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E-WASTE
VOLUME I

Inventory Assessment Manual

UNITED NATIONS ENVIRONMENT PROGRAMME

E-waste

Volume I: Inventory Assessment Manual

Compiled by

UNEP
Division of Technology, Industry and Economics
International Environmental Technology Centre

United Nations Environmental Programme
Division of Technology, Industry and Economics
International Environmental Technology Centre
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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.

This first manual on WEEE/ E-waste has been prepared as a guidance document to support WEEE/E-waste inventorisation and assessment risks involved. 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 the 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 WEEE/ E-waste inventorisation and assessment of risks involved. The manual has been prepared based on data from secondary sources including publications from scientific journals, reports and web sites.

The manual has been prepared in six chapters. Chapters 1 to 4 provide background information. Chapter 5 provides the guidelines for WEEE/E-waste assessment and Chapter 6 discusses case studies to show the field applications of these guidelines.

The manual is spread over 6 chapters. A basic understanding of the issue of waste management has been provided in the initial chapters. The “Definition” of WEEE/E-waste varies across the continents and countries. These definitions have been discussed to assist policy makers and practitioners to set the boundaries for WEEE/E-waste. Guidance notes are also provided 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 separately.

WEEE/ E-waste is a “tradable commodity” and its “mechanism of trading” are usually described in terms of WEEE/E-waste composition, potential for material recovery, WEEE/E-waste trade value chain (starting from manufacture, production, import, consumption, WEEE/E-waste generation, treatment and disposal), sources of generation, market controls like availability and implementation of regulations and facilities of material recovery, socio-economics and environmental impacts. WEEE/E-waste market assessment includes their classification and composition to help plan for WEEE/ E-waste inventory assessment.

Methodologies for WEEE/E-waste inventory vary as per their application, constraints, advantages, data requirements and sources of data. Before selecting a particular methodology, it is important to evaluate its constraints, advantages, data requirement and whether sources for collecting such data are available. The manual describes different tools and techniques for data acquisition, review and stakeholder engagement.

Finally, two case studies from developing countries are provided as examples of the field application of WEEE/E-waste inventory assessment methodology. This example can assist practitioners to design any WEEE/E-waste inventory assessment project. It is expected that these case studies will assist the practitioners in better understanding of on-the-ground situation.

ACRONYMS

BAN	Basel Action Network
B&W	Black and White
BDE	Brominated Diphenyl Ether
BFR	Brominated Flame Retardant
BPO	Business Process Organization
CAGR	Compounded Annual Growth Rate
CDMA	Code Division Multiple Access
CPU	Central Processing Unit
CRT	Cathode Ray Tube
CFC / HCFC / HFC / HC	Chlorofluorocarbon / Hydrochlorofluorocarbons / Hydrofluorocarbons / Hydrocarbons
CTV	Color Television
DEFRA	Department of Environment, Food and Rural Affairs
DTIE	Division of Technology, Industry, and Economics
EEE	Electrical and Electrical Equipment
EPR	Extended Producer Responsibility
EST	Environmentally Sound Technologies
EU	European Union
FR	Flame Retardant
GDP	Gross Domestic Product
GPS	Geographical Positioning System
GSM	Global System for Mobile Communication
IC	Integrated Circuit
ICT	Information and Communication Technology
IETC	International Environmental Technology Centre
IRGSSA	IRG Systems South Asia Pvt. Ltd.
IT	Information Technology
Kg	Kilogram
Lat/ Long	Latitude / Longitude
LCD	Liquid Crystal Display
L/D	Length/ Diameter
MAIT	Manufacturers' Association for Information Technology, India
MCIT	Ministry of Communication and Information Technology, India
MFA	Material Flow Analysis
MoEF	Ministry of Environment and Forest
MSDS	Material Safety Data Sheets
MT	Metric Tonnes
NCAER	National Council of Applied Economic Research, India
NCR	National Capital Region
NGO	Non Governmental Organization
ODS	Ozone Depleting Substance
OECD	Organization for Economic Co-operation and Development
PAH	Polycyclic Aromatic Hydrocarbons
PBDE	Poly Brominated Diphenyl Ether
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
SAEFL	Swiss Federal Agency for Environmental, Forests and Landscapes
StEP	Solving the E-waste Problem
TV	Television
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 first manual has been developed as a guidance document to implement WEEE/ E-waste inventory assessment and presented in the following chapters. In this chapter, the following sections describe objectives, scope and format of first manual.

1.1 Objectives

The major objective of first manual is to build capacity of practitioners and decision makers to guide and handhold them to plan, design and implement WEEE/ E-waste assessment 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 six chapters. Chapter 1 gives introduction and background. Chapters 2 to 5 provide background information supported by examples from different countries and followed by guidance notes. Chapter 2 describes the "definition" of WEEE/E-waste followed by guidance notes to assist policymakers/ other stakeholders to assess whether WEEE/E-waste is addressed in the existing environmental/ related legislation of the country. This will help them to identify the gaps and the regulations where WEEE/E-waste can be addressed or whether there is a need to address it separately. Chapter 3 describes assessment of WEEE/ E-waste market, where an understanding of WEEE/ E-waste as a "tradable commodity" and its "mechanism of trading" has been described in terms of WEEE/E-waste composition, potential for material recovery, WEEE/E-waste trade value chain (starting from manufacture, production, import, consumption, WEEE/E-waste generation, treatment and disposal), sources of generation, market controls like availability and implementation of regulations and facilities of material recovery, socio-economics and environmental impacts. Guidance notes at the end of this chapter have been provided to assist in WEEE/E-waste market assessment, which includes identification, their classification and composition and planning for WEEE/ E-waste inventory assessment.

Chapter 4 describes methodologies for WEEE/E-waste inventory, their application, constraints, advantages, data requirements and sources of data. Guidance notes suggest how a particular methodology should be selected in a geographical context and the data needs. Chapter 5 demonstrates how application of any WEEE/E-waste inventory assessment methodology can be customized in a developing country context using different tools and techniques. Guidance notes provide advice to the WEEE/E-waste investigation team on to apply the customized approach and methodology using these tools and techniques to assess existing and future WEEE/ E-waste inventory. Chapter 6 presents two case studies from developing countries, which encapsulates the experience about application of WEEE/E-waste inventory assessment methodology in a real developing country context. This will assist practitioners to design any WEEE/E-waste inventory assessment project.

Chapter 2: E-waste / WEEE Definition

2.0 Introduction

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. It is expected to grow to 2% by 2010. In USA, it accounts for 1% to 3% of the total municipal waste generation. In EU, historically, WEEE increases by 16-28% every five years, which is three times faster than average annual municipal solid waste generation. A recent source estimates that total amount of WEEE generation in EU ranges from 5 to 7 million tonnes per annum or about 14 to 15 kg per capita and is expected to grow at a rate of 3% to 5% per year. In developing countries, it ranges from 0.01% to 1% of the total municipal solid waste generation. In countries like China and India, though annual generation per capita is less than 1 kg, it is growing at an exponential pace. 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. The composition of WEEE/ E-waste is very diverse and differs in products across different categories. It contains more than a 1000 different substances, which fall under "hazardous" and "non-hazardous" categories. Broadly, it consists of ferrous and non-ferrous metals, plastics, glass, wood and plywood, printed circuit boards, concrete and ceramics, rubber and other items. Iron and steel constitutes about 50% of the WEEE followed by plastics (21%), non ferrous metals (13%) and other constituents. Non-ferrous metals consist of metals like copper, aluminium and precious metals like silver, gold, platinum, palladium etc. The presence of elements like lead, mercury, arsenic, cadmium, selenium, and hexavalent chromium and flame retardants beyond threshold quantities in WEEE / E-waste classifies them as hazardous waste. WEEE/ E-waste dismantling or incineration is considered toxic. Therefore, they are targeted for reuse, recovery or hazardous waste disposal. The recovery of metals is a profitable business, which results in local, trans-boundary and global trade. Environmental issues and trade associated with WEEE/ E-waste has driven the definition of WEEE/ E-waste both at national and international level. In this context, it is important to understand the existing WEEE/ E-waste definition and its evolution, its drivers and guidance notes for its assessment and formulation as described in following sections.

2.1 Definition

Globally, WEEE/ E-waste are most commonly used terms for electronic waste. There is no standard definition of WEEE/ E-waste. A number of countries have come out with their own definitions, interpretations and usage of the term "E-waste/WEEE". The most widely accepted definition of WEEE/ E-waste is as per an EU directive, and this is followed in member countries of European Union and other countries of Europe. Therefore, an effort has been made to review and describe WEEE/ E-waste definitions, which are being used in different countries across five continents. This review is based on data collected from secondary sources on the laws, regulations and scientific publications on WEEE/E-waste. During this review, no definitions of WEEE/ E-waste were found in countries of Africa though E-waste initiatives are under implementation in South Africa. At first WEEE/ E-waste definition has been described as per EU directive and Basel Convention. Further, prevalent definitions in countries of Asia, North America, South America and Australia have been described. Finally, WEEE/E-waste definitions under different initiatives/ conventions/ agencies/ NGOs ex. StEP, OECD and Basel Action Network have been described followed by analysis.

2.2 Definition as per European Union and Basel Convention

This section describes WEEE/E-waste definition in European Union followed by WEEE/ E-waste references in Basel Convention.

2.2.1 European Union

Definition as per EU directive with status of its transposition and variation in major EU countries is described in table 2.1 followed by E-waste's reference in Basel Convention.

<u>WEEE Directive (EU, 2002a)</u>

"Electrical or electronic equipment which is waste including all components, sub-assemblies and consumables, which are part of the product at the time of discarding." Directive 75/442/EEC, Article 1(a) defines "waste" as "any substance or object which the holder disposes of or is required to dispose of pursuant to the provisions of national law in force."

(a) 'electrical and electronic equipment' or 'EEE' means equipment which is dependent on electrical currents or electromagnetic fields in order to work properly and equipment for the generation, transfer and measurement of such current and fields falling under the categories set out in Annex IA to Directive 2002/96/EC (WEEE) and designed for use with a voltage rating not exceeding 1000 volts for alternating current and 1500 volts for direct current

Annex IA

Categories of electrical and electronic equipment covered by this Directive

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

Annex IB

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

1. <u>Large household appliances</u>

    - Large cooling appliances
    - Refrigerators
    - Freezers
    - Other large appliances used for refrigeration, conservation and storage of food
    - Washing machines

- Clothes dryers
- Dish washing machines
- Cooking
- Electric hot plates
- Microwaves
- Other large appliances used for cooking and other processing of food
- Electric heating appliances
- Electric radiators
- Other fanning, exhaust ventilation and conditioning equipment

2. Small household appliances

- Vacuum cleaners
- Carpet sweepers
- Other appliances for cleaning
- Appliances used for sewing, knitting, weaving and other processing for textiles
- Iron and other appliances for ironing, mangling and other care of clothing
- Toasters
- Fryers
- Grinders, coffee machines and equipment for opening or sealing containers or packages
- Electric knives
- Appliances for hair-cutting, hair drying, tooth brushing, shaving, massage and other body care appliances
- Clocks, watches and equipment for the purpose of measuring indicating or registering time Scales.

3. IT and telecommunications equipment

- Centralized data processing
- Mainframes
- Minicomputers
- Printer units
- Personal computing:
- Personal computers (CPU, mouse, screen and keyboard included)
- Laptop computer (CPU, mouse, screen and keyboard included)
- Notebook computers
- Notepad computers
- Printers
- Copying equipment
- Electrical and electronic typewriters
- Pocket and desk calculators
- And other products and equipment for the collection, storage, processing, presentation or communication of information by electronic means
- User terminals and systems
- Facsimile
- Telex
- Telephones

- Pay telephones
- Cordless telephones
- Cellular telephones
- Answering systems
- And other products or equipment of transmitting sound, images or other information by telecommunications

4. Consumer equipment

- Radio sets
- Television sets
- Video cameras
- Video recorders
- Hi-fi recorders
- Audio amplifiers
- Musical instruments
- Other products or equipment for the purpose of recording or reproducing sound or image, including signals or other technologies for the distribution of sound and image than by telecommunications

5. Lighting equipment

- Luminaries for fluorescent lamps with the exception of luminaries in households
- Straight fluorescent lamps
- Compact fluorescent lamps
- High intensity discharge lamps, including pressure sodium lamps and metal lamps
- Low pressure sodium lamps
- Other lighting or equipment for the purpose of spreading or controlling light with the exception of filament bulbs

6. Electrical and electronic tools (with the exception large-scale stationary industrial tools)

- Drills
- Saws
- Sewing machines
- Equipment for turning, milling, sanding, grinding, sawing, cutting, shearing, drilling, making, holes, punching, folding, bending or similar processing of wood, metal and other materials
- Tools for riveting, nailing or screwing or removing rivets, nails, screws or similar uses
- Tools for welding, soldering or similar use
- Equipment for spraying, spreading, dispersing or other treatment of liquid or gaseous substances by other means
- Tools for mowing or other gardening activities

7. Toys, leisure and sports equipment

- Electric trains or car racing sets
- Hand-held video game consoles
- Video games
- Computers for biking, diving, running, rowing, etc.
- Sports equipment with electric or electronic components
- Coin slot machines

8. Medical devices (with the exception of all implanted and infected products)

- Radiotherapy equipment
- Cardiology
- Dialysis
- Pulmonary ventilators
- Nuclear medicine
- Laboratory equipment for *in-vitro* diagnosis
- Analysers
- Freezers
- Fertilization tests
- Other appliances for detecting, preventing, monitoring, treating, alleviating illness, injury or disability

9. Monitoring and control instruments

- Smoke detector
- Heating regulators
- Thermostats
- Measuring, weighing or adjusting appliances for household or as laboratory equipment
- Other monitoring and control instruments used in industrial installations (e.g. in control panels)

10. Automatic dispensers

- Automatic dispensers for hot drinks
- Automatic dispensers for hot or cold bottles or cans
- Automatic dispensers for solid products
- Automatic dispensers for money
- All appliances which deliver automatically all kind of products

Table 2.1: WEEE/E-waste definition and its variation in major EU countries

Country	Regulation	Identical Definitions to EU WEEE Directives	Variation
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	√	
Belgium	Decree of the Flemish Government of 14 July 2004, modifying the Decree of the Flemish Government of 5 December 2003. Decision of the Brussels Capital Government of 3 June 2004 modifying the decision of the Brussels 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 12 October 2004; federal Level.	√	
Cyprus	Administrative Act No 668 of 2004, published in Official Gazette No 3888, Annex III (I), on 30/07/2004.	√	
Czech Republik	Act No. 7/2005 Coll., amending Act 185/2001 Coll. (the general waste management law of the Czech Republic) published on 06/01/2005. Decree 352/2005 published on 15/09/2005.	√	
Denmark	Statutory order No. 591 of 9June 2006 and Statutory order no. 873 of 11th August 2006	√	
Estonia	Amendments to the Waste Act of 01/05/2004. Regulation No. 376 of the Government of the Republic of 24/12/2004 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 01/01/2005. Minister of Environment Regulation No. 9 of 09/02/2005 on Requirements for Treatment of Waste Electrical and Electronic Equipment, which entered into force on 20/02/2005. Regulation on the Central Register of Producers, which was adopted on 19/01/2006 and will enter into force after its publication in the Estonian State Gazette	√	

Table 2.1: WEEE/E-waste definition and its variation in major EU countries (contd.)

