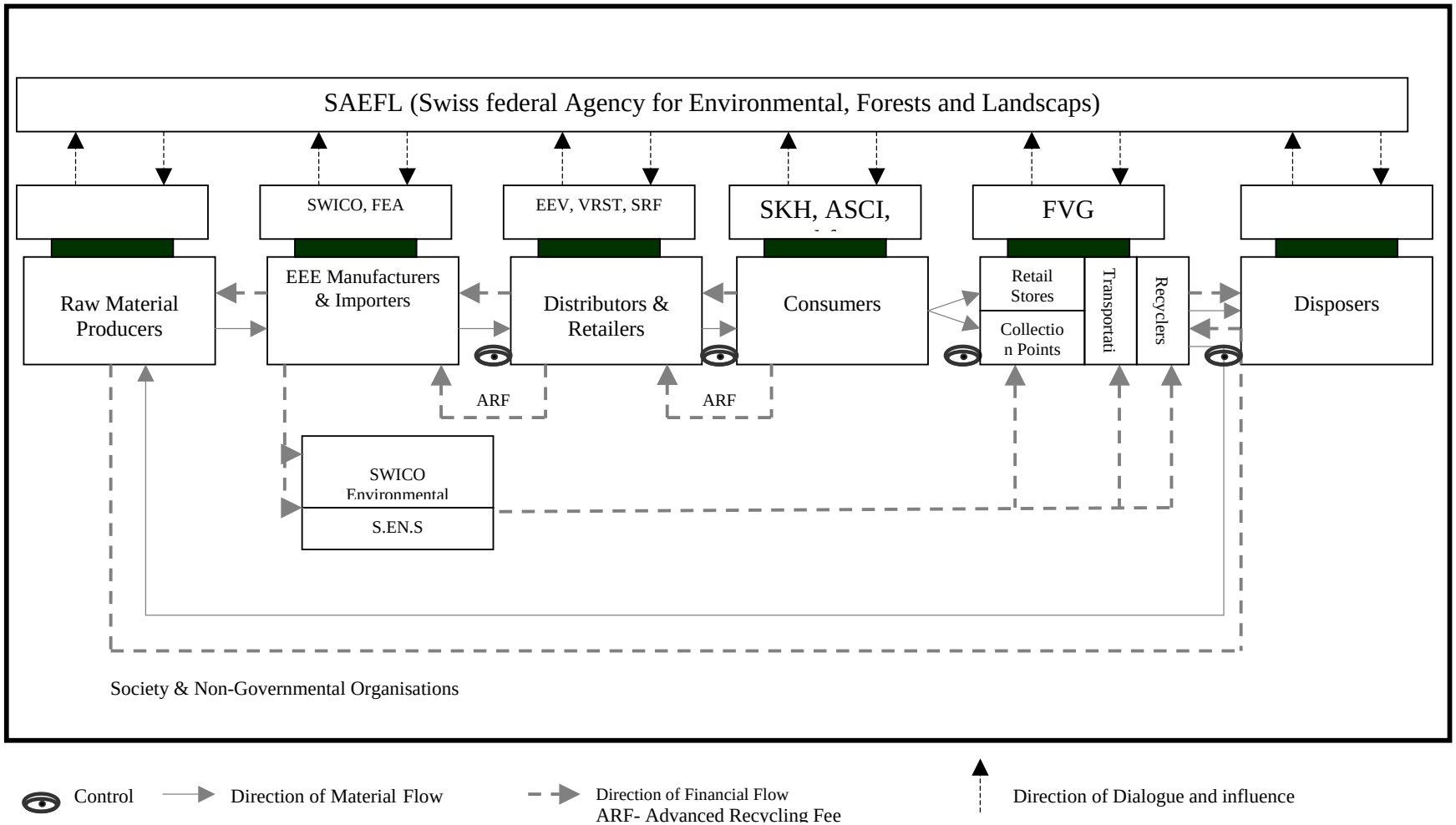


Figure 5.3: Financial Flow Model of Swiss WEEE/ E-waste



Source: Deepali Sinha-Khetriwal, Philipp Kraeuchi, Markus Schwaninger, A comparison of electronic waste recycling in Switzerland and in India, Environmental Impact Assessment Review 25 92005)492-504, ELSEVIER

Table 5.2: Summary of Financial Model, Fee Structure, Supply Chain Funding and Financial Guarantees in EU Countries

	Austria	Belgium	Cyprus
Historical B2C WEEE & Visible Fee	To be financed collectively by all producers according to market share in last quarter Visible fee optional, retailers not obliged to show it	Historical household WEEE to be financed collectively by all producers according to market share, or else by an individual financial guarantee	As Directive
New B2C WEEE & Financial Guarantee	Membership in collective scheme eliminates need for guarantee Collective scheme not required to provide guarantee	Only required from individual compliers Visible fee allowed for estimated costs of collection, treatment and recycling until 2011 (2013 for large appliances)	As Directive
	Czech Republic	**Denmark**	**Estonia**
Historical B2C WEEE & Visible Fee	By market share Only one system allowed in one category, must be joined by all producers Visible fee optional	WEEE from products placed on market before 31 March 2006 to be financed collectively according to market share	To be financed by all producers according to market share Visible fee not defined
New B2C WEEE & Financial Guarantee	Coll. System members may comply for new WEEE in the same way as for historical WEEE Guarantee only required from producers that comply individually	Individual compliers must provide guarantee Collective schemes may be exempted if members have >30% market share	By market share Guarantee only required from producers that comply individually
	Finland	**France**	**Germany**
Historical B2C WEEE & Visible Fee	Producers will fund historical WEEE according to market share. The visible fee is optional – actual costs may be shown until February 2011 (2013 for category 1)	Producers to divide cost pro rata to EEE placed on the market Visible fee mandatory throughout the supply chain	By market share in past year; in practice share of mass placed on market in previous month Visible fee optional
New B2C WEEE & Financial Guarantee	Guarantee required only from individual compliers	Pro rata principle to be applied at 'whichever date the EEE is placed on the market' Guarantee required only from individual compliers	By market share OR sorting own WEEE at each collection point All B2C producers to provide guarantee. 3 insurance based systems: GSA, ZVEI, Philips

	Greece	Hungary	Ireland
Historical B2C WEEE & Visible Fee	All WEEE to be treated as new waste. Producers to pay into compliance scheme or fund their own activities according to their market share Visible fee optional	Each producer obliged to collect, re-use recover a percentage of what the amount he placed on market in past year (the percentage varies by category and increases every year) Visible fee is optional (for both new and historic WEEE)	Producers to divide cost of household WEEE according to market share A visible fee is allowed for management costs of historical waste until 2011 (2013 for category. 1)
New B2C WEEE & Financial Guarantee	Financial guarantee only required from individual compliers	No distinction between the financing of historical and new WEEE Guarantee only required from individual compliers	Producer pays for own products Guarantee only required from individual compliers
	Italy	**Latvia**	**Lithuania**
Financing of Historical B2C WEEE & Visible Fee	Producers must set up collective systems, to be financed according to current market share Visible fee optional but if used must be shown to end-user	Govt. considering tender of WEEE management to one collective system, financed by Natural Resource Tax	By market share; separate order to determine % targets for management of historic WEEE Distributors to show visible fee if requested by producer
Financing of New B2C WEEE & Financial Guarantee	Until EU wide system for producer identification in place but no later than 13 August 2007 new WEEE to be financed as historic WEEE Guarantee: No explicit exemption for collective system members Obligation from 13/8/06, unclear if required before producer identification in place	Producers have 3 options to comply: -pay Natural Resource Tax -join collective system -comply individually	Options for producers: - manage WEEE individually or through WEEE management company; - join collective system - found/participate in a system which extends municipal WEEE management programme Guarantee required for individual or joint compliance
	Luxembourg	**Malta**	**Netherlands**
Financing of Historical B2C WEEE & Visible Fee	Costs proportional, for example to current market share Visible fee optional; but Ecotrel membersmust display visible fee	Cost of take-back to be allocated according to current market share Visible fee optional	Cost of take-back to be allocated according to current market share Visible fee is optional, but none on ICT products

Financing of New B2C WEEE & Financial Guarantee	Producer responsible for own products, may transfer obligation Guarantee only required from individual compliers	Collective or individual compliance will be possible Guarantee only required from individual compliers	Producer to finance WEEE from own products from retail and local govt. collection points Guarantee only required from individual compliers – membership of collective system = guarantee
	Poland	**Portugal**	**Slovakia**
Financing of Historical B2C WEEE & Visible Fee	By market share Producer to reach recovery targets as % of collected material from 2008 Product Fee charged on underachieved amounts Visible fee optional, may be set by the producer or collective system	By market share at the time the waste arises Visible fee optional until 2011 (2013 for category. 1)	Proportional to market share by category and weight in the previous year A visible fee is optional (the collective system Envidom has decided to display it)
Financing of New B2C WEEE & Financial Guarantee	Producer to finance own brand and any brand in same category proportional to market share Guarantee only required from individual compliers	Producer responsible for WEEE from own EEE placed on market Guarantee only required from individual compliers	Producer to finance WEEE from own products Guarantee only required from individual compliers
	Slovenia	**Spain**	**Sweden**
Financing of Historical B2C WEEE & Visible Fee	By market share Visible fee optional	Cost of take-back to be allocated according to current market share Visible fee mandatory until 2011 (2013 for category.1)	Cost of take-back to be allocated according to current market share Visible fee optional
Financing of New B2C WEEE & Financial Guarantee	Guarantee required from all producers (bank guarantee or insurance), further details to be defined	Producer responsible for own WEEE Only required from individual compliers	Producer responsible for own WEEE Only required from individual compliers

5.2 Financing of WEEE/E-waste Management in Developing Countries

Financing of WEEE/E-waste management in developing countries can be established by studying the existing WEEE/E-waste collection, transportation and recycling systems and comparing it with an established WEEE/E-waste collection, transportation and recycling systems in a developed country. In this context, existing WEEE/E-waste collection, transportation and recycling system in India has been studied. The existing system is shown in figure 5.4 and its salient features are given below.

1. There is no regulatory mechanism in India, which stipulates the management and handling of post-consumer WEEE/E-waste generated within the country.

2. Therefore, the Indian system has developed very organically, as a natural branching of the scrap industry which accepts scrap from many sources including old ships, end-of-life vehicles and building wastes.

3. The established scrap metal industry absorbs the new WEEE/E-waste stream to recover metals, which are then used as a feedstock to steel mills and non-ferrous smelters and refiners. Therefore, the existing WEEE/ E-waste management system is a successful case of industrial symbiosis which is self-organized and market-driven.

4. In the existing financial model, it is the waste collectors who pay consumers a positive price for their obsolete appliances, as shown in figure 5.4. The small collectors in turn sell their collections to traders who aggregate and sort different kinds of waste and then sell it to recyclers, who recover the metals. Therefore, the purchase price offered by recycler drive the WEEE/E-waste collection, transportation and its treatment. The collection and transportation costs are built into the price offered by recycler to trader and the price offered by the trader to the collector. Finally, the raw material producer offers the price to the recyclers as per the local metals, glass, plastic and other items rate or as per wholesale domestic or international market.

5. This recycling network consists of a series of private–private relationships among waste pickers, itinerant buyers, dealers, wholesalers and recycling enterprises. The entire industry is based on a network existing among collectors, traders and recyclers, each adding value, and creating jobs, at every point in the WEEE/E-waste trade value chain.

6. Since the low level of initial investment is required to start a collection, dismantling, sorting or recovery business, it is attractive for small entrepreneurs to join the industry.

7. The main incentive for the players is financial profit, not environmental or social benefits. The biggest drawback of the current Indian system is the uncontrolled emission of hazardous toxics that are going into the air, water and soil. The health hazards from fumes, ashes and harmful chemicals affect not only the workers who come into contact with the WEEE/ E-waste, but also the environment.

5.3 Analysis

A comparative analysis of financial flows for developing countries as shown in figure 5.4 has been carried out with respect to figure 5.3 as shown for developed countries. The following inferences have been drawn from this comparison.

1. EEE manufacturers and importers are not responsible for treatment and disposal of WEEE/E-waste or its fractions in developing countries.

2. WEEE/E-waste fractions/ materials also flow from EEEE manufacturers and importers to collectors/ traders/ recyclers for recycling and disposal in developing country.

3. Collectors/ traders/recyclers pay the salvage value of WEEE/E-waste and their fractions to consumers and EEE manufacturers and importers in developing country.

4. In developed countries with WEEE/ E-waste management system, enabling regulatory framework allows financial flows in the form of Advanced Recycling Fee (ARF)/ other financial instrument from consumers to retailers/ distributors and from retailers/ distributors to EEE manufacturers/ importers. This ARF/ other instrument is then passed on from EEEE manufacturers/ importers to collection points/ retail stores, transporters, recyclers and for disposal.

5. Raw material pays recyclers in both developing and developed countries.

The above analysis leads to identification of following drivers for development and implementation of financial model.

1. Enabling regulatory framework, which should be developed as described in background material and guidance notes of chapter 3.

2. Recycling standards and treatment. The level of recycling standards, quality control systems and processes varies significantly across countries e.g. Low supplier contract costs in certain countries may reflect lower contractor recycling standards.

3. Enabling collection and transportation system as described in background material and guidance notes of chapter 4. This will include distance and geography, population size and density and consumer behavior etc.

4. Enabling recycling infrastructure as described in background material and guidance notes of chapter 4.

5. Economics of collection, transportation, treatment and disposal. This will include costs of collection, cost of transportation, cost of treatment and cost of disposal.

The key success factors for establishment and operation of financial model for WEEE/E-waste management are given below.

1. Consultation process
   It is broadly accepted that national systems should be run and managed by industry/ recyclers/ producers within a sound legislative framework established in consultation with stakeholders.

2. Understanding local context

Build systems that meet local specifics of culture, geography and industry, and that take into account existing practices of waste collection. There is some indication that national approaches may face challenges from recyclers and producers seeking to develop pan-European or multi country systems.

3. Build upon existing infrastructure. Use experience with existing collection systems.

4. Build First, Measure and Monitor Later
   The experience of countries having WEEE/E-waste management systems show that countries should get any system up and running before committing themselves to performance and target setting.

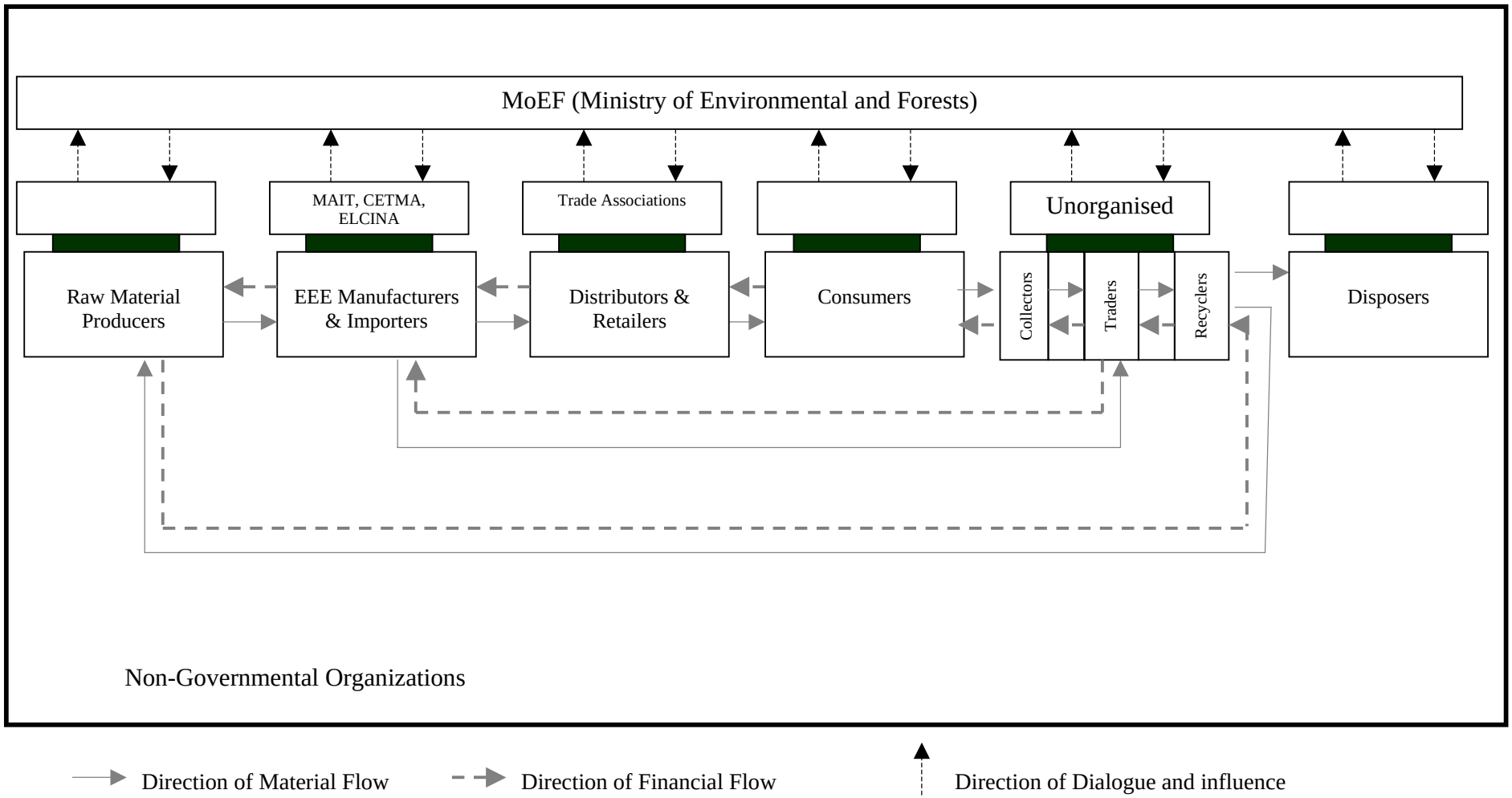
5. Balance Costs and Environmental Impact
   The lowest cost solution may compromise the desired environmental outcome. Therefore it is important that there are acceptable and realistic figures for volumes, costs and standards.

6. One Face for the Consumer
   The success or failure of a WEEE/ E-waste programme is dependent on the clarity with which it can be explained to the consumer, and the ease with which the consumer can engage with the collection and financing system. Different collection systems for different products cause consumer confusion and affect efficiency.