Country	Regulation	Identical Definitions to EU WEEE Directives	Variation
Finland	Act 452/2004 amending the Waste Act (1072/1993) adopted on 04/06/2004 and Government Decree on Electrical and Electronic Waste 852/2004 adopted on 09/09/2004.	√	The scope of products includes luminaries in households, which have been excluded from the scope of products in the WEEE Directive
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	√	
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	√	
Greece	Decree No 117/2004, Gazette No A82 on 05/03/2004	√	
Hungary	Government Decree 264/2004 on the take-back of WEEE of 23/09/2004, Ministerial Decree 15/2004 of 08/10/2004 Amendment 103/2004 to the Product Fee Act LVI.	√	
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 is waste within the meaning of article 1(a) of Council Directive 75/442/EEC of 15 July 1975	√	
Italy	Decree 25/07/2005 n.151	√	
Latvia	Law on Waste Management, as amended 19/02/2004, 02/12/2004 and 22/06/2005;Regulations of the Cabinet of Ministers No. 624 on Categories of EEE (adopted on 27/07/2004); Regulations of the Cabinet of Ministers No. 736 on Requirements for the Labelling of EEE and on Providing Information (adopted on 24/08/2004); Regulations of the Cabinet of Ministers No. 923 on the Management of WEEE (adopted on 09/11/2004);	√	
Lithuania	Amendment No. X-279 to the Law on Waste Management, adopted on 28/06/2005; Order of Minister of Environment No. D1-481 on Rules on Management of WEEE, adopted on 10/09/2004 Government Resolution No. 1252 on National Strategic Waste Management Plan, adopted on 05/10/2004.	√	

Table 2.1: WEEE/E-waste definition and its variation in major EU countries (contd.)

Luxembourg	Grand Duke's Decree 18th 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 16/03/2006, which entered into force on 01/04/2006	√	
Norway	relating to the recycling of Waste, 1 June 2004, Chapter 1	√	WEEE/ E-waste is defined as EE waste, where EE waste means scrap EE equipment. EE equipment is defined as EE equipment means products and components that depend on an electrical current or electromagnetic field in order to function correctly, as well as equipment for the generation, transfer, distribution and measurement of these currents and fields, including the components necessary for the cooling, heating, protection, etc., of the electrical or electronic components.
Poland	WEEE ACT 9/05 adopted in July 2005 with 3 orders and certain articles coming into force in July 2006	√	
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	√	
Slovakia	Act 733/2004, amending the Waste Act 223/2001, adopted on 02/12/2004. Ministerial Decree 208/2005 regarding the management of WEEE, adopted on 29/04/2005	√	

Table 2.1: WEEE/E-waste definition and its variation in major EU countries (contd.)

Country	Regulation	Identical Definitions to EU WEEE Directives	Variation
Slovenia	Decree 4871, 04/11/2004 with amendment published on 10/06/2005. A new "Decree on treatment of waste electrical and electronic equipment" (Official Journal of RS, No. 107/06) entered into force on 01/11/2006.This new decree in addition to transposition of EU directive also specified registration of producers and importers of WEEE.	√	
Spain	Royal Decree 208/2005	√	
Sweden	Swedish Code of Statutes 2005:209, "Ordinance on producer responsibility for electrical and electronic products" Published: 26 April 2005	√	
Switzerland	VREG:Ordinance on the return, the taking back and the disposal of electrical and electronic equipment (ORDEE)	√	The definition of WEEE/E-waste is identical to EU directives. However, equipment covered by this ordinance are electrically powered and fall under one of the following categories: - Entertainment electronics - Office, information, communication appliances - Household appliances - Fluorescents with light-bulbs - Fluorescents without light-bulbs - PCB containing fluorescents - Tools (Larger industrial tools excluded) - Sport/entertainment appliances and toys - Components of the aforementioned
United Kingdom	The Waste Electrical and Electronic Equipment Regulations 2006, to be enforced in 2007	√	

2.2.2 Basel Convention

Basel Convention covers all discarded / disposed materials that possess hazardous characteristics as well as all wastes considered hazardous on a national basis. Annex VIII, refers to E-waste, which is considered hazardous under Art. 1, para. 1(a) of the Convention:

A1010: Metal wastes and waste consisting of alloys of any of the following:

- Antimony
- Arsenic
- Beryllium
- Cadmium
- Lead
- Mercury
- Selenium
- Tellurium
- Thallium

A1020: Waste having as constituents or contaminants, excluding metal waste in massive form, any of the following:

- Antimony; antimony compounds
- Beryllium; beryllium compounds
- Cadmium; cadmium compounds
- Lead; lead compounds
- Selenium; selenium compounds
- Tellurium; tellurium compounds

A1030: Wastes having as constituents or contaminants any of the following:

- Arsenic; arsenic compounds
- Mercury; mercury compounds
- Thallium; thallium compounds

A1090: Ashes from the incineration of insulated copper wire
A1150: Precious metal ash from incineration of printed circuit boards not included on list B
A1170: Unsorted waste batteries excluding mixtures of only list B batteries. Waste batteries not specified on list B containing Annex I constituents to an extent to render them hazardous
A1180: Waste electrical and electronic assemblies or scrap containing components such as accumulators and other batteries included on list A, mercury-switches, glass from cathode-ray tubes and other activated glass and PCB-capacitors, or contaminated with Annex I constituents (e.g., cadmium, mercury, lead, polychlorinated biphenyl) to an extent that they possess any of the characteristics contained in Annex III. Annex IX, contains the mirror entry, B1110 Electrical and Electronic assemblies given below.

- Electronic assemblies consisting only of metals or alloys
- Waste electrical and electronic assemblies or scrap (including printed circuit boards) not containing components such as accumulators and other batteries included on List A, mercury-switches, glass from cathode-ray tubes and other activated glass and PCB-capacitors, or not contaminated with Annex 1.

A1190: Waste metal cables coated or insulated with plastics containing or contaminated with coal tar, PCB1, lead, cadmium, other organohalogen compounds or other Annex I constituents to an extent that they exhibit Annex III characteristics.
A2010: Glass waste from cathode-ray tubes and other activated glasses

2.3 Other Countries

Argentina
WEEE initiatives are under progress at a national level. The city of Buenos Aires has recently enacted the Regulation to the "Zero Waste Law" (the "Regulation") by publication of Decree 639. As per this law, WEEE/E-waste has been stated as "discarded electronic and electric equipment (EEE)" and "their wastes" and "end-of-life" batteries are classified as "special management" wastes and are subject to management plans.

Australia
There is no specific definition of E-waste/ WEEE in law. It is generally referred to as "end of Life" or "discarded" electrical or electronic product.

Brazil
Brazil has in place a national take-back program for tires, used lubricant oil, pesticide containers, and batteries. As of date, the battery take-back rules are the only federal scheme with a direct impact on the electronics industry. There is no specific definition of WEEE/E-waste but it is referred a as "end-of-life electronic products and components".

Canada
Canada's WEEE/ E-waste regulations are in the process of being developed at the provincial level. Alberta, British Columbia, Nova Scotia, Ontario and Saskatchewan have WEEE/ E-waste regulations in place. The WEEE/ E-waste definitions or statements as per these regulations are given below.

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

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

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

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

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

Computers include a computer monitor and computer peripheral. Computer peripheral means a keyboard, mouse or cable that attaches or is attached to a computer. Desktop printer means a printer that will print on paper not exceeding 8.5 inches in width but does not include a label printer.

"British Columbia Stewardship Plan for End-of-Life Electronics", a plan formulated in response to the above regulation defines WEEE/ E-waste as "End of Life" electronics where electronics means the electronic product category mentioned above.

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

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

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

Ontario: The Waste Electronic and Electrical Equipment (WEEE) regulation under the *Waste Diversion Act, 2002* (WDA) was filed on 14 December, 2004. The regulation designates seven categories of electronic and electrical equipment as waste, and targets more than 200 items that could be designated, including computers, telephones, broadcast equipment, televisions and CD players, children's toys, power tools, lawn mowers and navigational and medical instruments. Products targeted under Ontario WEEE legislation are given in table 2.2.

Table 2.2: Products Designated under Ontario Legislation

Priority Categories	List of WEEE Products	
Household Appliances	• Air conditioners • Clothes dryers • Clothes washers • Dishwashing machines	• Freezers • Refrigerators • Stove
IT Equipment	• CD-ROM and disk drives • Computers (desktop, handheld, laptop, notebook, notepad) • Monitors (CRT, LCD, plasma)	• PDAs • Keyboard, mouse, terminals • Printers, copiers, typewriters
Telecommunications equipment	• Fax/telephone answering machine • Modems	• Pagers • Telephones (cell, cordless, wire)
Audio-Visual Equipment	• Sound equipment • Cameras	• Televisions • Video player, projector, recorder

Saskatchewan: "The Waste Electronic Equipment Regulations" filed on 13 October 2005 under The Environmental Management and Protection Act, 2002, defines WEEE/ E-waste as "waste electronic equipment", which means electronic equipment that the consumer no longer wants. "Electronic Equipment" means any electronic equipment listed in Column 1 of Table 1 of these regulations. This table includes the following electronic equipment:

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

<u>Chile</u>

There is no specific regulation on WEEE/ E-waste but Chile's National Environment Commission (CONAMA) has circulated a draft of its national Strategy for Prevention and Minimization of Solid Wastes (the "Strategy"), where the concept of Extended Producer Responsibility (EPR) is key to the entire Strategy, calling for product stewardship and a focus on the life-cycle of the product. E-wastes figure prominently in the background study in the Annex of this strategy. There is no specific definition of WEEE/ E-waste and it is referred as E-waste.

China
There is no specific definition of WEEE/ E-waste in the regulatory system. E-waste is covered under 'Management Methods for Controlling Pollution Caused by Electronic Information Products Regulation" referred commonly as "China RoHS" promulgated on 28 February 2006, and effective from 1 March 2007. E-waste is covered under the term"control and reduce" pollution to the environment caused after disposal of Electronic Information Products.

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

In "The Law for Recycling of Specified Kinds of Home Appliances (Home Appliances Recycling Law)", E-waste is referred as"Used Consumer Electric Goods Discarded by Consumers". This law covers TVs, Refrigerators, Washing Machines and Air Conditioners.

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

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

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

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

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

Electronic equipment is also considered to be “Waste” if it has any of the following:

(a) A defect that materially affects its functionality. e.g. it does not power up; or

(b) Physical damage that impairs its functionality or safety e.g. the screen is broken or cracked; or

(c) A faulty hard disk drive, or RAM or video card; or

(d) Batteries containing lead, mercury or cadmium or liquid cathodes that are unable to be charged or to hold power; or

(e) Insufficient packaging to protect it from damage during transport.

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

Thailand
There is specific definition of WEEE/ E-waste in Thai regulations. However, WEEE/E-waste is referred as “End of Life” TV/PC/Cellphone.

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

2.4 Definition as per other Initiatives

Solving the E-waste Problem (StEP 2005)
E-waste refers to “The reverse supply chain which collects products no longer desired by a given consumer and refurbishes for other consumers, recycles, or otherwise processes waste.”

Organization for Economic Co-operation and Development (OECD 2001)
WEEE/ E-waste have been defined as “any appliance using an electric power supply that has reached its end-of-life.”

Basel Action network (Puckett and smith, 2002)
“E-waste encompasses a board and growing range of electronic devices ranging from large household devices such as refrigerators, air conditioners, cell phones, personal stereos, and consumer electronics to computers which have been discarded by their users.”

2.5 Analysis

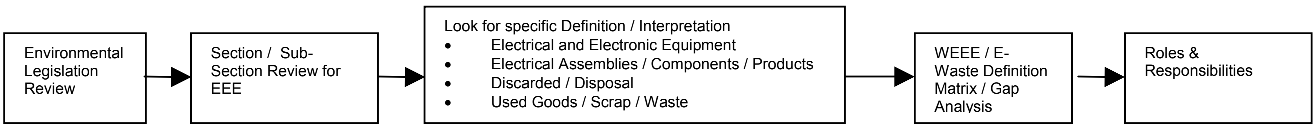
An analysis of above indicates that there are three major pointers to understanding the definition of WEEE/ E-waste. These are the definition of “electrical and electronic equipment” and the way ‘loss of utility” and “way of disposal” are defined. “Loss of Utility” indicates variation in consumer behavior, while “Way of Disposal” broadly reflects different national policies and regulations for considering waste as “pollutant” or a ‘resource”. The most widely accepted definition of WEEE/ E-waste is as per the EU directive. The major features of this definition include definition of “electrical and electronic equipment”, its classification into ten categories and its extent as per voltage rating of 1000 volts for alternating current and 1500 volts for direct current. Electrical and electronic equipment have been further classified into “components”, “sub-assemblies” and “consumables”. In other countries, the evolution of WEEE/ E-waste definition started with disposal of computers and televisions where CRT disposal was a major environmental concern. Therefore, computers and televisions were included into coverage of electronic equipment with amendments expected to include other items in future. In some definitions, the words “product” and ‘assemblies” or the phrase “’product and components” are mentioned in place of “equipment”. The words ‘discarded”, “end of life” and “dispose/ disposal” are invariably used in all definitions to describe ‘loss of utility” of electrical and electronic equipment. Similarly, words/ phrases “used goods”, “scrap” and “waste” are invariably used to describe “way of disposal”. These words are being used to harmonize WEEE/ E-waste with least disturbance to existing policies/regulations, where sometimes it is treated separately or under hazardous or solid waste management.

2.6 Guidance Notes

Objective: The major objective of guidance notes on WEEE/E-waste “Definition” is to assist policymakers/ 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 separately.

Guidance Procedure: Guidance procedure includes completion of following six steps as given below. The schematic representation of these steps is given in figure 2.1.

Figure 2.1: Guidance procedure for WEEE/E-waste definition



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 major pointers like definition of “electrical and electronic equipment”, ‘loss of utility” and “way of disposal”.

E-waste reference with respect to identified drivers

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

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

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

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

Step 6: Identify the gaps from the matrix and recommend tentative content, extent and coverage of WEEE/E-waste definition.

Chapter 3: Guidelines for Assessment of WEEE/ E-waste Market

3.0 Introduction

The worldwide WEEE/E-waste market is expected to increase from US$ 7.2 billion in 2004 to US$ 11 billion in 2009, with an annual growth rate of 8.8%. This growth rate is triggered by increasing "obsolescence rate" of electrical and electronic equipment, which fuels their "trading" for material recovery and hazardousness. Therefore, an assessment of WEEE/E-waste market structure requires an understanding of WEEE/ E-waste as a "tradable commodity" and its "mechanism of trading". WEEE/ E-waste as a "tradable commodity" can be described in terms of its composition and its potential for material recovery. "Mechanism of Trading" can be described starting from manufacturing, production, import, consumption, WEEE/E-waste generation, sources of generation, market controls like availability and implementation of regulations and facilities of material recovery. The impact of WEEE/ E-waste market can be described in terms of socio-economic characteristics like trade economics and related environmental, occupational health and safety issues. The following sections describe each of these items to facilitate an understanding of WEEE/ E-waste market followed by guidance notes to assess WEEE/E-waste market in a country/ geographical region/ city.

3.1 WEEE/ E-waste as a Tradable Commodity

WEEE/E-waste as a tradable commodity has been described in terms of components, which contain items of economic value. At first WEEE/ E-waste has been classified into 26 components forming "building blocks", which are easily "identifiable" and "removable", followed by description of elements for material recovery and their respective hazardousness. These commodities are refrigerator, washing machine representing "household's appliances", personal computer, monitor, laptop and cellular telephone representing "IT and Telecom equipment" and television representing "consumer equipments" as per Annex 1 B, EU Directive.

3.1.1 WEEE/ E-waste Components

Components, which are assembled to produce "Electrical and Electronic Equipment" are metal, motor/ compressor, cooling, plastic, insulation, glass, LCD, rubber, wiring/ electrical, concrete, transformer, magnetron, textile, circuit board, fluorescent lamp, incandescent lamp, heating element, thermostat, FR/ BFR-containing plastic, batteries, CFC/HCFC/HFC/HC, external electric cables, refractory ceramic fibers, radio active substances and electrolyte capacitors (over L/D 25 mm). Specific component, which are found in refrigerator, washing machine, personal computers, cellular telephones and TVs, are described in table 3.1. Observations from the analysis of table 3.1 are given below:

1. Radioactive substances, refractory ceramic fibers, electrolyte capacitors (over L/D 25 mm), textile and magnetron are not present in any item.
2. Plastic, circuit board and external electric cables are present in a majority of items. BFR/ FR containing plastic is present in refrigerator, laptop, television and cellular telephone.
3. Refrigerators are unique items because of presence of CFC/HCFC/HFC/HC, cooling, insulation, incandescent lamp and compressor.
4. Heating element is found in washing machine, while thermostat is found in both refrigerator and washing machine.
5. Fluorescent lamp is found only in laptop and cellular telephone.
6. Metal and motor are found in majority of items except refrigerator.
7. Transformer is not found in washing machine, refrigerator and cellular telephone.
8. CRT is found in personal computer and TV, while LCD is found in PC, TV and cellular telephone.
9. Batteries are found in PC, laptop and cellular telephone.

10. Concrete is found in washing machine.
11. Rubber is found in refrigerator and washing machine.
12. Wiring/ Electrical is found in all the items.

Large household appliance like refrigerator may consist of electric motor, a circuit board, a transformer, capacitor, thermal insulation, switches, wiring, plastic casing (containing flame retardants) etc. A typical washing machine may consist of the metal casing, concrete ballast, inner and outer drums, a motor, a pump, washing cycle controller unit, switches and other components. The latest trends in these appliances include phasing out of the use of ODS and improvement of energy efficiency. Old washing machines are likely to contain large capacitors, while in relatively new machines, variable speed motors are used, which are controlled from the circuit board. IT and telecom equipments sector is observing a trend of “micro miniaturization”, while CRTs in monitor are being replaced by LCD screens.

Table 3.1 indicates that the range of different items found in WEEE/ E-waste is diverse classifying it a waste of complex nature. However, it shows that WEEE/ E-waste from these items can be dismantled into relatively small number of common components for further treatment.

3.1.2 WEEE/ E-waste Composition, Recyclability and Hazardousness

Composition of WEEE/ E-waste components is very diverse and may contain more than 1000 different substances, which fall under “hazardous” and “non-hazardous” categories. Broadly, it consists of ferrous and non-ferrous metals, plastics, glass, wood and plywood, printed circuit boards, concrete and ceramics, rubber and other items. Iron and steel constitutes about 50% of the WEEE/ E-waste followed by plastics (21%), non - ferrous metals (13%) and other constituents. Non-ferrous metals consist of metals like copper, aluminium and precious metals ex. silver, gold, platinum, palladium etc. The presence of elements like lead, mercury, arsenic, cadmium, selenium, hexavalent chromium and flame retardants in WEEE/ E-waste and their components beyond threshold quantities as mentioned in Material Safety Data Sheet (MSDS) and regulations related to hazardous waste of different countries, classifies them as hazardous waste.

Since the recyclable potential of WEEE/ E-waste is specific for each appliance, the parts/materials found in WEEE/ E-waste have been divided broadly into following six categories.

- Iron and steel, used for casings and frames
- Non-ferrous metals, especially copper used in cables, aluminum and gold.
- Glass
- Plastic
- Electronic components
- Others (rubber, wood, ceramic etc.).

Table 3.1: Components in WEEE

	Metal	Motor \	Cooling	Plastic	Insulation	Glass	CRT	LCD	Rubber	Wiring / Electrical	Concrete	Transformer	Magnetron	Textile	Circuit Board	Fluorescent lamp (ineballast)	Incandescent lamp	Heating element	Thermostat	FR/ BFR – containing plastic	Batteries	CFC, HCFC, HFC, HC	External electric cables	Refractory ceramic fibers	Radioactive substances	Electrolyte Capacitors (over L/D 25mm)
Large Household Appliances																										
Refrigerator	√	√	√	√	√	√			√	√							√		√	√		√	√			
Washing Machine	√	√		√		√			√	√	√				√			√	√				√			○
IT & Telecom Equipment																										
Personal Computer (Base & Keyboard)	√	√		√						√		√			√						√		√			
Personal Computer (Monitor)				√			√	√							√								√			
Laptop		√		√				√		√		√			√	√				√	√		√			
Cellular Telephone	√			√		√		√							√	√				√	√					
Consumer Equipment																										
Television	√			√			√			√		√			√					√			√			

√ Present as a component
○ Possible presence as a component

Source: Prepared from WEEE & Hazardous Waste, A report produced for DEFRA, March 2004, AEA Technology

Table 3.2 provides an overview of the weight and composition of the four major electrical and electronic items, which constitute bulk quantities of WEEE/ E-waste in developing countries.

Table 3.2: Average weight and composition of selected electrical and electronic appliances

Appliances	Average weight (kg)	Iron (Fe) % weight	Non Fe-metal % weight	Glass % weight	Plastic % weight	Electronic components % weight	Others % weight
Refrigerators and freezers	48	64.4	6	1.4	13		15.1
Washing Machine	40 to 47	59.8	4.6	2.6	1.5		31.5
Personal computer	29.6	53.3	8.4	15	23.3	17.3	0.7
TV sets	36.2	5.3	5.4	62	22.9	0.9	3.5
Cellular Telephones	0.080 to 0.100	8	20	10.6	59.6		1.8

Source: (1) Data compiled from Waste from electrical and electronic equipment (WEEE) – quantities, dangerous substances and treatment methods, EEA Copenhagen, 2003; (2) QWERTY and Eco-Efficiency analysis on cellular phone treatment in Sweden. TU Delft, the Netherlands, 2004

Approximate recovery potential of items of economic value from PC, TV and refrigerators has been described in table 3.3, table 3.4 and table 3.5 respectively.

Table 3.3: Recoverable quantity of elements in a PC

Elements	Content (% of total weight)	Content (kg)	Recycling efficiency (%)	Recoverable weight of element (kg)
Plastics	23	6.25	20%	1.25069408
Lead	6	1.71	5%	0.08566368
Aluminum	14	3.85	80%	3.08389248
Germanium	0.0016	0.00	0%	0
Gallium	0.0013	0.00	0%	0
Iron	20	5.57	80%	4.45453312
Tin	1	0.27	70%	0.19188512
Copper	7	1.88	90%	1.69614576
Barium	0.0315	0.01	0%	0
Nickel	0.8503	0.23	0%	0
Zinc	2	0.60	60%	0.35979072
Tanialum	0.0157	0.00	0%	0
Indium	0.0016	0.00	60%	0.00026112
Vanadium	0.0002	0.00	0%	0
Terbium	0	0.00	0%	0
Beryllium	0.0157	0.00	0%	0
Gold	0.0016	0.00	99%	0.000430848
Europium	0.0002	0.00	0%	0
Tritium	0.0157	0.00	0%	0

Elements	Content (% of total weight)	Content (kg)	Recycling efficiency (%)	Recoverable weight of element (kg)
Ruthenium	0.0016	0.00	80%	0.00034816
Cobalt	0.0157	0.00	85%	0.00362984
Palladium	0.0003	0.00	95%	0.00007752
Manganese	0.0315	0.01	0%	0
Silver	0.0189	0.01	98%	0.005037984
Antinomy	0.0094	0.00	0%	0
Bismuth	0.0063	0.00	0%	0
Chromium	0.0063	0.00	0%	0
Cadmium	0.0094	0.00	0%	0
Selenium	0.0016	0.00	70%	0.00030464
Niobium	0.0002	0.00	0%	0
Yttrium	0.0002	0.00	0%	0
Rhodium	0	0.00	50%	0
Mercury	0.0022	0.00	0%	0
Arsenic	0.0013	0.00	0%	0
Silica	24.8803	6.77	0%	0

Source: Compiled from data presented in (1) Exporting Harm – High-Tech Trashing of Asia. Basel Action Network and Silicon Valley Toxics Coalition, US, 2005; (2) Management of Waste Electrical & Electronic Equipment, ACRR 2003

Table 3.4: Recoverable quantity of elements in a TV

Elements	%	ppm	Recoverable Weight of element (Kg)
Aluminium	1.2		0.4344
Copper	3.4		1.2308
Lead	0.2		0.0724
Zinc	0.3		0.1086
Nickel	0.038		0.013756
Iron	12		4.344
Plastic	26		9.412
Glass	53		19.186
Silver		20	0.000724
Gold		10	0.000362

Source: Compiled from data presented in " Mechanical Recycling of Consumer Electronic Scrap. Licentiate Thesis 2005:36, Luleå University of Technology, Luleå, Sweden",Cui.j, 2005

Table 3.5: Materials recovered from refrigerators

Material Type	%
CFCs	0.20
Oil	0.32
Ferrous Metals	46.61
Non-Ferrous Metals	4.97
Plastics	13.84
Compressors	23.80
Cables/Plugs	0.55
Spent PurFoam	7.60
Glass	0.81
Mixed Waste	1.30
Total	**100.00**
Materials disposed of to incinerator	0.20
Materials disposed of to landfill	8.90
Materials sent for Recycling	90.90

Source: Compiled from data presented in "Waste Electrical and Electronic Equipment (WEEE), Pilot Scheme Report, Producer Responsibility Unit Environment and Heritage Service, Government of U.K., 2005

It can be inferred from table 3.1 to table 3.5 that the presence of elements of economic value in WEEE/ E-waste and their recovery potential makes it a source of "secondary raw material" and a 'tradable commodity". However, the possible substances of concern, which may be released during recovery of secondary raw material, are given in table 3.6.

Table 3.6: Possible hazardous substances in WEEE/E-waste Components

Component	Possible Hazardous Content
Metal	
Motor \ Compressor	
Cooling	ODS
Plastic	Phthalate plasticize, BFR
Insulation	Insulation ODS in foam, asbestos, refractory ceramic fiber
Glass	
CRT	Lead, Antimony, Mercury, Phosphors
LCD	Mercury
Rubber	Phthalate plasticizer, BFR
Wiring / Electrical	Phthalate plasticizer, Lead, BFR
Concrete	
Transformer	
Circuit Board	Lead, Beryllium, Antimony, BFR
Fluorescent Lamp	Mercury, Phosphorus, Flame Retardants
Incandescent Lamp	
Heating Element	
Thermostat	Mercury
BFR – containing plastic	BFRs

Batteries	Lead, Lithium, Cadmium, Mercury
CFC, HCFC, HFC, HC	Ozone depleting substances
External electric cables	BFRs, plasticizers
Electrolyte Capacitors (over L/D 25mm)	Glycol, other unknown substances

Source: Compiled from WEEE & Hazardous Waste, A report produced for DEFRA, March 2004, AEA Technology

The substances within the above mentioned components, which cause most concern are the heavy metals such as lead, mercury, cadmium and chromium (VI), halogenated substances (e.g. CFCs), polychlorinated biphenyls, plastics and circuit boards that contain brominated flame retardants (BFRs). BFR can give rise to dioxins and furans during incineration. Other materials and substances that can be present are arsenic, asbestos, nickel and copper. These substances may act as a catalyst to increase the formation of dioxins during incineration. The description about hazardousness of these substances as per "level of concern" based on literature review is given in WEEE/ E-waste Manual II.

3.2 Mechanism of WEEE/ E-waste Trade

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

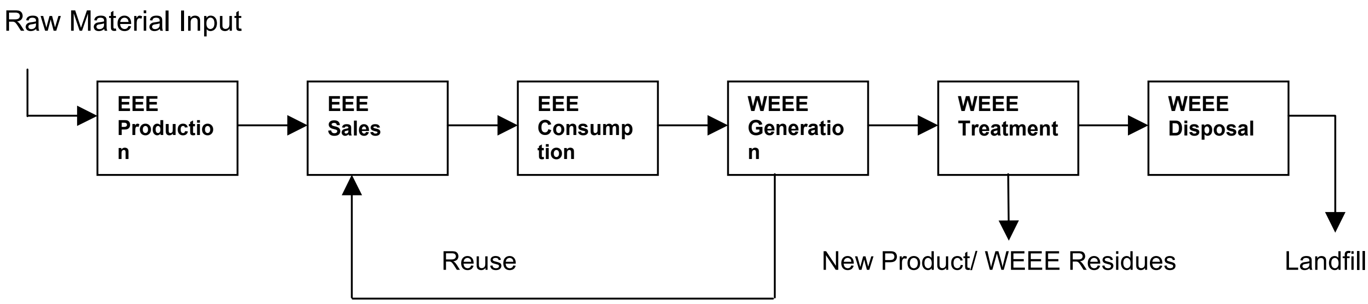
1. Material Flow
2. Life Cycle
3. Geographical Boundary

"Material Flow" along the "Life Cycle" of electrical and electronic equipment including the phase of obsolescence within a "Geographical Boundary" forms the basis of WEEE/ E-waste generation in cities/ countries. The following sections describe a conceptual understanding of material flow, along the life of electrical and electronic equipment, its conversion into an "obsolete" item followed by its transformation into new material.

3.2.1 Conceptual Understanding of WEEE/ E-waste Material Flow

Conceptual life cycle of electrical and electronic equipment (EEE) is shown in figure 3.1.

Figure 3.1: 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" ex. Input/ output balances in each phase forms the basis of quantification of WEEE/ E-waste in the life cycle analysis of electrical and electronic equipment. The WEEE/ E-waste material flow model developed by "European Topic Centre on Waste" has been described below and shown in Figure 3.2, to develop a conceptual understanding of WEEE/ material flow. The salient features of this model are given below.

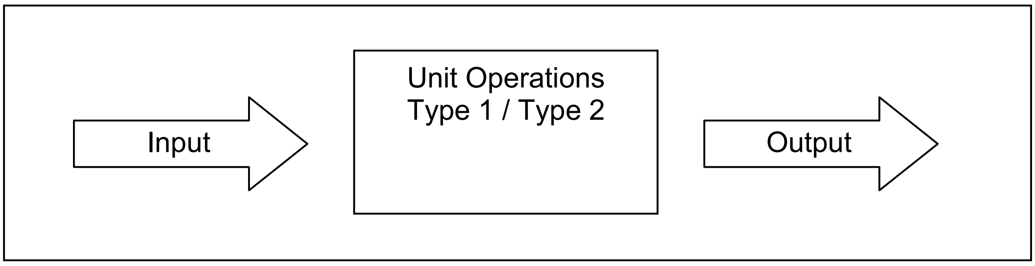
1. The model is based on the 'unit process approach', where a unit process represents processes or activities.

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

3. There are two different kinds of unit process. Type 1 receives material without any alteration, where there are no conversions. Therefore, input is equal to output ex. use and collection of electrical and electronic equipment. In Type 2, a conversion of materials takes place, thus creating new materials (products, waste, etc.) ex. 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 3.2: 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.