7. Efficient sorting and charging system
   Current market share model, either through fees on products sold, or allocation of actual costs to products placed on the market.

8. Recognition of different financing needs of specific sectors
   In EU, ICT companies prefer a system whereby real costs of collection, transportation and treatment system are apportioned according to market share, whilst brown goods companies prefer a model with a visible fee component.

Figure 5.4: Material and financial flows in Indian E-waste



Source: Deepali Sinha-Khetriwal, Philipp Kraeuchi, Markus Schwaninger, A comparison of electronic waste recycling in Switzerland and in India, Environmental Impact Assessment Review 25 92005)492-504, ELSEVIER

5.4 Guidance Notes

Objective: The major objective of guidance notes is to assist technical personnel/ WEEE/E-waste implementation agencies/ other stakeholders to develop financial model for WEEE/E-waste collection, transportation, treatment and disposal systems. This will lead to design and development of financial management options/ models for WEEE/E-waste management system.

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

Step 1: Define the enabling regulatory system as per step 1 to 8 mentioned in guidance procedure of chapter 3.

Step 2: Fix up collection and transportation system as per step 8 and 9 mentioned in guidance procedure of chapter 3.

Step 3: Prepare bills of quantities (inventory of items) for WEEE/E-waste collection and transportation system as per step 2 to step 4 mentioned in guidance procedure of chapter 4. This will include items like area of collection point, equipments required to store, load and unload and transport WEEE/E-waste, labour, electricity, material of construction and other items.

Step 4: Prepare bills of quantities (inventory of items and their quantities) for establishing WEEE/E-waste treatment system as per step 5 and 6 mentioned in guidance procedure of chapter 4. This will include items like area of treatment facility, equipments required to treat, load and unload WEEE/E-waste, labor, electricity, material of construction and other items.

Step 5: Prepare detailed cost estimates of WEEE/E-waste management system as given below.

1. Calculate capital cost of WEEE/E-waste collection and transportation as per bills of quantities given in step 3.
2. Calculate capital cost of WEEE/E-waste treatment system as per bills of quantities given in step 4.
3. Calculate operation and maintenance cost of collection and transportation system by calculating labour costs and equipment operating costs (fuel/ electricity/ maintenance)
4. Calculate operation and maintenance cost of treatment system by calculating labour costs and equipment operating costs (fuel/ electricity/ maintenance)
5. Calculate cost of disposal to landfill facility/ incinerator by calculating transportation costs and disposal cost

Step 6: Prepare forecasted revenue streams from sale of output by recyclers to raw material producers over a period of ten years, twenty years or more. This will also include scenario analysis with respect to recycling efficiency. A template for revenue generation is given in table 5.3 and table 5.4.

Table 5.3: Value of output evaluated after dismantling of single PC

Elements	Content (% of total weight)	Content (Kg)	Recycling efficiency (%)	Recoverable weight of element (kg)	80% Recoverable weight of element (kg)	Local Newspaper Quoted Unit Price (Rs./kg)	Market Price (Rs./kg)	Total Value (Rs.)	Total Value ($)
Plastics	23	6.25	20%	1.25069408	1.00055526	75	56.25	56.28123	1.279119
Lead	6	1.71	5%	0.08566368	0.06853094	76	57	3.906264	0.088779
Aluminum	14	3.85	80%	3.08389248	2.46711398	105	78.75	194.2852	4.415573
Germanium	0.0016	0.00	0%	0	0		0	0	0
Gallium	0.0013	0.00	0%	0	0		0	0	0
Iron	20	5.57	80%	4.45453312	3.5636265	20	15	53.4544	1.214873
Tin	1	0.27	70%	0.19188512	0.1535081	690	517.5	79.44044	1.805465
Copper	7	1.88	90%	1.69614576	1.35691661	287	215.25	292.0763	6.638098
Barium	0.0315	0.01	0%	0	0		0	0	0
Nickel	0.8503	0.23	0%	0	0	2310	1732.5	0	0
Zinc	2	0.60	60%	0.35979072	0.28783258	142	106.5	30.65417	0.696686
Tanialum	0.0157	0.00	0%	0	0		0	0	0
Indium	0.0016	0.00	60%	0.00026112	0.0002089		0	0	0
Vanadium	0.0002	0.00	0%	0	0		0	0	0
Terbium	0	0.00	0%	0	0		0	0	0
Beryllium	0.0157	0.00	0%	0	0		0	0	0
Gold	0.0016	0.00	99%	0.000430848	0.00034468	965000	723750	249.461	5.669568
Europium	0.0002	0.00	0%	0	0		0	0	0
Tritium	0.0157	0.00	0%	0	0		0	0	0
Ruthenium	0.0016	0.00	80%	0.00034816	0.00027853		0	0	0
Cobalt	0.0157	0.00	85%	0.00362984	0.00290387		0	0	0
Palladium	0.0003	0.00	95%	0.00007752	6.2016E-05		0	0	0
Manganese	0.0315	0.01	0%	0	0		0	0	0
Silver	0.0189	0.01	98%	0.005037984	0.00403039	19,465	14598.75	58.83862	1.337241
Antinomy	0.0094	0.00	0%	0	0		0	0	0
Bismuth	0.0063	0.00	0%	0	0		0	0	0
Chromium	0.0063	0.00	0%	0	0		0	0	0
Cadmium	0.0094	0.00	0%	0	0		0	0	0
Selenium	0.0016	0.00	70%	0.00030464	0.00024371		0	0	0
Niobium	0.0002	0.00	0%	0	0		0	0	0
Yttrium	0.0002	0.00	0%	0	0		0	0	0
Rhodium	0	0.00	50%	0	0		0	0	0
Mercury	0.0022	0.00	0%	0	0		0	0	0
Arsenic	0.0013	0.00	0%	0	0		0	0	0
Silica	24.8803	6.77	0%	0	0		0	0	0
Total								**1018.398**	**23.1454**

Table 5.4: Value of output evaluated after dismantling of single TV

Elements	%	ppm	Recoverable Weight of element (Kg)	80% Recovery (kg)	Newspaper Quoted Unit Price (Rs./kg)	Market Price (Rs./kg)	Total Value (Rs.)	Total Value ($)
Aluminium	1.2		0.4344	0.34752	105	78.75	27.3672	0.621982
Copper	3.4		1.2308	0.98464	287	215.25	211.9438	4.816904
Lead	0.2		0.0724	0.05792	76	57	3.30144	0.075033
Zinc	0.3		0.1086	0.08688	142	106.5	9.25272	0.210289
Nickel	0.038		0.013756	0.0110048	2310	1732.5	19.06582	0.433314
Iron	12		4.344	3.4752	20	15	52.128	1.184727
Plastic	26		9.412	7.5296	75	56.25	423.54	9.625909
Glass	53		19.186	15.3488	1	0.75	11.5116	0.261627
Silver		20	0.000724	0.0005792	19,465	14598.75	8.455596	0.192173
Gold		10	0.000362	0.0002896	965000	723750	209.598	4.763591
Total							**976.1641**	**22.18555**

Step 7: Calculate the break even year. In order to reduce the break even period, a recycling fee or some other financial instrument e.g. waste tax or any other instrument can be levied (depending on country's policy) to complement the revenue stream. This will include cost of collection, transportation and treatment along with a reasonable rate of return on investment. The additional revenue stream will take into account tradeoff between opportunity cost of capital and time period of availability of revenue stream.

Chapter 6: Case Study

6.0 Introduction

Knowledge of WEEE/E-waste management in a developing country context is important for practitioners, while designing any WEEE/E-waste management project. This chapter presents a case study from India describing each aspect of WEEE/E-waste management including techno-economic feasibility of establishing WEEE/E-waste treatment facility in India.

6.1 Case Study: Proposed WEEE/E-waste treatment facility

The case study has been presented in terms of brief description of WEEE/E-waste scenario describing the WEEE/E-waste availability, existing regulatory environment, downstream WEEE/E-waste market and treatment technology/ equipment supply conditions in India. A cumulative risk profiling followed by financial analysis has been carried out to assess the financial viability of the proposed facility.

6.1.1 WEEE/E-waste Scenario

In India, the Electronics industry is one of the fastest growing segments of industry both in terms of production and exports. At the same time, the software industry has been growing at a compound annual growth rate of over 46%. In 1990-91, hardware accounted for nearly 50 percent of total IT revenues while software's share was 22 percent. The scenario changed by 1994-95, with hardware share falling to 38% and software's share rising to 41percent. Within electronic industry segment, IT industry was the prime mover with an annual growth rate of 42.4 percent between 1995 and 2000. The Indian PC industry is growing at a 25 percent compounded annual growth rate with an installed base of 4.64 million desktops, about 431 thousand notebooks and 89 thousand servers at the end of March 06. The increase of electronic products, consumption rates and higher obsolescence rate leads to higher generation of WEEE/E-waste. It is reported that in India, about 146180 tonnes of WEEE/E-waste is generated from computers, TVs, refrigerators and washing machines during 2005, which is expected to exceed 800000 tonnes by 2012. Sixty-five cities in India generate more than 60% of the total WEEE/E-waste generated in India. Ten states generate 70% of the total WEEE/E-waste generated in India. Maharashtra ranks first followed by Tamil Nadu, Andhra Pradesh, Uttar Pradesh, West Bengal, Delhi, Karnataka, Gujarat, Madhya Pradesh and Punjab in the list of WEEE/E-waste generating states in India. Among top ten cities generating WEEE/E-waste, Mumbai ranks first followed by Delhi, Bangalore, Chennai, Kolkata, Ahmedabad, Hyderabad, Pune, Surat and Nagpur. This assessment was based on the market studies for electrical and electronic equipment, which predicted that computers (Information and Communication Technologies), TVs (brown goods), refrigerators and washing machines (white goods) will drive the future growth of electronics hardware industry in India. The growth rate of computer has been estimated to be 25% and all other items in the range of 15 to 20% annually. It was established that the obsolescence rate of computers is seven years, for TV, washing machine and refrigerator is fifteen years. There is no large scale organized WEEE/E-waste recycling facility in India and the recycling exists in un-organized sector. In this context, an entrepreneur in India embarked on establishing a WEEE/E-waste treatment facility with

an annual capacity of 7200 tonnes per annum near a major urban centre, which is generating more than 25,000 tonnes per annum WEEE/E-waste in India.