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

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

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

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

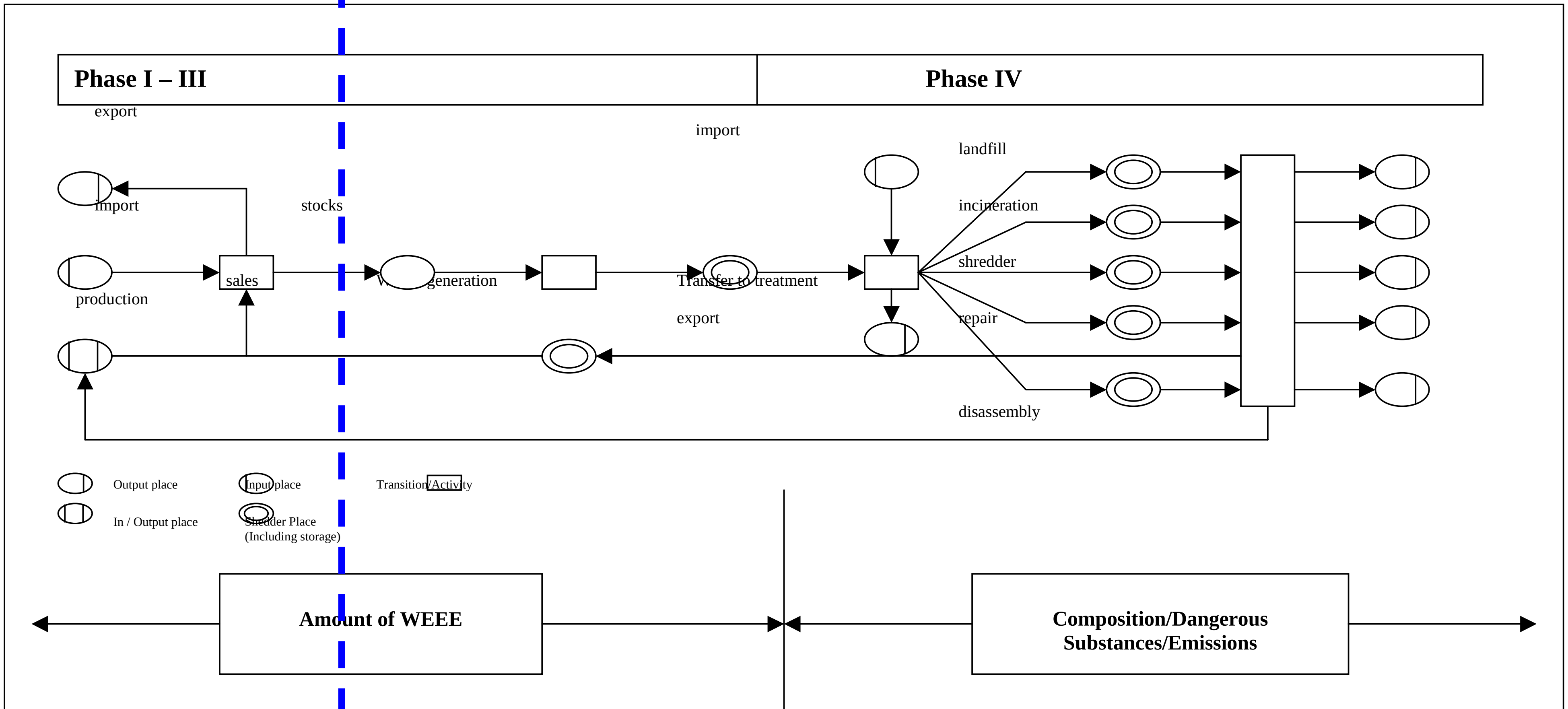
Phase III:
Unit Operations/ Processes/ Activities: Collection of end-of-life electrical and electronic equipment, including transfer to treatment/disposal sites, import/export.

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

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

The four phase model has been shown in figure 3.3 while the input/ output material balances explaining the mathematical relationship has been described in table 3.7. The dotted vertical line in the figure 3.3 indicates the stage of "obsolescence" in between the second and third phase of life cycle.

Figure 3.3: The 'Four-Phase-Model'



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

Table 3.7: Phase wise Life Cycle of Electrical and Electronic Equipment

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

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

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

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

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

3.2.2 Average Life of Electronic Goods

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

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

The number of years, a machine can be effectively used is called its active life. After active life, it can be refurbished or reused for certain time period. This time period constitutes passive life. Storage includes storage time before disposal and storage at repair shops before dismantling.

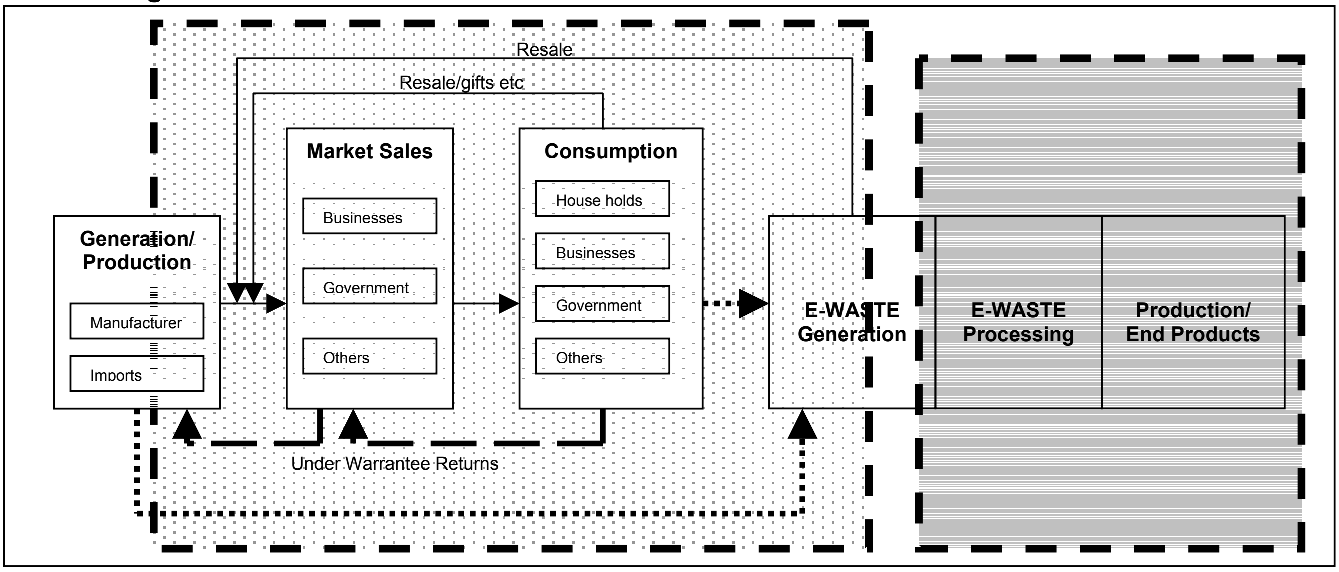
In developed countries, average life cycle of electrical and electronic equipment is generally equivalent to "Active Life", while in developing countries, it is a sum of active life, passive life and storage. Therefore, in developing countries, a second hand market exists for WEEE/ E-waste after its active life. All the three parameters vary in different geographical regions. Therefore, average life cycle/ obsolescence rate varies in each geographical region and leads to different WEEE/ E-waste inventory.

3.3 Source of E-waste Generation in Developing Countries

Sources of WEEE/ E-waste generation have been described in terms of E-waste trade value chain, description of major stakeholders and facilities for material recovery in developing countries.

The material flow analysis (MFA) described in the 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 organised/ formal sector. In developing countries, a part of the trade occurs in unorganised/ informal sector. An example of generic E-waste trade value chain based on MFA in a developing country is shown in figure 3.4. 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.

Figure 3.4: 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.

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[2] 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.

3.3.1 Major Stakeholders

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

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

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 on to relatives or friends. In the 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 requirement 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 unorganised/ informal sector. Immediately after securing WEEE/ E-waste from various sources, scrap dealers decide which item ought to be dismantled and which to be retained for resale. 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 and segregated leading to different WEEE/E-waste fractions.

Recyclers/ Smelters

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 unorganised/ informal sector to recover different metals.

3.3.2 Facilities for material recovery

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

1. First Level – Preliminary E-waste Generators.
2. Second Level – Secondary E-waste Generators.
3. Third Level – Tertiary E-waste Generators.

The input to "Preliminary E-waste Generator" comes from formal organized market 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 ex. dismantling of CRT, PCB, plastic and glass from E-waste. "Tertiary Level Stakeholders" are the major stakeholders between second and third level and are metal extractors, plastic extractors and electronic item extractors. They use extraction process, which are hazardous in nature. 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.

3.4 Availability and implementation of Regulations

Availability and implementation of regulations is an important aspect of WEEE/E-waste recycling. An example of the role of regulations related to E-waste management in a developed and a developing country context has been reported[3] in a comparative WEEE/ E-waste case study of Switzerland and India and shown in figure 3.5 and figure 3.6.

Switzerland is one of the most technologically advanced countries with one of the highest per capita (GDP per capita for 2003 was US$ 39,800) in the world. As per 2004 estimates, it has an installed base of 3.15 million computers with 99% household having refrigerators and 96% households having TVs. Switzerland ranks seventh on the 2005 Environmental Sustainability Index[4] and has a score of 1.39 for environmental governance. Switzerland is the first country in the world with established formal WEEE/ E-waste management system, where legislation on E-waste management was introduced in 1998. This legislation is based on principle of Extended Producer Responsibility (EPR). EPR has been defined as 'an environmental protection strategy to reach an environmental ojective of a decreased total impact from aproduct, by making the manufacturer of the product responsible for the entire life cycle of the product and especially for the take back, recycling and final disposal of the product".

India is one of the fastest growing economies in the world, where penetration of consumer durables is substantially lower than developed countries, but is experiencing exponential increase in demand since last decade. It ranks 101th on 2005 Environmental Sustainability Index and has a score of - 0.10 (66th Rank) for environmental governance. WEEE/ E-waste is partially covered under existing environmental regulations. The existing regulations do not stipulate the management and handling of WEEE/ E-waste generated within the country.

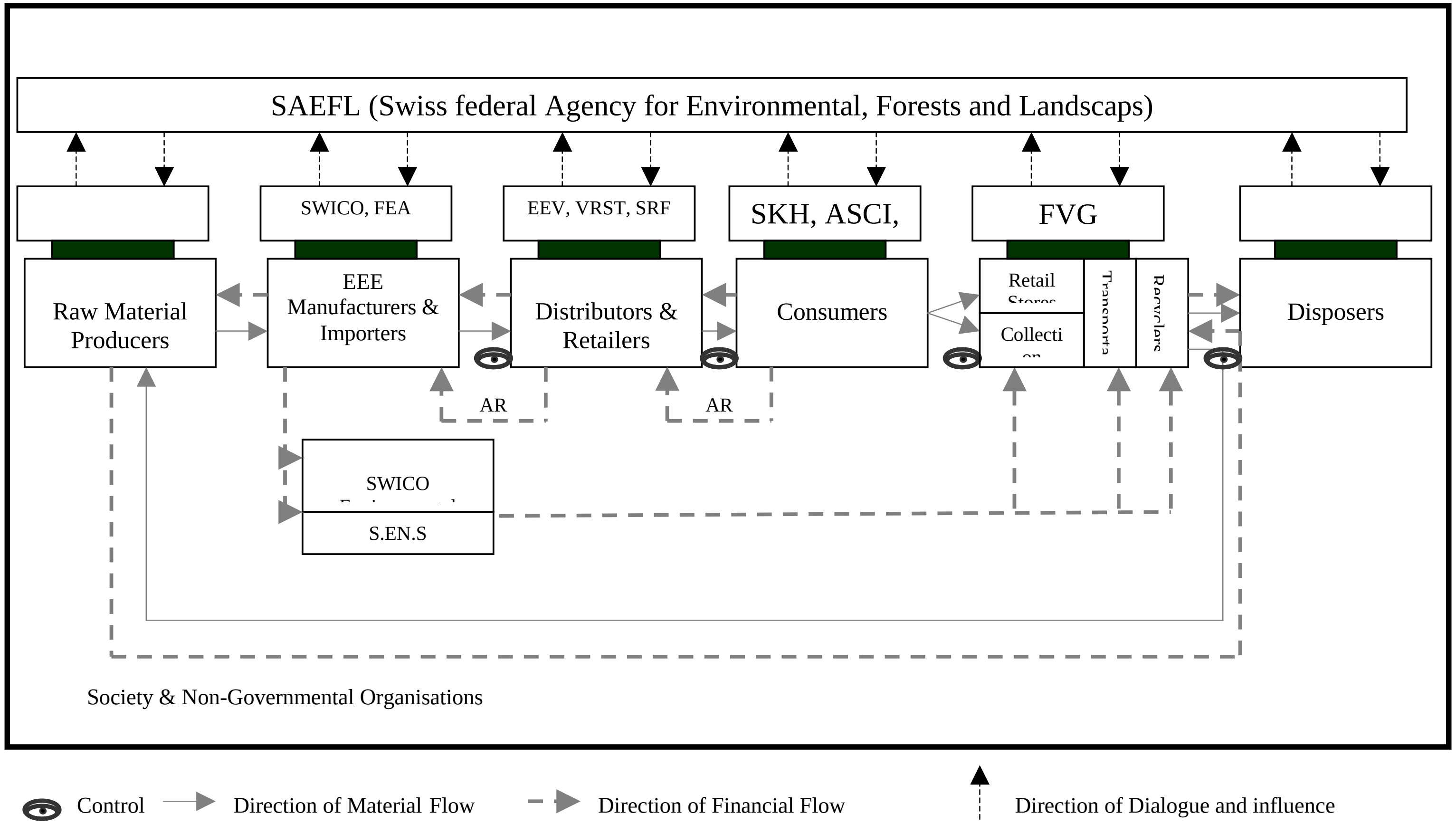
Figure 3.5 shows that in Switzerland there is control at every stage/ phase of WEEE/ E-waste trade, while figure 3.6 shows that in India, control is virtually non existent, though existing environmental regulations partially control WEEE/ E-waste trade till the stage of EEE manufacturers and importers. This difference gets reflected in low environmental

[3] 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.

[4] 2005 Environmental Sustainability Index, Yale Centre for Environmental Law and Policy, World Economic Forum (http://www.yale.edu/esi)

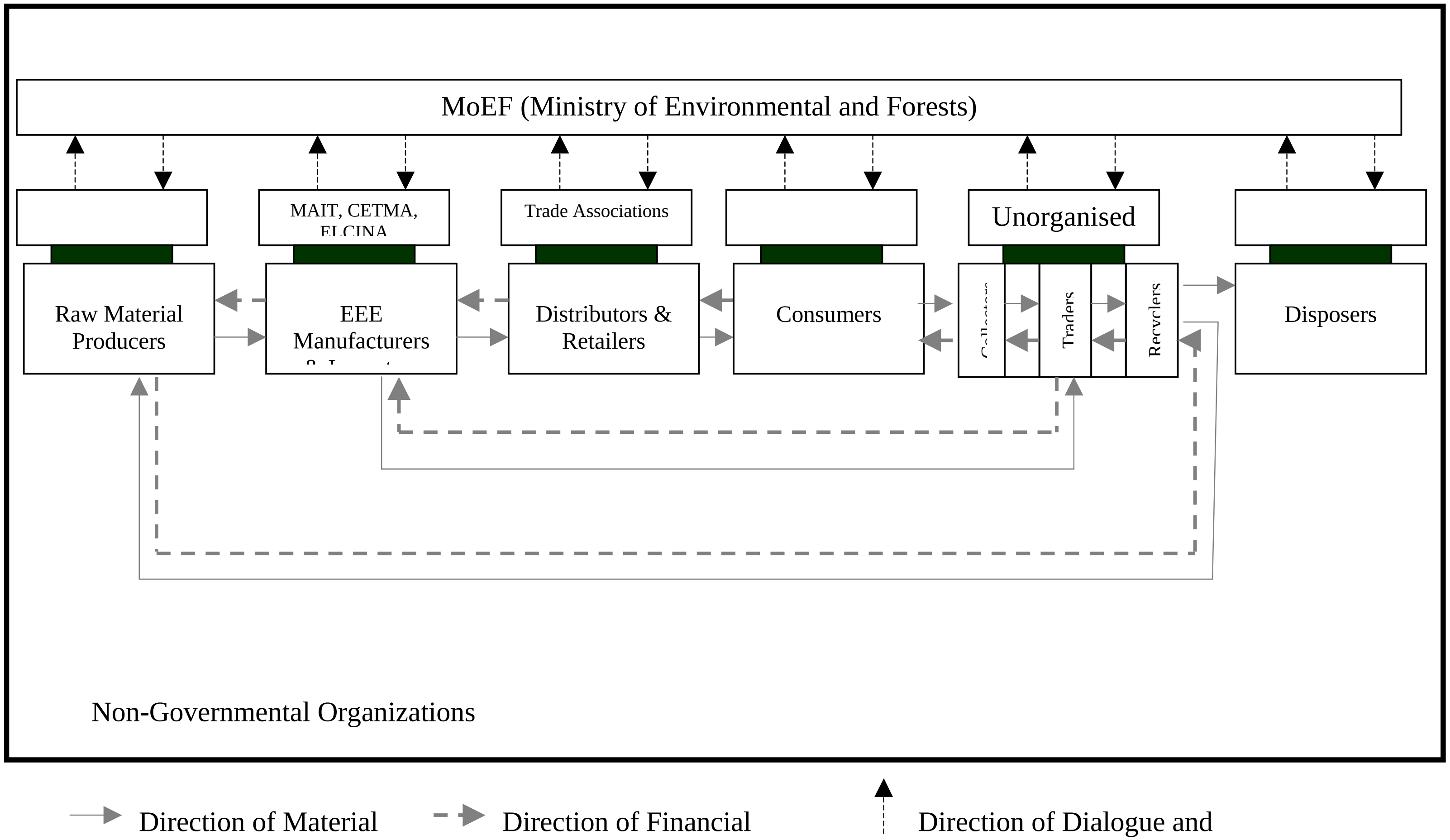
governance score. This also reflects that WEEE/ E-waste get recycled in unorganised/ informal sector, which is unregulated. WEEE/ E-waste treatment in unorganised/ informal sector leads to uncontrolled emissions into the environment, and at the same time gives a different socio-economic and occupational health and safety dimension to this trade.