6.1.2 WEEE/E-waste Treatment Technology

The proposed facility has been designed based on first and second level of WEEE/E-waste treatment. The conceptual process flow diagram is given in figure 6.1 and figure 6.2.

Figure 6.1: Process flow of non- CRT based WEEE/ E-waste treatment

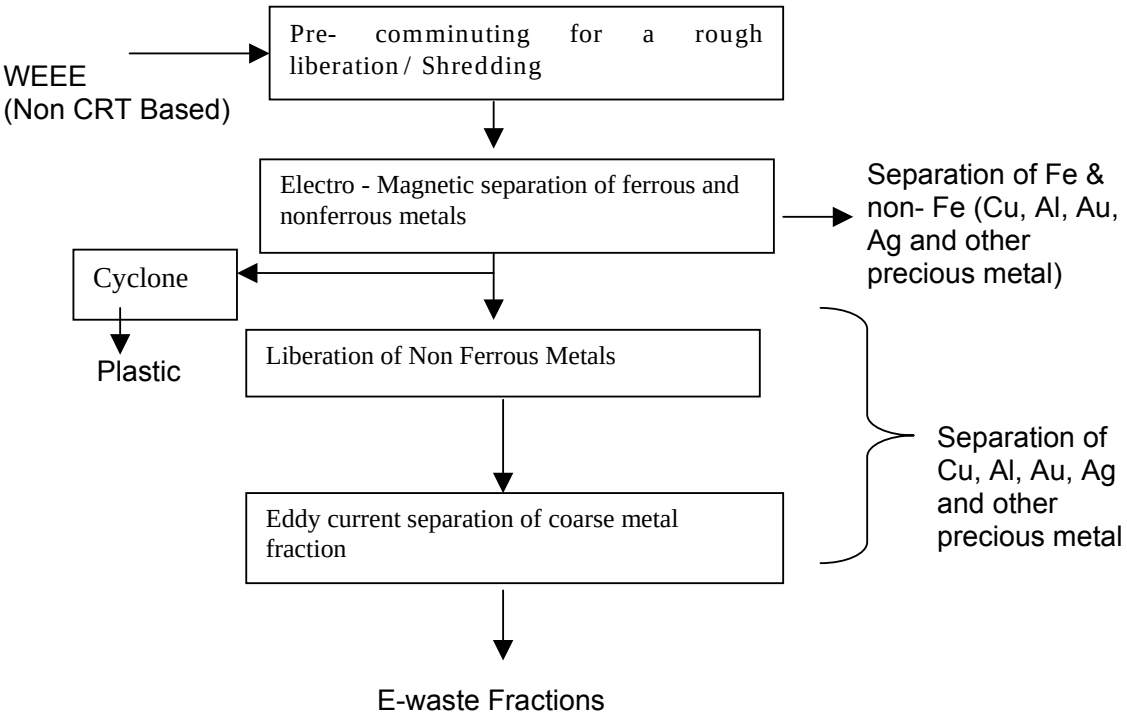
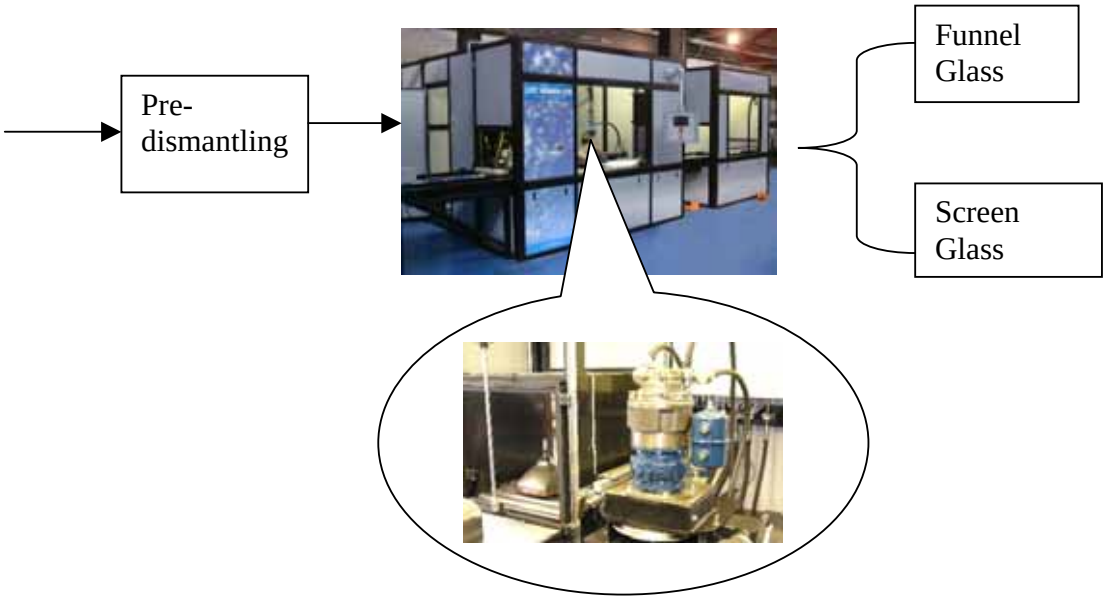


Figure 6.2: Process flow of CRT based WEEE/ E-waste treatment



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

10. 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 machine or air conditioners.

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

    II. Plastic
    III. CRT/ Glass
    IV. Metals (ferrous/ non-ferrous)/ Non metals

12. There will be different lines for WEEE/ E-waste and CRT treatment.

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

14. 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 pre-comminuting stage includes separation of Plastic, CRT and remaining non CRT based WEEE/ E-waste. Equipments 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. A heavy-duty hammer mill grinds the material to achieve separation of inert materials and metals. 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. 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.

The salient features of CRT based WEEE treatment technology and process is given below.

1. CRT is dismantled manually by removing 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. System utilizes powerful hydraulics and dry diamond cutting blades to separate the funnel glass from the panel glass.

5. Powerful hydraulic motors drive the diamond blades through a reduction gearbox to provide masses of torque and a high degree of speed control. This allows cutting very large and very small screens.

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

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

8. Two types of glass eg. Screen glass and funnel glass are separated and sorted out automatically.

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

6.1.2 Risk Profiling

The entrepreneur identified technology supplier from abroad. Further, detailed assessment of regulatory framework (existing/ expected framework), market assessment including WEEE/ E-waste supply and demand, prices, competition, collection and transportation system, proposed technology and its comparison with best available technology (BAT) in the world was also carried out. Risks related to each of these attributes were identified and their intensities were assessed based on existing and future market and regulatory conditions. The cumulative risk profile is given in table 6.1.

Table 6.1: Cumulative Risk Profile

Factors/ Intensity		High	Medium	Low
Regulatory Risks				
Risks due to lack of definition of WEEE/ E-waste in existing regulations		√		
Risks due to part inclusion of WEEE/ E-waste in existing regulations			√	
Risks due to lack of harmonization of WEEE/ E-waste in Export/ Import rules			√	
Market Risks				
Risks of availability of raw material (WEEE)	Short term			√
	Long term		√	
Risk associated with collection	Short term		√	
	Long term			√
Risk associated with transportation	Short term			√
	Long term			√
Risk associated with competition	Short term			√
	Long term	√		
Risk associated with quality of raw material	Short term		√	
	Long term			√

Technology Risks			
Type of raw material/ input to WEEE recycling system			√
Scale of operation			√
Expected yield/ output		√	
Experience of technology supplier			√
Environmental Issues			√

The intensities of risks have been fixed as per following analysis followed by mitigation measures.

1. There is no clear definition of WEEE/ E-waste in existing regulatory framework. Therefore, there is no understanding of what constitutes WEEE/ E-waste and how it should be tackled. The fundamental issue of WEEE/ E-waste treatment directly affecting the supply of WEEE/ E-waste to treatment facility is partly addressed in existing regulations and so this risk has been envisaged as high.

2. Risks due to part inclusion of WEEE in existing rules have been termed as medium. Authorization has been granted by state level regulatory agencies to the two WEEE/E-waste facilities for inter state transportation of WEEE/ E-waste under the existing regulation. Therefore, the entrepreneur's proposed facility will also be operating under the same regulation by state level agencies till such time amendments to the existing regulations/ new regulation with respect to WEEE/ E-waste are in place.

3. Risks due to lack of harmonization of WEEE/ E-waste in Export/ Import rules. As per exim rules, all the secondhand electronic items/ WEEE/ E-waste are banned into India. This creates problem of WEEE/E-waste generated in duty free zones to come into domestically generated WEEE/E-waste supply chain. The clear definition of WEEE/ E-waste, its inclusion in existing regulatory framework or in a separate regulatory framework is expected to harmonize in exim rules of India.

4. Risks of availability of raw material (WEEE/ E-waste) has been assessed as low since enough WEEE/ E-waste is being generated at national and local level to be processed both in the short term and long term especially after 2011. There may be risk in the long term considering similar facilities come up at local level, state and national level. This will depend on the structure of regulatory regime. The entrepreneur has secured long term memorandum of understanding (MOU) with existing corporate/ business houses in the zone of influence of the proposed facility for supply of WEEE/E-waste. Therefore, the model is expected to be business to business (B2B).

5. Risk associated with quality of raw material has been assessed as risk of medium intensity, while it is considered to be low in the long term. This has been assessed based on the assumption that the specifications need to be defined for input raw material in the short term. These specifications will become standardized in the long term and so risk perceived will be low as both the supplier and buyer would be aware of the specifications.

6. Risk associated with collection are expected to be medium in the short term as there are no collection mechanism like product take back scheme in place both at the local and national level. The concept of extended producer responsibility (EPR) does not exist in India. In this situation, the entrepreneur will face the risk of collecting WEEE/ E-waste from the source, which could be geographically dispersed. In the long term this risk is expected to be low with the promulgation of legislation and subsequent compliance.

7. Risk associated with transportation are expected to be low in the short and long term as there is transportation mechanism in place both at the local and national level to carry hazardous waste. The transporters in India have experience of transporting hazardous waste to existing hazardous waste landfill/ incineration facilities, therefore the expected risk associated with transportation is low. The entrepreneur has identified approved hazardous waste transporters on all India basis, who can transport WEEE/E-waste locally as well as from any part of India.

8. Risk associated with competition is expected to be low in the short term since existing WEEE/ E-waste, which is being generated is more than existing treatment facilities. This situation is expected to continue till 2011 till all the regulations are in place and market is aware about the facilities. In the long term, risks associated with competition are expected to be high due to price competitiveness on account of new facilities, fall in recovery of precious materials or fall in their prices. Therefore, the proposed facility's B2B model will mitigate the anticipated risk.

9. The efficiency of recycling system in terms of output is dependent on quantity and quality of Input raw material/ WEEE/ E-waste. The quality of raw material is dependent on the type and obsolescence rate of the WEEE/ E-waste item. WEEE/ E-waste to be recycled at proposed facility will not be dismantling refrigerators. The expected obsolescence rate of personal computers, TVs and cell phones, which will form the bulk of input raw material, has been assessed to be 5, 15 and 2 years. The operating facilities using BAT are recycling WEEE/ E-waste having similar obsolescence rates. Therefore the risk associated with this factor has been identified as low. The entrepreneur ensured performance guarantee (operational guarantee) of the technology from the technology supplier so that expected output and yields are achieved. It also ensured adequate supply of spare parts of the equipment and training of its personnel for smooth operation of the proposed plant.

10. One of the risks associated with technology is the scale of operations. The entrepreneur proposes to use technology with a throughput of 1500 kg per hour. The technology supplier supplies non-ferrous metal separators with different useable belt widths from 400 mm to 1500 mm. The throughput amount per 1000 mm width of belt can reach more than 20,000 kg/h, depending on the specific weight and bulk density of the material. Therefore, the scale of operations has been identified as a low risk factor for the proposed technology.

11. The efficacy/ profitability of the recycling system are dependent on the expected yields/ output of the recycling system. The expected yields/ output from the recycling system is dependent on the optimization of separation parameters. These parameters are particle size, particle shape, feeding rate/ RPM and

Optimum operations. Size properties are essential for choosing an effective separation technique. Since, eddy current separator to be supplied by technology supplier was evaluated as one of the best for granular non-ferrous materials >5mm, separation of non-metal fraction is expected to be adequate. Particle shape is dependent on comminuting and separation. Since hammer mills and screens will be used in the proposed technology, the variations are expected to be the same as that of BAT. The feeding rate can be optimized based on the speed and width of the conveyor.

14. Technology supplier has supplied enough number of electrostatic separators globally. Therefore, the risk associated with experience of technology supplier is low.

15. Environmental risks associated with this technology are expected to be low as it is a dry process, which is fully automated. Occasionally dust emissions are expected at localized places in the process, which can be easily mitigated. The phosphor coating is securely collected and stored for disposal in secured hazardous waste landfill facility. It Is located on 100 acres of land, which is located within ten kilometers of proposed facility.

6.1.3 Financial Analysis

Financial analysis has been carried out by computing the capital costs and operation and maintenance costs. Capital cost includes the total investment cost of USD ($) 5.5 million, which includes cost of land. The operating cost consists of items summarized in table 6.2.

Table 6.2: Operating Costs

S. No.	Items	Costs
1.	Raw material	$0.4/ kg for TV and $0.6/kg for PC
2.	Labor	$795/ day
3.	Electricity	$0.102/unit
4.	Collection and Transportation system	0.034 cents/ km/kg
5.	Maintenance Cost (100% capacity Utilization)	$110000/annum

Assumptions for computing these costs are given below.

1. An average cost of Rs. 25 per kg has been taken as raw material cost.
2. It has been assumed that about 30 personnel will be working for managing the proposed facility. An average cost of Rs. 35,000 per day has been taken as the labor cost. This figure has been arrived considering the following breakup of personnel
   - three top management staff (CEO, CFO and general manager)
   - Eight technical personnel
   - 17 to 25 semiskilled staff

3. Electricity charges are based on the existing rate of Rs. 4.50 per unit provided by the utility to industries. It is computed based on operating hours and capacity utilization.

4. Collection and transportation costs have been estimated considering MSW collection and transportation system in Delhi, where the private operator charges Rs. 350 to Rs. 650 per ton for collection and transportation of MSW from bins to sanitary landfill site. Therefore, considering an average of 30 km of round trip, the average collection and transportation cost comes out to be Rs. 0.01 to 0.02 per kg per km.
5. Machinery maintenance cost is assumed to be 2% of the capital expenditure every year if operated at full capacity utilization. It gets reduced in proportion to capacity utilization.
6. An exchange rate of Rs. 44 to $1 has been assumed in all calculations.

Payback period for the proposed investment has been estimated for dismantling of TVs and personal computers in two scenarios. The first scenario describes the sale of output from the proposed facility in domestic market. The second scenario describes the sale of output from the proposed facility in both domestic and international market. In order to compute revenue stream, the selling price of the output to be exported from the WEEE/E-waste treatment facility has been taken as 75 percent of the price offered in London Metal Exchange while selling price of outputs to be sold in India has been taken from local commodities, metal and scrap market. The weight of TV and PC has been assumed to be 36.5 kg and 27.2 kg respectively. The analysis was carried out in terms of payback period under two scenarios at 70% and 95% capacity utilization of the facility and the results are summarized in table 6.3.

Table 6.3: Scenario Analysis

Electronic Item/ Capacity utilization	Television		Personal Computer	
	70%	95%	70%	95%
Scenario 1 (Years)	12	8	6.8	4.6
Scenario 2 (Years)	10.7	7	5.3	3.7

A comparative analysis of the payback period under two scenarios indicates that payback period improves if the output from the proposed facility is exported. Therefore, there is a need for long term export contract between the entrepreneur and importing company. Payback improves if the capacity utilization is higher. Capacity utilization depends upon the availability of the raw material. It is expected that WEEE/ E-waste generation from TV and personal computer in the region of influence of proposed facility is expected to exceed 14,000 tonnes and 29,000 tons during 2015. These quantities are more than 50% higher required for payback period of 4 to 5 years.

6.2 Conclusion

The case study shows that the first and second level WEE/E-waste treatment facility for TVs and personal computer is viable in a geographical region based on B2B model even in the absence of recycling fee/ other financial instrument and WEEE/E-waste collection and transportation infrastructure. The model works even when the recycler pays for the raw material and collection and transportation cost. There is a scope of further reduction of technology costs if the developing country has got infrastructure to for the local fabrication of machinery and equipment.