Fig 3.5: Material and financial flows in Swiss 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

Fig 3.6: 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

3.5 Socio-Economic Characteristics

The socio-economic characteristics of WEEE/E-waste management have been described in terms of trade economics, employment potential, occupation hazards and environmental emissions.

Trade economics drives the WEEE/ E-waste trade value chain in all the countries. In majority of developed countries, "polluter pays principle" is applied to drive the WEEE/ E-waste trade economics, where "Recycling Fee" is charged to the consumer and passed on to the "Producer Responsibility Organisations" (PROs). PRO is a body of producers/ manufacturers, responsible for collection, transportation and recycling of WEEE/ E-waste based on the fundamental principles of "Extended Producers Responsibility" both legally and operationally. EPR is an environmental protection strategy, where the manufacturer of electrical and electronic products is responsible for the entire life cycle of the product especially for its take back, recycling and final disposal in order to reach an environmental objective of a decreased total impact on account of the product.

In developing countries, WEEE/ E-waste collection, transportation and recycling has become a profitable business in the unorganised/ informal sector, where the WEEE/E-waste trader/ collector/ recycler pay the consumer for the WEEE/E-waste item. Since low level of investment is required in unorganised/ informal sector, small investors find WEEE/E-waste trade as attractive business proposition, where the main incentive is financial benefit irrespective of environmental, occupational and health issues.

In Cambodia, a retailer in second hand TV sets and computers earn about $600 and US$ 720 per year and workers at WEEE/E-waste collection site earn about US$ 360 per year, while the average country income level is US$ 317 per year. In Thailand, a second hand PC in working condition can be procured for US$ 99 to US$ 150. In Sana'a, Yemen, second hand computers are stored and resold. If the computers are not in working condition, it is dismantled and their parts are sold to repair the existing computers. A typical printed circuit board has been reported to be sold at US$ 0.60. In Lagos, Nigeria, it has been reported that most of the WEEE/ E-waste is reused after repair, while the non reusable WEEE/ E-waste is either dumped or burnt at open dumpsites. PC/ laptop repair is a flourishing business, where repairs cost from US$ 40 to US$ 100. In Sri Lanka, metal scrap industry, which is involved in metal scrap recovery from different wastes including WEEE / E-waste, gives an income of approximately US$ 15 million per annum. There is a booming market of second hand electrical and electronic items in most of the developing countries all over the world. In India, the WEEE/ E-waste trade economics, considering twelve dismantling/ recycling processes for personal computers in Delhi and surrounding areas indicated that the annual WEEE/E-waste trade turnover during the year 2003 was US$ 5 million with approximately 20% operating profit. These processes include IC extraction from printed circuit board, surface heating of printed circuit board and extraction of components, regunning of CRT, dissembly of monitor and extraction of components, yoke core dismantling, dismantling of metallic transformer, extraction of rare earth core of transformer, extraction of rare earth static transformer, extraction of copper wire from cable, plastic shredding, gold extraction from pins and combs using chemical and metallurgical process and acid bath process for printed circuit board. Similarly, in Western India, the total annual WEEE/ E-waste trade turnover in Mumbai Metropolitan Region (MMR) and, Pune, Pimri Chinchwad region has been reported to be about US$ 8 million. In this region, average labour cost per day from this trade has been reported to be more than US$ 12, which is much higher than US$ 2.3, the states' per capita income a day. Therefore, the labour finds this trade to be lucrative. The total operating profit per day ranges from US$ 900 to US$10, which is about 5 to 7% of the total trade turnover. The lower profit margin in MMR, Pune, Pimpri Chinchwad region in comparison to Delhi can be attributed to absence of precious metal extraction and CRT regunning process in this region. This substantiates the fact that metal extraction is a profitable business, which drives the WEEE/ E-waste movement after first and second level dismantling in MMR, Pune Pimpri Chinchwad region to Delhi and its surrounding region.

A number of studies have reported negative impacts of unorganized/ informal WEEE/ E-waste recycling on surrounding environment and health of inhabitants. Some of the evidence in developing countries is given in figure 3.7.

Figure 3.7: Evidences of air, water and soil pollution and Occupational, Health and Safety Hazards

Examples of scientific evidence for Guiyu town and Guangdong region, major WEEE/E-waste recycling centres in China are given below.

<u>Air Pollution</u>: Air around e-waste recycling areas in Guiyu, contains the highest levels of dioxins ever recorded. It has been reported that the dioxin concentrations in the air around Guiyu were 12-18 times higher than those in Chendian, a town 9 kilometers (km) from Guiyu, and 37-133 times higher than those in Guangzhou, which is 450 km from the e-waste site. The results suggest that dioxin pollution from e-waste recycling is spreading to nearby areas. It has been found that exposure of adults to dioxins through

inhalation is 15-56 times higher than the World Health Organization recommended maximum of 1-4 pg TEQ/kg/day.

Water Pollution: Scientific evidence of excessive releases of metals from primitive e-waste processing in Lianjiang (As, Cr, Li, Mo, Sb and Se) and Nanyang (Ag, Be, Cd, Co, Cu, Ni, Pb and Zn) rivers within Guiyu than the reservoir outside of Guiyu has been reported. Pb isotopic composition of dissolved Pb confirmed that more than one non-indigenous Pb were present in Lianjiang and Nanyang River.

Soil Pollution: It has been reported that PAH concentrations in the Guiyu soil were affected by the primitive E-waste recycling activities.

Health and Safety: Exposure to polybrominated diphenyl ethers among workers at an electronic waste dismantling region in Guangdong, China has been reported based on the scientific study carried out on evaluation of the PBDE serum levels in residents from an electronic waste dismantling region, residents living within 50 km of the dismantling region, and a referent group with no occupational PBDE exposure. It has been found that the levels of all PBDE congeners in serum of residents from electronic waste dismantling region are significantly higher than those in the two other groups. The study confirms that BDE-209 is released to the environment and can bioaccumulate in the blood of electronic waste dismantling workers, and extensive occupational exposure to PBDEs leads to elevated concentrations of all PBDE congeners in serum.

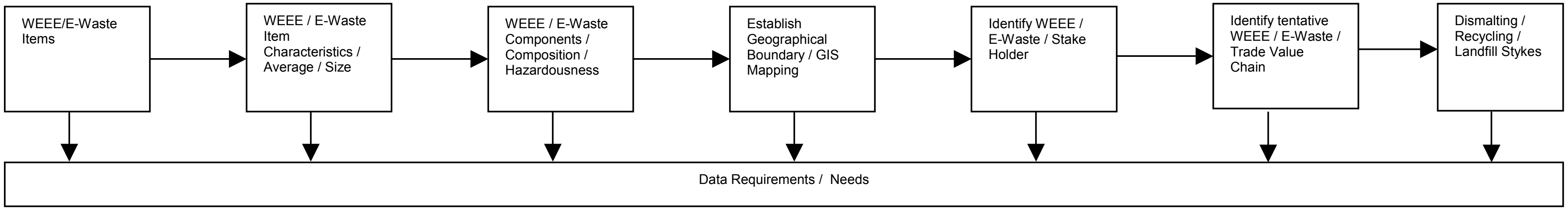
A qualitative comparative study of WEEE/ E-waste recycling facility of a developed country and a developing country shows that ‘employment potential” is very high in a developing country but at the cost of high “emissions of toxics” to the environment and “occupational hazards”. The scientific evidence mentioned above substantiates this comparison.

3.6 Guidance Notes

Objective: The major objective of guidance notes on WEEE/E-waste market is to assist in WEEE/E-waste market assessment, which includes identification, their classification and composition and planning for WEEE/ E-waste inventory assessment. This planning will include delimiting the area, establishment of WEEE/E-waste trade value chain, identification of stakeholders and their geographical location and mapping on a map.

Guidance Procedure: Guidance procedure includes completion of following eight steps. The schematic representation of these steps is given in figure 3.8.

Figure 3.8: Guidance procedure for defining WEEE/E-waste market assessment



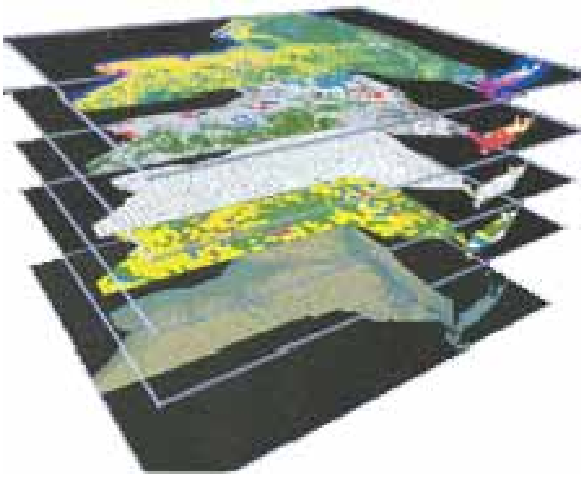
Step 1: Determine WEEE/ E-waste item of interest. This will assist in studying the item of interest ex. PCs, TVs, cellular telephones, and refrigerators etc. Determine the brands, local, national and international, which are available in the market for each item and the year of their introduction in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

Step 2: Determine average weight and size of local, national and international WEEE/ E-waste item from each brand ex. capacity of refrigerator (litres)/ washing machine, size of monitor/ TV/ cellular phone. The variation in size of each item should be documented under each brand. Average weight and size along with percentage composition should be estimated. This can be further confirmed while carrying out field survey for documenting dismantling operation as described in Chapter 5.

Step 3: Determine broad components out of the 26 components of WEEE/ E-waste items as per classification given in table 3.1. Table 3.1 provides a checklist of different components of WEEE/E-waste items, which can be used to interview dismantler of each item. Determine composition of WEEE/E-waste item from available source like industry association/ manufacturer. Determine technology of WEEE/ E-waste item e.g. ODS based refrigerator/ 486/586/ Pentium series of PCs and laptops/ CRT/ front loading/ top loading washing machines etc. Determine approximate quantity of recoverable elements from each item based on outputs of step 2 (Use table 3.2 to table 3.5 for guidance). Determine possible hazardous substance in WEEE/E-waste item (refer table 3.6 as a guide)

Step 4: Establish geographical boundary/ system boundary of study area (city/ region). Procure maps of the area and prepare base map of the area with physical features marked on it. If the detailed map is not available easily then procure city map and fix up the municipal boundaries. Alternately, maps of the study area can be prepared based on standard map search engines available on the internet. The base map will be used for generation of different thematic layers as shown in figure 3.9. This mapping will give an insight into the possible sources of WEEE/E-waste and assist in carrying out the primary survey.

Figure 3.9: Geographical mapping of different attributes



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

Step 6: Prepare a tentative WEEE/ E-waste trade value chain as per conceptual life cycle shown in figure 3.1, four phase model given in figure 3.3 and E-waste trade value chain given in figure 3.4. These figures should be customized as per preliminary survey, which will be confirmed and established during field survey as described in Chapter 5.

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

Step 8: Identify data needs from these stakeholders based on identified stakeholders in step 5 and trade value chain identified in step 6. An example of data needs is given below.

- Production and import data for electrical and electronic equipment
- Sales and export data for electrical and electronic equipment
- Local WEEE/ E-waste generation data
- Imported WEEE/ E-waste data
- WEEE/ E-waste data transferred for disposal/ treatment/ reuse.

Chapter 4: Guidelines for Selection of Methodology for WEEE/ E-waste Inventory

4.0 Introduction

WEEE/E-waste inventory in a particular country/ region/ city forms the basis of any disposal/ treatment strategy. Globally, five methods have been used to determine WEEE/E-waste inventory. Each of these methods use “Material Flow” model as described in Chapter 3. This chapter describes each of these methods, their application, constraints, advantages, data requirements and sources of data. Further, constraints in their application in developing countries have been enumerated followed by guidance notes.

4.1 The Time Step Method

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

Mathematically, the time step method is given below.

WEEE generation (t) =

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

with $t_1 < t$

$\text{Stock}_{private}$ = Number of households *saturation level of households / 100

= Population / average size of household *saturation level of households / 100

$\text{Stock}_{industry}$ = number of work places *saturation level in the industry / 100

= number of employees / number of users per appliance

<u>Requirements</u>

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

<u>Constraints</u>

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

<u>Advantages</u>

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

4.2 The Market Supply Method

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

Mathematically, the market supply method is given below

WEEE generation (t) = sales ($t - d_N$) + reuse ($t - d_S$)

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

Requirements

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

Constraints

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

Advantages

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

4.3 The Carnegie Mellon Method

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

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

Constraints

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

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

Advantages

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

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

4.4 Approximate Formula

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

4.4.1 Approximation 1

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

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

Stock $_{private}$ = Number of households *saturation level of the households / 100

= Population / average size of household *saturation level of the households / 100

Stock $_{industry}$ = number of work places *saturation level in the industry / 100

= number of employees/number of users per appliance *saturation level in the industry / 100

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

Constraints

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

Advantages

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

4.4.2 Approximation 2

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

Mathematically, it can be represented as given below.

WEEE generation (t) = sales (t)

Constraints

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

Advantages

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

4.5 Data Requirements and Data Sources

Data requirements for the application of above mentioned methods are given in table 4.1. The extent of data required depends on the extent of geographical boundary, which could be national, regional or city boundary.

Table 4.1: Data Requirements for WEEE/E-waste Inventory Assessment

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

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

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

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

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

An example of data source for each item used in mathematical formulation of all the five methodologies is given in table 4.2

Table 4.2: Tentative Sources of Data

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

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

Availability of data

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

Reliability of data

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

Amount and Range of data

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

Completeness of data

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

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

4.6 Constraints/ limitations for developing WEEE / E-waste inventory in developing countries

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

<u>Sales Data (Export/ Import and Manufacturing/ Production Data)</u>

1. Since export and import regulations differ in each developing country, export and import data/ statistics related to electrical and electronic equipment is not readily available. This makes the task of calculation of electrical and electronic equipment sales very difficult, even when domestic manufacture/ production data is easily available.

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

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

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

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

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

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

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

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

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

Analysis of above constraints shows that the data for electrical and electronic equipment in a developing country available from secondary sources is limited, scattered and reliable to a limited extent. Therefore, WEEE/E-waste inventory assessment in a developing country requires collection of available secondary data followed by its strengthening by national/ regional/ local assumptions and trend analysis. The secondary data is further confirmed through primary data collection and analysis as described in Chapter 5 and 6.