Appendix 1

Table 3.1: Policies/ Laws/ Regulations/ Institutional Roles for WEEE/E-waste in European Union and Other European Countries

Country/ Features	Policies/ Laws/ Regulations	B2C WEEE Collection	B2B WEEE Responsibility	National Register	Clearing House	Collective Systems
Austria	Verordnung des Bundesministers für Land- und Forstwirtschaft, Umwelt undWasserwirtschaft über die Abfallvermeidung, Sammlung und Behandlung von elektrischen und elektronischen Altgeräten (Elektroaltgeräteverordnung (EAG-VO), April 2005	Local govt. to organize collection free-of-charge for consumers. Producers compensate municipalities with infrastructure lum sum 1:1 take back at retailers Producer systems to set up at least one collection point per political district for free take-back from retailers and consumers	Dual use defined in scope guidelines available Producers to pay for historical non-household WEEE if supplying replacement; otherwise end-user responsible	Environment Agency (Umweltbundesamt)	Elektroaltgeräte-Koordinierungsstelle Austria GmbH, industry owned and managed	UFH Altlampen UFH Elektroaltgeraet ERA EVA ERP
Belgium	Decree of the Flemish Government of 14 July 2004, modifying the Decree of the Flemish Government of 5 Dec 2003. Decision of the Brussels Capital Government of 3 June 2004 modifying the decision of the Brussels	Local govt. to organize free-of-charge collection in container parks 1:1 take-back by retailers Recupel	Producers to pay for historical non-household WEEE if supplying replacement; otherwise end-user	Producers complying collectively to register with Recupel only Individually complying companies to register with 3	Not required, one system	Recupel (6 divisions); Currently no collection system for categories 7, 8, 9, 10 Individual compliance requires approval

Country/ Features	Policies/ Laws/ Regulations	B2C WEEE Collection	B2B WEEE Responsibility	National Register	Clearing House	Collective Systems
	Capital Government of 18 July 2002. Decree of the Walloon Government of 10 March 2005, modifying the Decree of the Walloon Government of 25 April 2002. Royal Decree on the prevention of hazardous substances in electrical and electronic equipment of 12Oct 2004; federal Level.	compensates retail and local governments for collection	responsible	regional environmental agencies		of 3 regional environmental agencies
Cyprus	Administrative Act No 668 of 2004, published in Official Gazette No 3888, Annex III (I), on 30 July 2004.	Local govt. not obliged to collect WEEE Producers to finance entire WEEE management	As Directive	Producers must register with the Environment Service of the Ministry of Agriculture, Natural Resources and Environment	Not required, one system	EDHHA, founded by Chamber of Commerce in Aug 2005, to be financed and owned by around 16 importers
Czech Republic	Act No. 7/2005 Coll., amending Act 185/2001 Coll. (the general waste management law of the Czech Republic) published on 6 Jan 2005. Decree 352/2005 published on 15 Sept 2005.	Producers to finance separate collection Municipalities may collect in which case producers must provide containers 1:1 take-back by retailers free-of-charge	Producer to register, but no guarantee New WEEE: producer responsible, unless otherwise agreed with purchaser Historic WEEE only on a 1:1 basis	Environment Ministry responsible Producers to apply for registration by 12 Sept 2005.	Not yet required, only one system per category	Elektrowin, Ekolamp, Retela, REMA, Asekol Government to choose in December 2005 which system may handle which category

Country/ Features	Policies/ Laws/ Regulations	B2C WEEE Collection	B2B WEEE Responsibility	National Register	Clearing House	Collective Systems
		to consumers				
Denmark	Statutory order No. 591 of 9June 2006 and Statutory order no. 873 of 11th August 2006	Local govt. to ensure sufficient free-of-charge collection points, may organise pick-up collection themselves or in collaboration with producers) Retailers accept WEEE on 1:1 basis	Producers responsible for new WEEE, unless alternative arrangements agreed Producers responsible for historic WEEE on 1:1 basis; otherwise, end-users pay	The WEEE System	The WEEE System	EPA Elretur Denmark to begin April 2006.
Estonia	Amendments to the Waste Act of 1May 2004. Regulation No. 376 of the Government of the Republic of 24 Dec 2004 on Requirements and Procedure for Marking Electrical and Electronic Equipment, Requirements, Procedure and Targets for Collection, Return to Producers and Recovery or Disposal of Waste Electrical and Electronic Equipment, and Time Limits for Reaching Targets, which entered into force on 1 Jan 2005. Minister of	Producers to financing WEEE management entirely 1:1 take-back by retailers; they must take back WEEE from any category they sell if no industry collection point within 10 km.	Producers responsible for WEEE on 1:1 basis	Environment Information Centre (EIC), to be under government control	Not provided for	EES-Ringlus Further system in preparation

Country/ Features	Policies/ Laws/ Regulations	B2C WEEE Collection	B2B WEEE Responsibility	National Register	Clearing House	Collective Systems
	Environment Regulation No. 9 of 9 Feb 2005 on Requirements for Treatment of Waste Electrical and Electronic Equipment, which entered into force on 20 Feb 2005. Regulation on the Central Register of Producers, which was adopted on 19 Jan 2006 and will enter into force after its publication in the Estonian State Gazette					
Finland	Act 452/2004 amending the Waste Act (1072/1993) adopted on 4 June 2004 and Government Decree on Electrical and Electronic Waste 852/2004 adopted on 9 September 2004.	1:1 take-back by retailers (or retailers must inform consumers about alternative collection) Producers responsible for organising & funding collection, may contract local authorities or waste management companies All collectable WEEE to be collected – not only 4 kg.	Producers responsible for B2B WEEE placed on the market after 13 August 2005, unless alternative arrangements agreed Producers to bear the cost of pre 13 August 2005 WEEE if a replacement is purchased; otherwise, end-users pay	Only individual compliers must register with the Pirkanmaa Regional Environmental Centre	Not required, only one system per category	SERTY Oy (household WEEE) FLIP Py (lamps and lighting) ICT Producer Cooperative (ICT) SELT Ry (lighting, heaters, surveillance and control equipment)

Country/ Features	Policies/ Laws/ Regulations	B2C WEEE Collection	B2B WEEE Responsibility	National Register	Clearing House	Collective Systems
France	TEXTES GÉNÉRAUX MINISTÈRE DE L'ÉCOLOGIE ET DU DÉVELOPPEMENT DURABLE Décret no 2005-829 du 20 juillet 2005 relatif à la composition des équipements électriques et électroniques et à des déchets issus de ces équipements	Producer must either establish an individual system for separate collection or pay a clearing house which reimburses municipalities for extra costs for separate collection (extra cost not defined) 1:1 take-back at retailers, may delegate this to a compliance system	New EEE: producer responsible unless otherwise agreed. Historic B2B EEE: end-user responsible even if replacement purchased, unless otherwise agreed Mandatory visible fee to be set for some large appliances	To be prepared and operated by ADEME (Environment Agency)	Not yet set up	4-8 collective producer systems expected competing in several categories, e.g. Recylum ECO-Systèmes Eco-Logic ERP
Germany	Electrical and Electronic Equipment Act, "Gesetz über das Inverkehrbringen, die Rücknahme und die umweltverträgliche Entsorgung von Elektro- und Elektronikgeräten (Elektro- und Elektronikgerätegesetz (ElektroG))vom 16. März 2005	Local govt. to finance collection, may manage WEEE itself. Local govt. sends take back request to Clearing House which notifies producer with highest	Treatment costs of historic B2B EEE to be borne by the final user, but users and producers may negotiate their own agreements for different arrangements. Producers	EAR Foundation, industry-managed; responsibilities designated by UBA 6 July 2005.	EAR Foundation	Producers cannot transfer responsibility. (Purchasing) consortia restricted by competition authority, e.g ERP, ProReturn, ENE, LARS, Olav, BSH-Miele-Philips, Quelle Waste mgmt

Country/ Features	Policies/ Laws/ Regulations	B2C WEEE Collection	B2B WEEE Responsibility	National Register	Clearing House	Collective Systems
		unfulfilled obligation to pick up container Retailer or producer may take-back from consumers	responsible for B2B WEEE placed on the market after 13 Aug 2005, unless alternative arrangements agreed.			systems/services: ALBA, DSD, DHL, e-back, EGR, Entec, AVR, Fliege Cleanaway, Hellmann, Interseroh, Landbell, Pape, Remondis, TechProtect/ RENE, Take-E-Way, Vfw, Zentek
Greece	Decree No 117/2004, Gazette No A82 on 5 March 2004	Local govt. to organize free-of-charge collection 1:1 take-back by retailers Collection to be co-ordinated by compliance scheme, in collaboration with local govt.	Producers responsible for new B2B WEEE, unless alternative arrangements agreed Producers responsible for historic B2B WEEE if a replacement is purchased. otherwise, end-users pay	Environment Ministry responsible for registration and data collection	Not required	All producers are expected to join the approved collective compliance scheme (Recycling of Appliances S.A.), but the law provides an individual compliance option
Hungary	Government Decree 264/2004 on the take-back of WEEE of 23 September 2004, Ministerial Decree 15/2004 of 8 October 2004 Amendment 103/2004 to	Producers to bear costs of collection, must reimburse local govt. for collection &	New WEEE: producer responsible; no provision for other agreement Historic WEEE:	National General Directorate of Environment and Water Management	None, obligated parties to prove achievement of collection targets as % of amount placed on market	Four competing systems, open to all producers on same terms: Elektro-Coord (all categories B2C, B2B)

Country/ Features	Policies/ Laws/ Regulations	B2C WEEE Collection	B2B WEEE Responsibility	National Register	Clearing House	Collective Systems
	the Product Fee Act LVI.	sorting Producers may establish and operate collection centres 1:1 take-back by retailers above minimum selling area; mobile phone take back by retailer Product Fee (tax) payable on the difference between the recovery targets and recovery achieved (members of collective system exempt)	producer only responsible on 1:1 replacement basis, otherwise last user responsible			Ökomat Kht (all categories B2C, B2B, except mobile phones and refrigerators) Elektro-Waste Kht (IT) Re-Elektro Kht
Ireland	Statutory Instrument No. 340 of 2005 on Waste Management (Waste Electrical And Electronic Equipment) Regulations 2005 defines E-waste/ WEEE as electrical and electronic equipment, which	Local govt. to finance collection through delivery to civic amenity sites Distributors	Producers responsible for B2B WEEE placed on the market after 13 Aug 2005, unless alternative	National WEEE Registration Body, WEEE Register Ltd	'Black Box' system provides confidential clearing house service	ERP WEEE Ireland Ltd