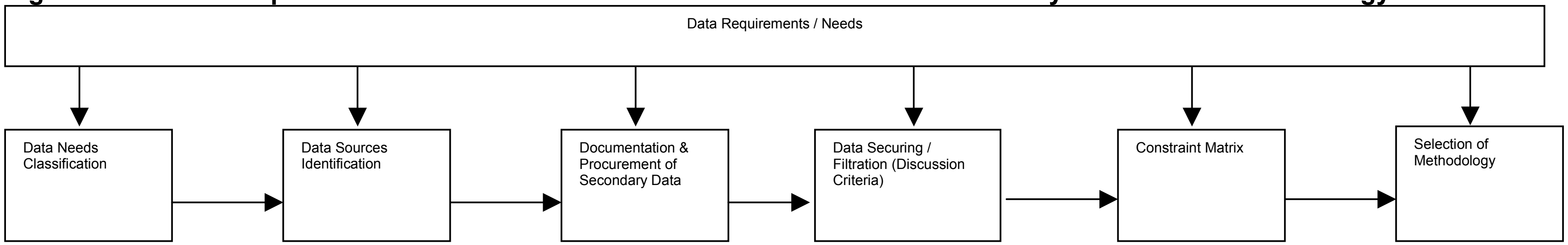
4.7 Guidance Notes

Objective: The major objective of guidance notes is to assess the data needs/ data requirements and the selection of suitable WEEE/E-waste inventory assessment methodology.

Guidance Procedure: Guidance procedure includes completion of following five steps as given below. The schematic representation of these steps is given in figure 4.1.

Step 1: Identify data requirements by fine tuning outputs from step 8 of Chapter 3. This is carried out by classifying data needs under the heads of saturation level, households, calculated sales, stock data, average life, storage data, reuse, recycle and landfill for each electronic item ex. PC, TV, refrigerator, cellular phone, etc. as given in Table 4.1.

Figure 4.1: Guidance procedure for assessment selection of WEEE/E-waste inventory assessment methodology



Step 2: Identify tentative sources of data for each electrical and electronic item as described in table 4.2. Refer information guide in appendix 1 for preparing preliminary or detailed interview guide/ checklist/ questionnaires for data collection for each time.

Step 3: Document secondary sources of data for each electrical and electronic equipment and visit the respective agency to procure data i.e. published/ unpublished/ historical.

Step 4: Check the availability, reliability, amount and range and completeness of data against following decision criteria.

Availability of data

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

Reliability of data

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

Amount and Range of data

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

Completeness of data

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

Step 5: Prepare the constraint matrix as given in table 4.3 by mapping outputs of steps 4 and step 5 as shown below. Write **Yes** or **No** against each item for data and compare it with output from table 4.1 to select the methodology for WEEE/E-waste assessment. Decide the most suitable and applicable methodology for WEEE/E-waste inventory assessment by checking the number of 'Yes" against each methodology and comparing it with √ for that methodology in table 4.1.

Table 4.3: Constraint Matrix

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

Chapter 5: Guidelines for WEEE/E-waste Inventory Assessment

5.0 Introduction

Application of any WEEE/E-waste inventory assessment methodology in a developing country context requires its customization and strengthening in order to arrive at reasonable WEEE/ E-waste inventory estimates. The following sections describe the conceptual approach and methodology to customize "market supply method", tools and techniques to carry out the assessment followed by guidance notes to assist WEEE/E-waste investigation team to arrive at existing as also predict future WEEE/E-waste inventory.

5.1 Conceptual Approach & Methodology

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

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

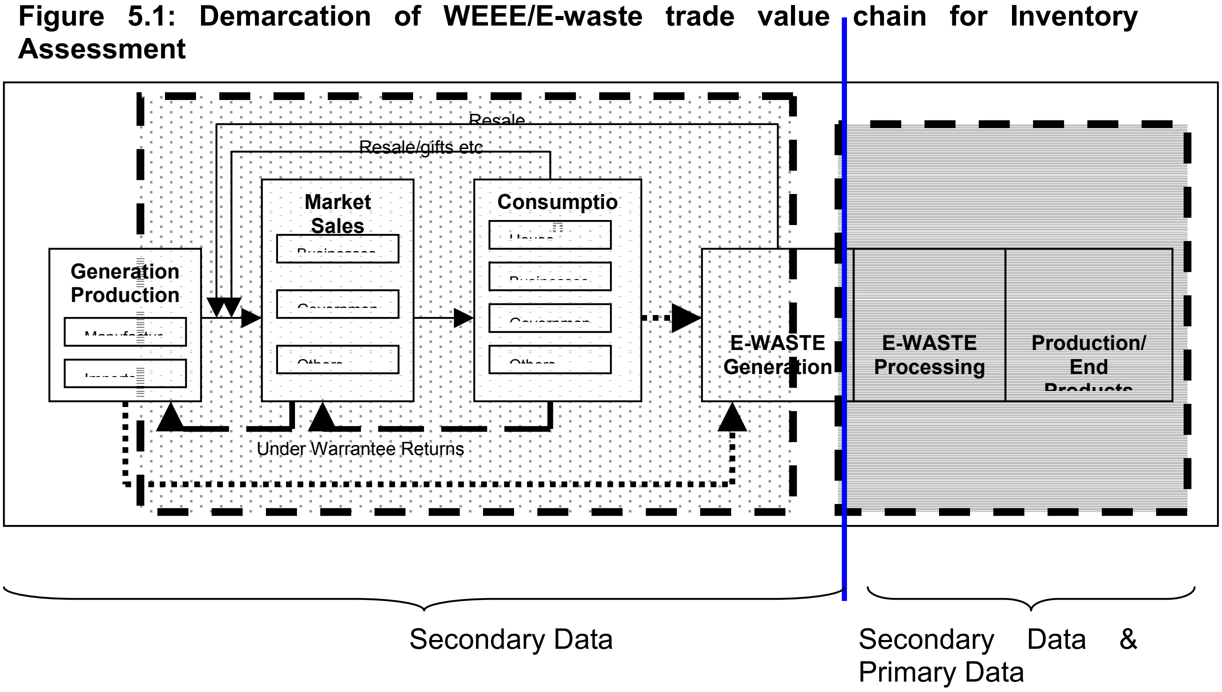
The above constraints are overcome by demarcating the WEEE/ E-waste trade value chain into two parts at the point of start up of dismantling process. WEEE/E-waste from domestic sources, irrespective of delays due to storage and reuse and imported WEEE/E-waste irrespective of its point of entry will pass through dismantling process. Therefore, the point of entry before dismantling step in WEEE/E-waste trade value chain has been taken to demarcate the chain for application of two different approaches.This is described below and shown in figure 5.1

Approach and methodology upstream of demarcation

1. At first WEEE/E-waste inventory is assessed using sales data based on saturation level/ penetration rate and obsolescence rate/ average life data given by market research agencies.
2. Obsolescence rate/ average lifecycle is further checked by using data on depreciation and book value/economic value of the EEE from insurance agencies. All fixed assets such as electronic/electrical equipments; building, furniture etc. gradually diminish in value as they get older and become worn out by constant use in business. "Depreciation" is the term used to describe this decrease in book value of an asset. There are a number of methods of calculating depreciation. However, the most common method which is also approved by tax authorities is the diminishing balance method. Here each year's depreciation is calculated on the book value (i.e., depreciated value) of the asset at the beginning of the year rather than original cost. Note that as the book value decreases every year, the amount of depreciation also decreases every year. Therefore, a range of obsolescence rate/ average life cycle of an electrical and electronic item can be fixed with an "upper limit" and "lower limit".

3. Scenario analysis of WEEE/ E-waste inventory is carried out using secondary data and obsolescence rate using "upper limit" and "lower limit".

Figure 5.1: Demarcation of WEEE/E-waste trade value chain for Inventory Assessment



Approach and methodology downstream of demarcation

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

1. Confirm obsolescence rate from data of primary survey using "tracer technique". Tracer has been defined as a component, which forms an integral part of WEEE/E-waste item, whose movement takes the investigation team through the WEEE/ E-waste trade value chain starting from dismantling, recycling till disposal e.g. CRT in TV/ PC/ Monitor, compressor in refrigerator and LCD in cellular phone as shown in figure 5.2.

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

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

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

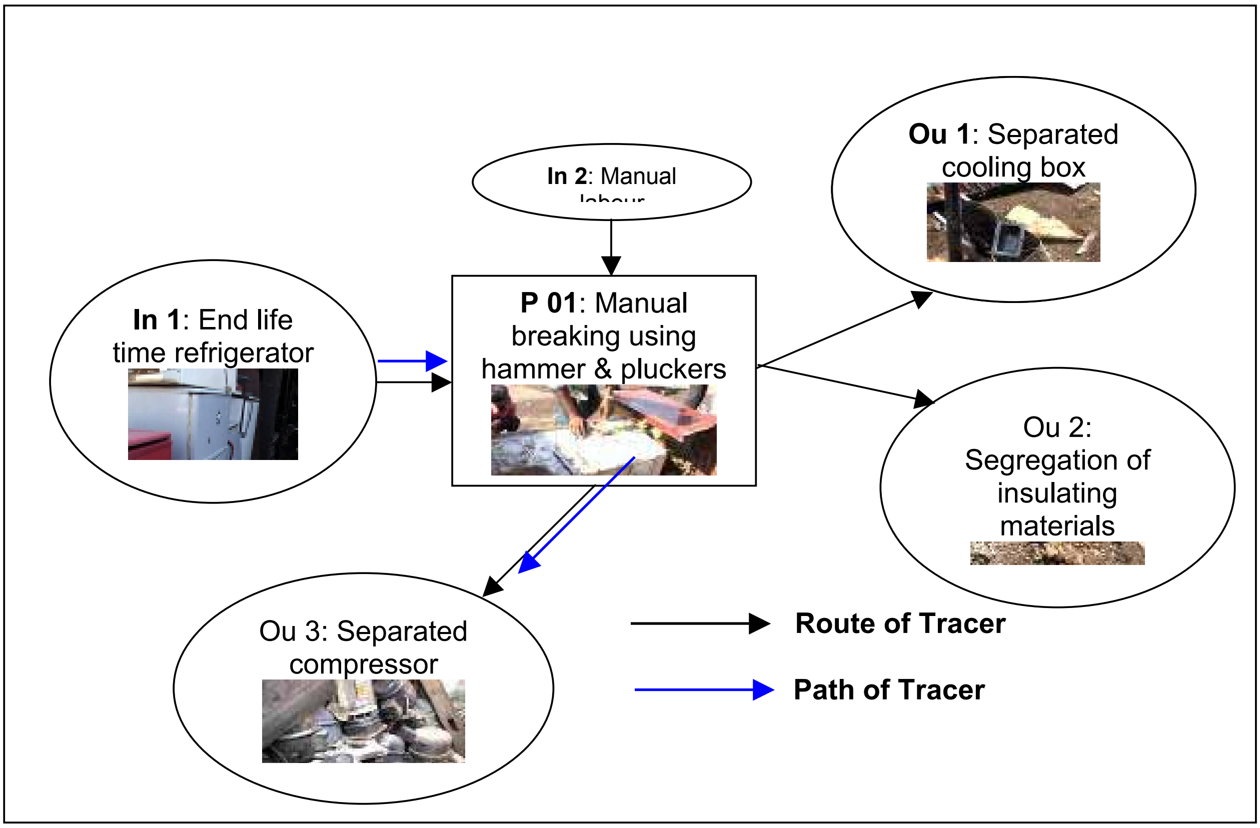
5. Carry out photo documentation and geographical setting of each step. Also find out from primary data, the number of dismantlers involved at the last stage of dismantling.

6. Estimate the quantity of material dismantled at each step using the last step of WEEE/E-waste dismantling and multiplying it with number of stakeholders.

Back calculate to check the best fit scenario of WEEE/ E-waste inventory obtained from “upper limit” and “lower limit” scenarios.

7. Estimate the quantity of electronic waste for a particular year based on market projections and obsolescence rate.

Figure 5.2: Dismantling of Refrigerator and Segregation of Compressor and Cooling Box



5.2 Tools for Data Acquisition

A number of tools can be used for data acquisition for upstream and downstream of demarcation shown in figure 5.1 are given below.

- Secondary data review
- Communications
- Tools for exploring time (Temporal Dimension).
- Tools for exporting space (spatial dimension).
- Tools for exploring socio-economic issues (social dimensions).

5.2.1 Secondary data review

Relevant maps, literature, statistics and report available are used in the preparation phase as discussed in Chapter 4. The agencies, which need to be consulted for data collection are defined and reference guide given in appendix 1.

5.2.2 Communication

The tools, which can be used under this head include

Interviews: Structured/ semi structured interviews with individuals, key-persons, and establishment owner in case of Informal sector and structured for organized sector.

Discussion: with focus groups/ communities like WEEE/E-waste workers/collectors/ recyclers/dismantlers/ experts/ officials.

Workshops and meetings: To share and verify data and information collected.

Models/Charts/Photographs: They are used for visualizing results and activities and for linking "cause and effect" and "quantity flows".

5.3 Categorize of key stakeholders

The key stakeholders described in Chapter 3 as per tentative WEEE/ E-waste trade value chain are classified into two categories formal and informal/ unorganized as described below.

5.3.1 Formal/ Organised Sector

The formal/ organized sector (retailers/ repairs shop/ service providers etc.) was covered using a questionnaire as per the format given below.

Questionnaire for formal sector

Dated	
Survey Type	Vendor/Manufacturer/AMC/Repair/Old System Shop
Area	
Name of Shop	
Number of persons	
Area of establishment	
Repair facility	
Waste Generation	
Waste Quantity	In kgs
Who purchase the waste	
Type of Business	
Source of Material supply	
Major Findings:	
Next Steps	

An example of usage of format is given in appendix 2. The analysis of the outputs from the format in appendix 2 shows that it leads the surveyor from one stakeholder to another stakeholder along the material flow.

5.3.2 Informal/ Unorganised Sector

The informal sector can be covered using semi-structured interviews, focused and community/ dismantler's/ recycler's/ stake holder's discussions. This can be carried out through preparation of interview guide, one "to" one direct contact and telephone. The purpose, principle and application of these tools are given below.

Semi-structured interviews

Purpose	Learn from the interviewed people about their situation
Principle	A semi-structured interview does not involve a formal questionnaire, but instead makes use of a flexible interview guide (prepared from appendix 1) to help ensure that the interviews stay focused on the relevant issues, while remaining conversational enough to allow participants to introduce and discuss issues that they deem relevant.
Application	Interviewed people comprised of repair-shop keeper, scrap-dealer, dissembler, recycler etc.

Tools for exploring time

Time line and daily activity chart method was used for exploring temporal dimension to WEEE / E--waste. This included the historical record of installed capacity of WEEE / E-waste items, number of items added each year into the installed capacity, estimation of obsolescence rate and its changing pattern over the years. In other words, trend analysis is used over time.

Tools for exploring space and social issues

Spatial and social issues were explored using transect, tracer and hazardous process walk. The purpose, principle and application of these three walks are described below.

Transect walk

Purpose	Get an idea about applied practices, geographical patterns, system understanding, etc.
Principle	During a transect walk, a kind of exploratory walk is undertaken by the team along a pre-defined path with the stakeholders to observe and record in minute detail the differences of a particular area.
Application	Different transect walks through recycling areas can be defined by the investigation team. During the transect walk, the team observes, interviews people and describe in detail what happened along the path. This type of walk can be useful for data collection as described in step 10 and step 11 of Chapter 2.

Tracer walk

Purpose	Get an idea about the routes of different tracer items
Principle	Tracer items of the object of investigation are defined and followed along there life cycle. During this walk, the team observes and describes in detail what is observed on the path of movement of tracer along the material flow in WEEE/E-waste trade value chain. This type of walk is useful for data collection as described in this chapter.
Application	Tracer items, such as plastic casings, keyboards, CRT's, are defined by the investigation team. During the tracer walk, the team follow the defined tracers and observe in detail what happen in different places along the route.

Hazardous processes walk

Purpose	Get an idea about the hazards caused by the investigated object on the environment and on human beings
Principle	Places, where potentially hazardous processes take place are identified and visited. Stakeholders are interviewed using semi-structured interviews
Application	Socio-economic mapping

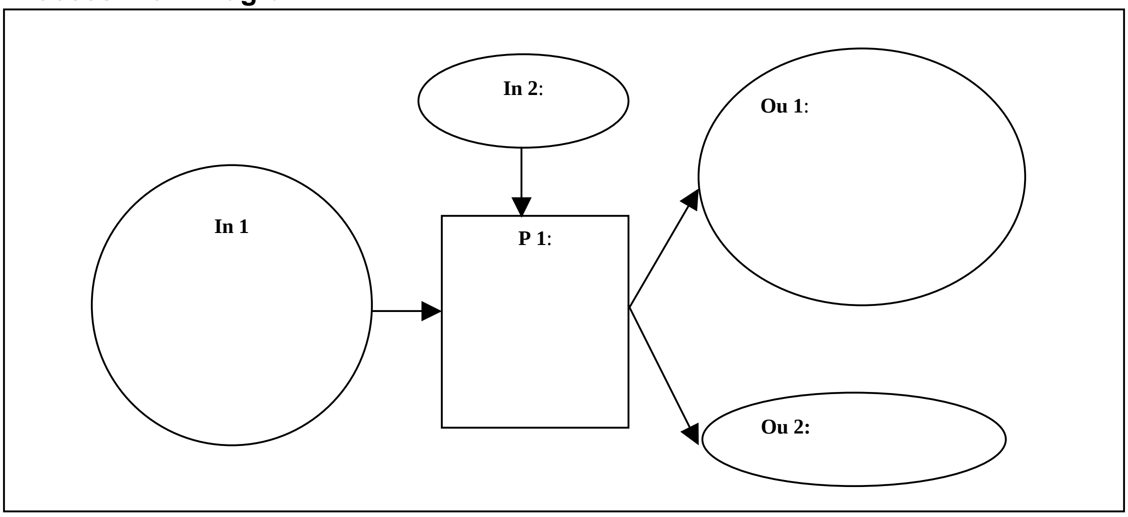
These tools have been tested in WEEE/ E-waste inventory assessment in two geographically different regions in India, where material flow approach is followed along the WEEE/ E-waste trade value chain.

Questionnaire for informal sector

1. Site Description
2. Date:
3. Person Responsible for Survey
4. Coordinate (GPS) Lat/ Long
5. Type of Processed Material
6. Quantity of Processed Material
7. Number of Employees/
8. Working Hours
9. Material Flow Analysis

Carry out the material flow analysis by documenting the process flow diagram and input/ output analysis.

Process Flow Diagram



Process

Numbers	Name	GPS Lat/ Long	**Description** Detailed Description of the Technologies applied; thermal recovery, landfill, environment, open burning, transport (Vehicle Type, Distance) 1. Health and Safety Measures 2. Labour intensity (Persons*hours/Processed Material) 3. Average Wages of employees, taxes paid to public authorities, cost of equipments, etc	Photo Documentation
P 1				

Input

Numbers	Material/Energy	Price $/Unit	**Description** Supplier, Specification	Photo Documentation
In 1				
In 2				

Output

Numbers	Material/Energy	Price $/Unit	**Description** Costumer, Specification	Photo Documentation
Ou 1				
Ou 2				

An example of the use of the format is given in appendix 3. The analysis of the outputs from the format in appendix 3 shows that it leads the surveyor from one stakeholder to another stakeholder along the tracer in the material flow.

5.4 Guidance Notes

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

Guidance Procedure: Guidance procedure for carrying out WEEE/ E-waste inventory assessment includes completion of following activities with an example summarised in case studies 1 and 2. The schematic representation of these steps is given in figure 5.3.

Activity 1 : Establishment of the study area and its geographical limit

Activity 2 : Identification of WEEE/ E-waste and establishment of WEEE/ E-waste trade value chain (Identify the WEE/ E-waste streams, Identify the WEEE/ E-waste processes, Identify a tracer item and

		Follow the tracer item through the process in the WEEE/ E-waste stream)
Activity 3	:	Estimate WEEE/ E-waste quantities and obsolescence rate / average lifespan through secondary data
Activity 4	:	Verification of obsolescence rate/ average lifespan through primary data
Activity 5	:	Identify the products, by products and waste products
Activity 6	:	Establish WEEE/ E-waste trade economics
Activity 7	:	Identify and assess the impacts

Activity 1: Establishment of the study area and its geographical limit

This activity will include the establishment of geographical limits of study area i.e. geographically defining the area. This will include assessment of landuse maps of the study area, fixing of rural and urban boundaries and mapping of tentative locations of stakeholders as described in step 4 to step 5, guidance notes of Chapter 3. The investigation team will geographically verify the tentative locations where generation, stockpiling, collection, handling and brokering, processing and production of other items from WEEE/ E-waste are taking place by using transect walk.

Activity 2: Identification of WEEE/ E-waste and establishment of WEEE/ E-waste trade value chain

This activity will include identification of specific WEEE/ E-waste item and its tracer (CRT/ Compressor/ LCD screen/ any other) followed by tracking of tracer's geographical movement within the identified geographical limits of the area to its final end of life, e.g. places where items are unloaded, traded, transported, dismantled, recycled, reused, repaired and disposed, using output of activity 1. The following steps are involved in field investigations.

Step1: Identify the WEE/ E-waste streams of specific WEEE/E-waste item

Step 2: Identify the WEEE/ E-waste processes i.e. unloaded, treated, transported, dismantled, recycled, reused, repaired, and disposed.

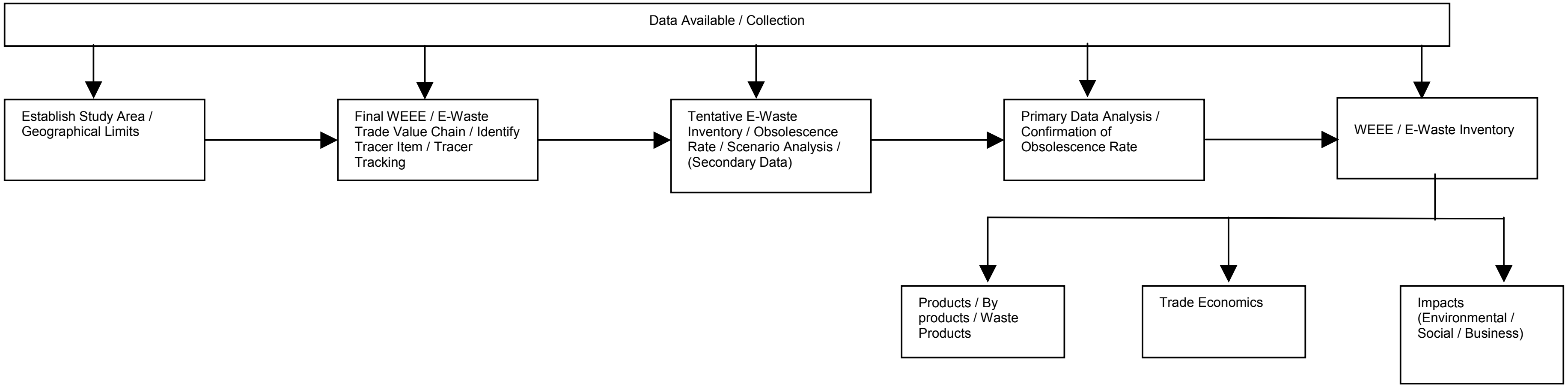
Step 3: Follow the WEEE/E-waste tracer through the process in the WEEE/ E-waste stream by using tracer/ hazardous process walk.

The different stakeholders as identified in step 4 and step 5, guidance notes of Chapter 3 will form key links in the material flow chain to facilitate input/ output analysis. A typical, WEEE/ E-waste trade chain will be established in a geographical context after verification of the tentative trade value chain (example figure 3.4 given in Chapter 3) obtained as an output of activity 1 and activity 2. This superimposition of WEEE/E-waste trade value chain on a map will facilitate spatial analysis.

Activity 3: Estimate the WEEE/ E-waste and obsolescence rate/ average life through secondary data by following "approach and methodology upstream of demarcation" mentioned in section 5.1.

By using secondary data e.g. market research data like market supply and imports data, installed base of the WEEE/E-waste item.

Figure 5.3: Guidance procedure for carrying out WEEE/E-waste inventory



The key to estimate WEEE/ E-waste is fixing of obsolescence rate based on market research data, industry data or on consumer behaviour. Since obsolescence rate is dynamic in nature, therefore, a range is fixed with upper and lower limits. Carry out sensitivity analysis for WEEE/ E-waste inventory using upper and lower limits of obsolescence rate.

Activity 4: Verification of obsolescence rate/ average lifespan through primary data

The obsolescence rate/ average life can be verified through identification of WEEE/ E-waste stream and WEEE/ E-waste processes and tracking of tracer item. The following steps are involved in tracer verification.

Step 1: Identify the tracer item
Step 2: Follow the tracer item through the process in the WEEE/E-waste stream
Step 3: Identify all the organised and unorganised market of a tracer in the geographical area.
Step 4: Establish the extent of dismantling/ recycling happening in a geographical boundary.

The primary survey methodologies used for tracer technique and outputs are described in table 5.1.

Table 5.1: Methodology for estimation of WEEE quantity

Objective	Detail	Primary Survey Methodologies	Output
WEEE / E-waste stream	Material flow	• Follow tracer materials: semi-structured interviews about quantities, quality, economics, labor(using appendix 1)	• Key-players are known (dealers, disassembly workers, recycler) • Material flow (quantities / qualities) from input to output are identified • Labor in WEEE/ E-waste streams are identified
	Input quantities / Import	• Interviews with WEEE/ E-waste producers (manufacturers / retailers, auctions…) to find out WEEE/ E-waste quantities • Survey of key-players for import: structured questionnaires/ interviews (using questionnaires given in section tools and technique with examples summarised in appendix 1 and appendix 2)	• WEEE/ E-waste quantity input is estimated • Percentage of imported / household WEEE/ E-waste is known
	Reuse	• Surveys of scrap dealers, retailers, computer repair shops: structured interviews	• Quantities of reused entire equipment are estimated • Quantities of reused equipment

Objective	Detail	Primary Survey Methodologies	Output
		(using questionnaires given in section tools and technique with examples summarized in appendix 3)	parts are estimated
	Disposal	• Sampling on different landfills (using questionnaires given in section tools and technique with examples summarized in appendix 3)	• Existence of WEEE/ E-waste fractions in landfills is known
Recycling technologies	Recycling technology	• Transect walks in different districts (semi-structured interviews using information guide given in appendix 1)	• Applied recycling technologies are known • Labor needed for different recycling processes is known
	Hazardous processes	• Semi-structured interviews in districts, where potentially hazardous processes[5] take place using information guide given in appendix 1 and questionnaire given in section tools and technique with examples summarized in appendix 3.	• Hazards in different recycling processes are identified

The structured and semi structured interviews can be conducted using questionnaires described in section tools and technique with examples summarised in appendix 2 and 3. The questionnaire has been developed to quantify and photo document each step in the WEEE/ E-waste value chain.

If the geographical area is about 100 km^2 and number of stakeholders is limited then 100% primary survey of stakeholders is recommended. If the geographical area and number of stakeholders is above 100 km^2, then primary survey is restricted to a sample size of 10% to 15%.

Activity 5: Identify the products, by products and waste products and back calculaate WEEE/E-waste dismantled by using 'approach and menthodology downstream of demarcation" mentioned in section 5.1.

Identify products, by products and waste products. This can be carried out by using a combination of qualitative and quantitative estimations with the identified stakeholders across the value chain using photo documentation of sampled WEEE/ E-waste tracer as shown in figure 5.2 and appendix 3. Using this data, back calculate to check the best fit scenario of WEEE/ E-waste inventory obtained as an output from activity 3. The output from back calculation should confirm the obsolescence rate/ average life of WEEE/E-

[5] Potentially hazardous materials /processes: Components, such as (rechargeable) batteries, PCB capacitors, mercury bulbs / processes for precious metals, copper recovery

waste within the range used in activity 3. This obsolescence rate is used for calculating WEEE/E-waste projections based on historical data.

An example of WEEE/E-waste dismantling/ recycling/ disposal documentation is given in table 5.2, while photo documentation is shown in appendix 3.

Activity 6: Establish WEEE/ E-waste trade economics

Each stakeholder in the dismantling processes is linked to the other and the trade between the two takes place based on profit. Therefore, the basic parameters driving this trade, which should be estimated, are as follows.

1. Input cost
2. Selling Price
3. Operating margin

Estimate input cost in terms of raw material cost/ energy cost and labour cost. Estimate raw material cost/ energy cost and labour cost using data collected from questionnaire (refer appendix 3). Add the two costs to arrive at input cost. Estimate selling price of the product by using data from questionnaire (refer appendix 3). Establish operating margin as the difference between selling price and input cost.

Activity 7: Identify and assess the impacts

Identify the effluents/ solid waste/ emissions from each of the process. Establish their quantity if possible. Establish the geographical location of their discharge and history of the site. Classify impacts into environment, health and business impacts. Use relative ranking technique to quantify impacts. Relative ranking technique is based on scores where each sector i.e. health, environment and business are assigned with individual score subject to identified negative and positives impacts on the workers, surroundings and economy. An example of usage of relative ranking technique for impact analysis is given in table 5.3.

Table 5.2: E-waste Recycling/reusing Process Documentation

S. No.	Processing Components	Process Details	Geographical Location 1		Geographical Location 2	
			Processing	Remarks	Processing	Remarks
Personal Computer						
1	Cathode ray tube (CRT), Computer casing, Printed circuit boards (PCBs), Printed wire boards (PWBs), Integrated circuits (ICs), Yoke copper and Copper, Computer casing, Rare earth core and Gold from pin and comb	Dissembling of Monitor and extraction of components	Yes	In local market	No	In local market
2		Regunning of CRTs	No	Exported	No	Sent to Location 1
3		IC's Extraction from PWB	Yes	Reselling and reuse in local market	No	Sent to Location 1
4		Acid Bath for PWB	No	Exported	No	Sent to Location 1
5		Surface Heating of PWB and Extraction of components	Yes	Reselling and reuse in local market	No	Sent to Location 1
6		Wire PVC and Copper	Yes	Reselling and reuse in local market	Yes	In local market
7		Plastic Shredding	Yes	In local market	Yes	In local market
8		Gold Extractions from pins and Comb	No	Exported	No	Sent to Location 1
9		Yoke core and copper extraction from wire	Yes	Reselling and reuse in local market	No	Sent to Location 1
10		Metallic Core of Transformer and Copper	Yes	Reselling and reuse in local market	No	Sent to Location 1
11		Rare Earth Core of Transformer and Copper	Yes	Reselling and reuse in local market	No	Sent to Location 1
12		Rare Earth Core of Static Transformer	Yes	Reselling and reuse in local market	No	Sent to Location 1
Television						
13	TV cabinet, CRT, Yoke core and PCB	Dismantling of TV cabinet and CRT	Yes	In local market	No	Sent to Location 1
14		Regunning of CRTs	No	Exported	No	Sent to Location 1
15		Yoke core and copper extraction from wire	Yes	In local market	No	Sent to Location 1

S. No.	Processing Components	Process Details	Geographical Location 1		Geographical Location 2	
			Processing	Remarks	Processing	Remarks
16		Plastic shredding	Yes	Reselling and reuse in local market	Yes	In local market
Cellular Phone						
17	Aerials, Battery connectors, PCBs, Gold-coated edge contacts on PCBs, ICs, Keyboards, LCD screens, Lenses, Microphones, Phone housings, Screws, SIM card assemblies and Speakers.	Separate metals recovery (including precious and semiprecious metals)	Yes	Repairing and reuse in local market	No	Sent to Location 1
18		Batteries repairing and reselling	Yes	Repairing and reuse in local market	No	Sent to Location 1
19		Outer body plastic granulation and reuse	Yes	In local market	Yes	In local market
20		Reuse of valuable components (flash memory devices, PCBs, ICs, keyboards, LCD screens, lenses, microphones, phone housings, and speakers) with minor repairing	Yes	Repairing and reuse in local market	No	Sent to Location 1
Refrigerator						
21	Casing, Cotton insulator, Evaporator, Heating rod, Condenser, Compressor, Fan and Motor	Dismantling of refrigerator and segregation of compressor and cooling box	Yes	Reselling in local market	Yes	In local market
22		Extraction of steel and copper from heating rod	Yes	Reselling in local market	No	Sent to Location 1
23		Extraction and shredding of ABS plastic from fan	Yes	Reselling and reuse in local market	No	Sent to Location 1

Table 5.3: Summary of impacts

Impact / Process	Health (score)	Environment (score)	Business ($/Man Hours)	Business (score)
IC's Extraction from PWB (manual plucking)	0	0	269	+1
Surface heating of PWB and extraction of components	-1	-1	189	0
Dissembling of monitor and extraction of components	-1	-1	44	-1
Yoke core	+1	0	190	0
Metallic transformer	+1	0	119	0
Rare earth core of transformer	+1	-1	147	0
Rare earth static transformer	+1	-1	95	-1
Wire PVC and copper (manual stripping)	+1	0	100	0
Plastic shredder	-1	-1	89	-1
Refrigerator Compressor	-1	0	140	0
Mobile Phone Dismantling	0	0	18	-1

Note: Environment & health score: (-1) Negative Impacts, (0) Neutral, (+1) No Impact Business score: (-1) 0-100 Low Value, (0) 101-200 Medium Value, (+1) >200 High Value

Chapter 6: Case Study

6.0 Introduction

Practitioners designing a WEEE/E-waste assessment project need knowledge about application of WEEE/E-waste inventory assessment methodology in a real developing country context. The summary of guidance notes have been described in figure 6.1. This chapter describes two case studies from Cambodia and India where application of WEEE/E-waste assessment methodology (Chapter 4 and Chapter 5) has been demonstrated. It is recommended that the case studies should be studied be referred in the context of guidance notes.