Country/ Features	Policies/ Laws/ Regulations	B2C WEEE Collection	B2B WEEE Responsibility	National Register	Clearing House	Collective Systems
	is waste within the meaning of article 1(a) of Council Directive 75/442/EEC of 15 July 1975	must either take back WEEE on a 1:1 basis or display a notice informing retailers about the available collection systems Producers to finance take-back from local govt. and other collection points	arrangements agreed Producers responsible for historic WEEE on 1:1 replacement basis; otherwise, end-users pay			
Italy	Decree 25 July 2005 n.151	Municipal govt. to organise separate collection on their territory except for category 5. 4 kg target postponed by 2 yrs Producers to finance take-back from mun. collection points on, may	Producers responsible for new B2B WEEE, unless alternative arrangements agreed. Must provide financial guarantee. Producers responsible for historic WEEE on 1:1 basis if old EEE less than double weight of new	Activity code as EEE producers at Chamber of Commerce which will feed Register To be set up by 'Supervision and Control of WEEE Mgmt Committee' consisting of govt. representatives - sub-decree	Under 'Supervision and Control of WEEE Mgmt Committee'	8-10 systems competing in one or several categories expected, e.g. Ecolamp, Ecolight, Ecodom, Remedia, EcoR'It, ERP

Country/ Features	Policies/ Laws/ Regulations	B2C WEEE Collection	B2B WEEE Responsibility	National Register	Clearing House	Collective Systems
		set up own collection 1:1 take-back by retailers.				
Latvia	Law on Waste Management, as amended 19 February 2004, 2 December 2004 and 22 June 2005; Regulations of the Cabinet of Ministers No. 624 on Categories of EEE (adopted on 27July 2004); Regulations of the Cabinet of Ministers No. 736 on Requirements for the Labelling of EEE and on Providing Information (adopted on 24 August 2004); Regulations of the Cabinet of Ministers No. 923 on the Management of WEEE (adopted on 9 Nov 2004);	Producers responsible for separate collection	Producers responsible for new B2B WEEE, unless alternative arrangements agreed	Environment Ministry may delegate responsibility to organisation by producers that has been active for at least 5 years	Not planned	LZE (by LETERA, LDTA will cover IT, perhaps other categories) CECED Latvia may set up an organisation to cover household appliances
Lithuania	Amendment No. X-279 to the Law on Waste Management, adopted on 28 June 2005; Order of Minister of Environment No. D1-481 on Rules on Management of WEEE, adopted on 10 September 2004 Government Resolution No. 1252 on National Strategic Waste Management Plan,	Legislation leaves several options, form coll. system to state run WEEE management programme 1:1 mandatory take-back at retailers of all sizes	Producers are responsible for new WEEE and historic WEEE on 1:1 basis only – otherwise final holder responsible	Environment Ministry and Agency to operate register, regional environmental departments to register producers and importers	Not planned	System by INFOBALT (category 3, 4, excl TVs), system by CECED, Zaliasis Taskas (packaging compliance organisation) considering WEEE management

Country/ Features	Policies/ Laws/ Regulations	B2C WEEE Collection	B2B WEEE Responsibility	National Register	Clearing House	Collective Systems
	adopted on 5 Oct 2004.	Producers responsible for meeting collection targets through own and municipal systems				
Luxembourg	Grand Duke's Decree 18 January 2005 Environmental Agreement between the Ministry of the Environment, Ecotrel and professional associations (including the Luxembourg Chamber of Commerce, the Chamber of Trade and the Skilled Tradesmen's Federation) on 16 March 2006, which entered into force on 1April 2006	Existing public infrastructure to be used; producers to finance take-back at least from there on; they may set up separate collection 1:1 take-back by retailers who may inform of alternatives if they have insufficient space	Producers responsible for new B2B WEEE through individual or collective system Producers responsible for historic B2B WEEE on 1:1 replacement basis	Administration of the Environment; Ecotrel (for producers complying through Ecotrel;	None	ECOTREL set up February 2004 by industry and retail federations: approved 28 October 2005 – fees payable from 1 Sept 2005, all categories
Malta	RoHS Regulations adopted August 2004; Eco-tax imposed on EE from September 2004 Draft WEEE Regulations on October 2004 still not adopted;	Eco-tax on EEE: Environment Ministry empowered to grant full or partial exemption according to	Producers responsible for new B2B WEEE unless agreed differently Producers responsible for historic B2B	Malta Environment and Planning Authority to be responsible	None	None (some WEEE currently collected by WasteServ, a government-owned company)

Country/ Features	Policies/ Laws/ Regulations	B2C WEEE Collection	B2B WEEE Responsibility	National Register	Clearing House	Collective Systems
		recovery rate achieved and/or for members of a compliance system Free of charge take-back at existing sites & new ones to be set up	WEEE on 1:1 replacement basis			
Netherlands	BEA Decree and REA Regulation adopted in July 2004	1:1 take-back by retailers Local govt. collection points take back household WEEE from households and distributors Producers may arrange their own take-back from households	Producers responsible for new B2B WEEE unless agreed differently Final user responsible for historic B2B WEEE	Ministry of Housing, Spatial Planning and the Environment	None	ICT-Milieu (IT, office equipment, telecoms) and 6 non-competing systems under NVMP umbrella: VLEHAN - white goods FIAR - brown goods VLA - ventilation equipment SVEG - electrical tools SMR - metal and electrical products Stichting Lightrec
Poland	WEEE ACT 9/05 adopted in July 2005 with 3 orders and certain articles coming into force in July 2006	Producers to finance WEEE from collection point operators (municipalities,	Producer responsible for historic B2B WEEE on 1:1 replacement basis	Chief Inspector of Environmental Protection, may delegate to producer organisation with >	References to Clearing House removed from Act as adopted	Elektro-Eko, single system by major associations CECED, KigEIT (competition

Country/ Features	Policies/ Laws/ Regulations	B2C WEEE Collection	B2B WEEE Responsibility	National Register	Clearing House	Collective Systems
		retailers) Start date for take- back from municipal collection not defined 1:1 take-back at retailers from 1July 2006. No collection targets set yet	Producers always responsible for new B2B WEEE	75% market share		authority approval pending) ERP
Portugal	Decree Law 230/04 adopted in Sept 2004, published in December 2004, plus amendment approved in Septe,mber 2005 and 25 Oct 2005 by Law Decree 174/2005	Producers to set up collection system which combines local authority WEEE collection centres and WEEE collected by retailers 1:1 take-back by retailers also on delivery of new products to private households	Producer responsible for historic B2B WEEE on 1:1 replacement basis Producers responsible for new B2B WEEE unless agreed otherwise	Register to be run by producer associations and the compliance system (ANREE), under licence from the National Waste Institute	none	Amb3E ERP
Slovakia	Act 733/2004, amending the Waste Act 223/2001, adopted on 2 December 2004. Ministerial Decree	Producers to finance containers (7 types) and	There is a tax on EEE, linked to the recovery rate achieved	Environment Ministry	Provisions in place, but no operations yet	No approval required for collective systems.

Country/ Features	Policies/ Laws/ Regulations	B2C WEEE Collection	B2B WEEE Responsibility	National Register	Clearing House	Collective Systems
	208/2005 regarding the management of WEEE, adopted on 29 April 2005	take back from municipal sites 1:1 take back at retailer only mandatory if retailer is producer Producer to reach annually increasing collection targets as % of EEE placed on market Product fee (tax) charged on underachieved quantities				Ekolamp (Category. 5) Envidom (Category. 1, 2) SEWA (Category 3, 4) Etalux (Category 5) Individual compliance through waste management companies (Envi-Geos Nitra, Logos, Enzo, Brantner).
Slovenia	Decree 4871, 4 November 2004 with amendment published on 10 June 2005. A new "Decree on treatment of waste electrical and electronic equipment" (Official Journal of RS, No. 107/06) entered into force on 1 November 2006.This new decree in addition to transposition of EU directive also specified registration of producers and importers of WEEE.	Tender to one system to be called in 2009 if recovery targets not met Local authorities currently operate collection centres for WEEE – producers to provide containers	There will be a tax on EEE, linked to the recovery rate achieved	Ministry of Environment and Spatial Planning	Environment Ministry	Ekolamp, ZEOS (all other categories); Individual compliance: Slopak, Interseroh

Country/ Features	Policies/ Laws/ Regulations	B2C WEEE Collection	B2B WEEE Responsibility	National Register	Clearing House	Collective Systems
		There is a tax on EEE, linked to the recovery rate achieved				
Spain	Royal Decree 208/2005	1:1 take-back by retailers free-of-charge to consumers Local govt. collection points take back household WEEE from households and distributors Producers may arrange their own take-back from households	Producer responsible for historic B2B WEEE on 1:1 replacement basis Producers responsible for new B2B WEEE unless agreed otherwise; local govt. may take back B2B if there is a voluntary agreement	The National Register of Industrial Establishments, but producer must also register with the competent body of the Autonomous Region where their head office is located	National Register of Industrial Establishments	ECOLEC (categories 1, 2) TRAGAMOVIL (mobile phones) ECOFIMATICA (office IT and reprographic) ECOASIMELEC ECOTIC (category. 4, air conditioners, medical equipment, toys) Ambilamp (category 5)
Sweden	Swedish Code of Statutes 2005:209, “Ordinance on producer responsibility for electrical and electronic products” Published: 26 April 2005	Local govt. responsible for collecting WEEE that has not been returned to a producers’ collection system Producers to organise collection from municipal sites	Producers to finance take-back of products placed on market after 12 August 2005, and of historical waste if a replacement is bought; otherwise, end-	The Environmental Protection Agency is to run the National Register Registration expected to start early 2006	None	El-Kretsen runs the El-Retur system jointly with local govt., and also operates a recovery system for ICT products El-Kretsen is revising its statutes to bring them into line with the

Country/ Features	Policies/ Laws/ Regulations	B2C WEEE Collection	B2B WEEE Responsibility	National Register	Clearing House	Collective Systems
		No new obligations for retailers – unchanged from previous (2000) legislation – i.e take-back optional	users to fund historical waste			requirements of the new Statutory Order
Norway	relating to the recycling of Waste, 1 June 2004, Chapter 1	Retailers and Municipalities to take back free of charge. Producers to collect and take back from municipalities and retail collection centers. Collection system to recover fee from producers and importers.	Business can deliver to dealer on 1:1 take back. Producers are responsible for both historic and new.	Norwegian Pollution Control Authority	None	El-Retur AS RENAS AS Ragn-sells AS Veolia AS Eurovironment
Switzerland	VREG:Ordinance on the return, the taking back and the disposal of electrical and electronic equipment (ORDEE)	Distributors, Retailers and manufacturers must take back free of charge (even if no equipment is purchased). Consumers	Distributors, Retailers and manufacturers must take back free of charge (even if no equipment is purchased). Consumers	Responsibility of Environment ministry but no registry implementation. It is done by Swiss Cantons.	None	SWICO – ICT SENS – White goods SENS with SLG (Luminaries and Illuminants)

Country/ Features	Policies/ Laws/ Regulations	B2C WEEE Collection	B2B WEEE Responsibility	National Register	Clearing House	Collective Systems
		fund the collection and recycling through ARF	fund the collection and recycling through ARF			
United Kingdom	The Waste Electrical and Electronic Equipment Regulations 2006, to be enforced in 2007	Direct 1:1 take back by distributors from consumers free of charge If member of DTS, direct consumers to nearest DCF to dispose of their WEEE. Producers to finance in both cases	Not a collective obligation. Individual producer responsibility. For non hazardous luminaries, producers take back where collective system will charge flat monthly fee per item of equipment.	UK environmental agencies to issue preliminary 2007 market share percentage to based on 2006 sales data submitted with producer's registration. Environmental gency to approve and give registration number to agency.	Environmental Agency	REPIC – White goods Valpak – IT and Office Equipment Lumicon – Non-Household Luminaries

Source: Prepared by modifying and updating table given in the section "Executive Summary" transposition of the WEEE and RoHS Directives in Other EU Member States", Perchards, United Kingdom, November 2005.

Table 3.2: Policies/ Laws/ Regulations/ Institutional Roles for WEEE/E-waste in Other Developed Countries

Country/ Features	Policies/ Laws/ Regulations	B2C WEEE Collection	B2B WEEE Responsibility	National Register	Clearing House	Collective Systems
Australia	No Specific WEEE/E-waste regulation. Voluntary product stewardship initiative are under development	Municipal collection system exists for major household items. Voluntary mobile phone industry recycling program exists (take back at retailers)	No industry wide take back exists	Does not Exist	Does not Exist	Does not Exist
Canada	Canada's WEEE/ E-waste regulations are in the process of being developed at provincial level based on extended producer's responsibility/ stewardship. Alberta, Saskatchewan, British Columbia, Ontario and Nova Scotia have WEEE/ E-waste regulations in place.	Under development based on the principles of extended producer's responsibility/ stewardship	Under development	Does not Exist	Does not Exist	Under development
Japan	Reduce; Recycling; Recover, "The Law for Recycling of Specified Kinds of Home Appliances (Home Appliances Recycling Law)" 1998 and "The Law for Promotion of the Effective Utilization of Resources" 2000	1:1 take back for home appliances by retailers for free. In case of non replacement with new item, consumers to pay for	Exists	Ministry monitors recycling rates	Does not Exist	Joint recycling services offered by companies eg. Hitachi and IBM Japan

Country/ Features	Policies/ Laws/ Regulations	B2C WEEE Collection	B2B WEEE Responsibility	National Register	Clearing House	Collective Systems
		disposal/ recycling charges and transportation. Collection points are located at retailers, collection centers or post offices (for direct delivery to OEM) OEM responsible for collection and transportation of WEEE/E-- waste but generator to pay for collection and management costs.				
Korea	Producer Responsibility/ Product Stewardship. Article 2 of Act for Resource Recycling of Electrical and Electronic Equipment and Vehicles adopted on 2nd April 2007	Municipality collect for old discarded and charge for collection and disposal of WEEE/E-waste (in case of no new purchase) 1:1 take back of household	1:1 limited mandatory free take back for WEEE (purchase of new product) by producers	Ministry of Environment, which announces the quantity of recycling based on amount market, previous records and given capacity of recyclers.	Does not Exist	Mutual Aid Association on Recyclers

Country/ Features	Policies/ Laws/ Regulations	B2C WEEE Collection	B2B WEEE Responsibility	National Register	Clearing House	Collective Systems
		by retailers for limited items (new purchase)				
New Zealand	No specific legislation, which defines WEEE/ E-waste in New Zealand. However, Imports and Exports (Restrictions) Order (No 2) 2004 covers WEEE/E-waste.	Drop off at retail stores, recycling/ refurbished centers; curbside collection centers; local authorities collection centers	Voluntary schemes developed by industry eg. HP, IBM, Dell, Fisher and Paykel, Vodafone, Telecom, Exide	Does not Exist	Does not Exist	Does not Exist
USA	No specific legislation at federal level. But seven states have banned some electronics from landfills, and four have instituted recovery programs	On going drop off at non profit institutions Ongoing drop off at retailers 1:1 take back by retailers in some states Sporadic collection events	Not clearly defined. States have different systems	Does not Exist	Does not Exist	Does not Exist

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1. www.usepa.gov/epaoswer/hazwaste/recycle/ecycling/index.htm
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6. www.doe.gov.my
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About the UNEP Division of Technology, Industry and Economics

The UNEP Division of Technology, Industry and Economics (DTIE) helps governments, local authorities and decision-makers in business and industry to develop and implement policies and practices focusing on sustainable development.

The Division works to promote:

> sustainable consumption and production,
> the efficient use of renewable energy,
> adequate management of chemicals,
> the integration of environmental costs in development policies.

The Office of the Director, located in Paris, coordinates activities through:

- **The International Environmental Technology Centre** - IETC (Osaka, Shiga), which implements integrated waste, water and disaster management programmes, focusing in particular on Asia.
- **Production and Consumption** (Paris), which promotes sustainable consumption and production patterns as a contribution to human development through global markets.
- **Chemicals** (Geneva), which catalyzes global actions to bring about the sound management of chemicals and the improvement of chemical safety worldwide.
- **Energy** (Paris), which fosters energy and transport policies for sustainable development and encourages investment in renewable energy and energy efficiency.
- **OzonAction** (Paris), which supports the phase-out of ozone depleting substances in developing countries and countries with economies in transition to ensure implementation of the Montreal Protocol.
- **Economics and Trade** (Geneva), which helps countries to integrate environmental considerations into economic and trade policies, and works with the finance sector to incorporate sustainable development policies.

UNEP DTIE activities focus on raising awareness, improving the transfer of knowledge and information, fostering technological cooperation and partnerships, and implementing international conventions and agreements.

For more information, see **www.unep.fr**

For more information, contact:
UNEP DTIE
International Environmental Technology Centre

Osaka Office
2-110 Ryokuchi Koen, Tsurumi-ku
Osaka 538-0036, Japan
Tel: +81 6 6915 4581
Fax: +81 6 6915 0304

Shiga Office
1091 Oroshimo-cho, Kusatsu City
Shiga 525-0001, Japan
Tel: +81 77 568 4581
Fax: +81 77 568 4587

E-mail: ietc@unep.or.jp
URL IETC: http://www.unep.or.jp/

www.unep.org

United Nations Environment Programme
P.O. Box 30552 Nairobi, Kenya
Tel.: ++254-(0)20-762 1234
Fax: ++254-(0)20-762 3927
E-mail: uneppub@unep.org

This book is the second volume of E-waste manual to build the capacity of practitioners and policy makers for preparing and developing WEEE/E-waste management system.

This manual summarises the current practices in developed and developing countries on WEEE/E-waste management, the technologies for E-waste management (collection, transportation, treatment and disposal) and the important pre-requisites for effective and sustainable WEEE/E-waste management.

Conceptual approach for developing regulatory system of E-waste management has been provided for policy makers in order to design an E-waste management system. Current practices for E-waste management have been reviewed from developed and developing countries. Financial viability of E-waste management has been discussed for effective and sustainable E-waste management.

A case study from a developing country, which describes each aspect of E-waste management including techno-economic feasibility of establishing E-waste treatment facility is also presented.

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