6.1 Case Study 1: WEEE/ E-waste Inventory Assessment in Cambodia[6]

Cambodia is one of the countries in Asia, which is a major market for second hand consumer electronics and ICT items. It has a population of 13,800,000. Though, lifestyle changes and increasing urbanization in Cambodia has led to increasing penetration of electrical and electronic items, the increasing domestic demand is being met by second hand items due to low prices. The major imported second hand electronic item in Cambodia is TV, which is resold in domestic market for reuse or dismantled for recovery of primary components for their usage during repair of other TV sets. It has been reported that second hand electronic products are imported into Cambodia from different countries like China, Finland, France, Hong Kong, Japan, Malaysia, Republic of Korea, Singapore, Thailand, USA etc. The regulatory structure in the country permits import of WEEE/ E-waste for usage as second hand item and not for final disposal and recovery. Therefore, no recycling or recovery of precious metal has been reported in the country. A typical WEEE/E-waste trade value chain as reported in the source is given in figure 6.2.

Analysis of WEEE/ E-waste trade value chain shows that there are no manufacturers of electronic equipments in Cambodia. There is no WEEE/E-waste recycling facility in Cambodia. It has been reported that most of the electronic waste is not disposed of at open dump sites because of items of economic value except broken CRTs. Used electronic equipment is collected or purchased by waste collectors/ scavengers and is sold to local/ central merchants and then exported illegally for recycling in other countries.

6.1.1 Amount of WEEE/ E-waste release

The amount of WEEE/ E-waste release in Cambodia has been assessed by using the following data.

- Number of electronic equipment users (personal computers, TV sets, mobile phones and fixed telephones)
- Year when electronic equipment is once discharged

[6] Report on the Survey of the Import and the Environmentally Sound Management of Electronic Wastes in the Asia-Pacific Region" , Basel Convention Regional Centre in China published in December 2005

Figure 6.1: Summary of guidance notes

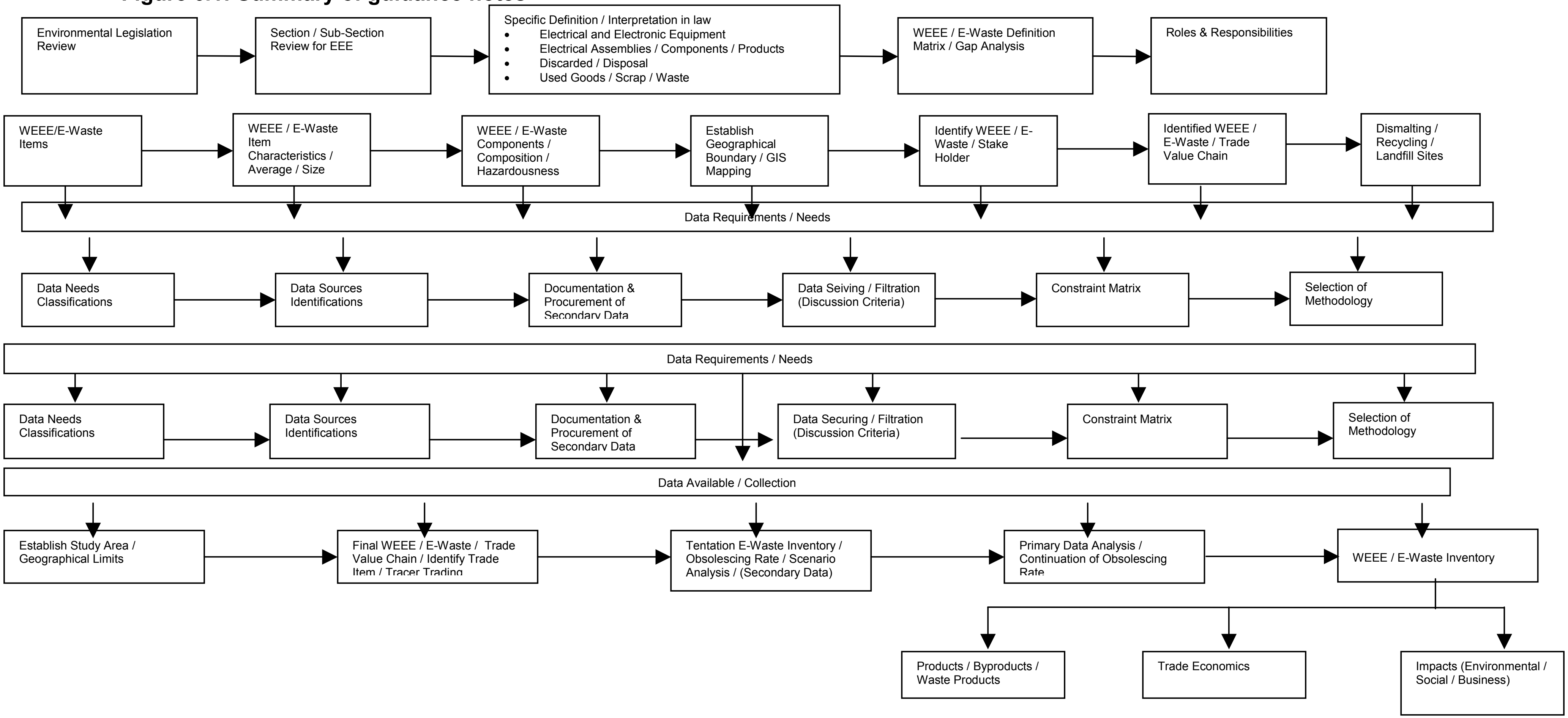
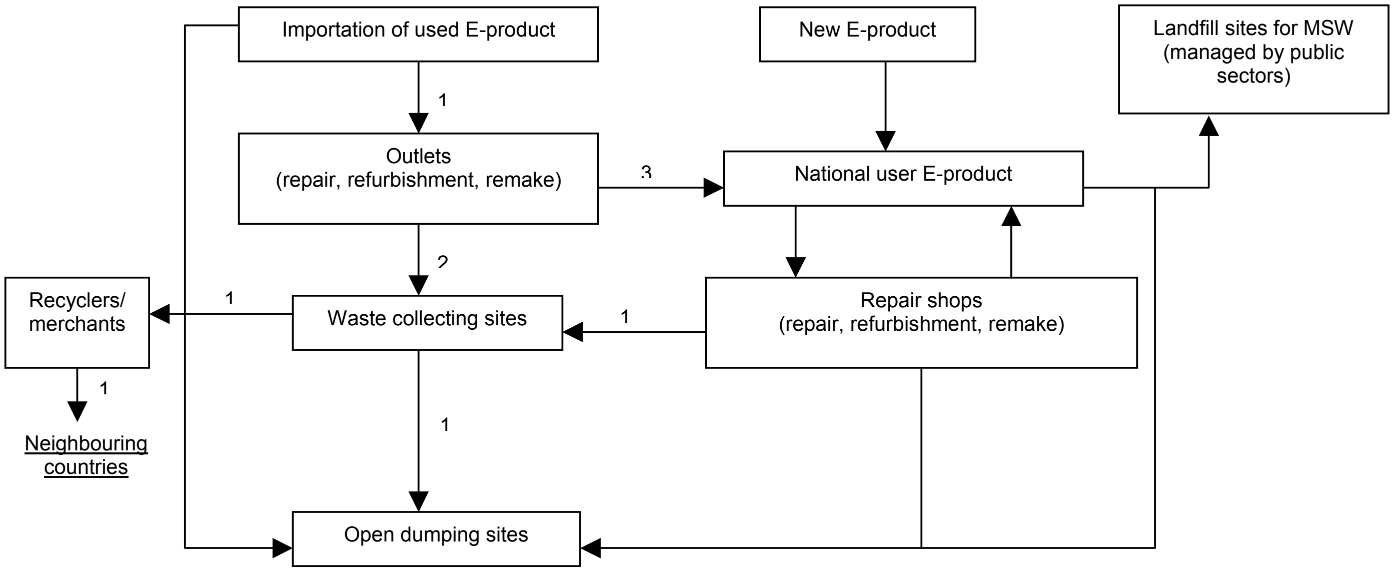


Figure 6.2: E-waste stream/ WEEE/E-waste trade Value Chain



1. Used E-product from other countries;
2. Used E-products;
3. Recyclable wastes (print circuit boards, plastic frame, etc.);
4. Non recyclable wastes (broken CRTs, etc.);
5. Obsolete or broken E-product;
6. Repaired E-product as second-hand products;
7. Broken E-product and Non recyclable E-product (collected with MSW by private sectors);
8. Non recyclable wastes (broken CRTs);
9. Recyclable waste (print circuit boards, plastic frame, etc.);
10. Print circuit boards and plastic frames;
11. Non recyclable wastes.

- The transportations of 2,5,9 are done mostly by scavengers and sometimes by owner (type of transport: hand-carts, motorcycles)
- The transportation of 4,7,8 and 12 are done mostly by private sector and sometimes by owner through scavenger (type of transport: trucks, hand-carts, motorcycles and bicycles)
- The transportations of 11 are done by owner (type of transport: trucks)

Installed base of Electrical and Electronic Item

As per the World Development Indicators from the World Bank Report, the penetration rate of following electronic items in Cambodia is given below.

- Computers per 1,000: 1
- TV sets per 1,000: 1
- Mobile phones per 1,000: 1
- Fixed telephones per 1,000: 1

Since the population in Cambodia is 13,800,000, therefore the installed base of electronic items in terms of number of each product (unit) or users are calculated by multiplying penetration rate mentioned above with population.

1. Computers: 13,800,000 /1,000= 13,800 units
2. TV sets: 13,800,000 /1,000= 13,800 units
3. Mobile phones: 13,800,000 /1,000= 13,800 units
4. Fixed telephones: 13,800,000 /1,000= 13,800 units

Consumer Behaviour

As per Ministry of Environment, Government of Cambodia estimates, the years when electronic equipment is discharged are given below:

- Approximately 2% of users change the computer every year
- Approximately 20% of users change the TV sets every year
- Approximately 40% of users change the mobile phone every year
- Approximately 5% of users change the telephone mainline every year

WEEE/E-waste Inventory

WEEE/ E-waste release is roughly calculated by multiplying installed base with user's consumption pattern as shown below.

- Computer: = 13,800 units × 0.02= 276 units
- TV sets: = 13,800 units × 0.2= 2,760 units
- Mobile phone: = 13,800 units × 0.4= 5,520 units
- Fixed telephones: = 13,800 units × 0.05= 690 units

6.1.2 Analysis

The case study indicates that the installed base of electrical and electronic equipment in Cambodia during 2004-05 was 55,200 units (TV/PC/ mobile phones/ fixed telephones) where 0.1% of the total population is user of major electronic equipment. The installed base has been calculated based on penetration rate, while the consumer behaviour gets reflected in the data, where a certain percentage of population changes their equipment every year. WEEE/E-waste inventory in a particular year based on these data has been estimated to be 9246 units, which is about 16% of the total installed base.

The analysis of the above shows that a version of "Approximation 2" method has been used for WEEE/E-waste inventory assessment in Cambodia. Inventory assessment has been carried out based on secondary sources of data without primary assessment to confirm consumer behaviour and to factor "externalities" like reuse, storage and import. Further, future WEEE/E-waste projections are not predicted due to absence of historical data. Therefore, this method provides a useful onetime preliminary WEEE/ E-waste inventory assessment at a country level.

6.2 Case Study 2: E-waste assessment methodology and validation in India[7]

6.2.1 Introduction

Electronics and information technology (IT) is a fast growing segment of Indian industry.The market trends over the past 5 years indicate that the Indian IT industry has recorded a compounded annual growth rate (CAGR) of more than 42.4%, which is almost double the growth rate of IT industries in developed countries[8]. The total value of software and services exported from India was estimated at Rs. 555.1 trillion (US$12.2 billion) in 2003–2004, an increase in dollar value over the previous year. The Indian IT software and services industry is expected to account for about 2.64% of India's GDP and 21.3% of exports during 2003–2004 and is projected to reach 7% of India's GDP and 35% of total exports by 2008[9]. India's vibrant IT software and services industry has been projected to reach an export potential of $57–65 billion for the software and services sector by 2008[8].The Indian consumer electronics industry has a size of around Rs. 102 billion (US$2.37 billion), comprising a color television (CTV) market of Rs. 80 billion (US$1.86 billion), an audio equipment market of Rs. 9 billion (US$0.21 billion), and a black-and-white TV market of Rs. 7 billion (US$0.16 billion). Within the consumer electronics industry, the most prominent sector is televisions, with a market size of around Rs. 87 billion[9] (US$2.02 billion).

The increased growth rate of the IT and electronics industry in India is propelled by increased consumption of electronic items and IT hardware. The increased consumption pattern leads to an increased obsolescence rate of these products, which will result in the higher generation of electronic waste (e-waste). The increasing obsolescence rates of electronic products added to the huge import of junk electronics will create a complex scenario for solid waste management in India. It has been reported by the Basel Action Network (BAN), WA, and Toxics Link, India, that 1.38 million personal computers (PCs) will be obsolete from the business sector and individual households in India. At the same time, around 1050 tonnes of electronic scrap is being produced by manufacturers and assemblers in a single calendar year in India. Reports of the import of 30 metric tonnes (MT) of e-waste at Ahmedabad[10] a town in India, have also been published.

There is no reliable database of the total amount of e-waste in India. At the same time, no scientific evidence exists regarding the application of a standard approach and methodology to estimate e-waste in India. Therefore, an attempt has been made to establish an approach and a methodology to quantify e-waste in the Indian context by testing it in a city in India.

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[7] Amit Jain · Rajneesh Sareen , E-waste assessment methodology and validation in India, J Mater Cycles Waste Manag (2006) 8:40–45 © Springer-Verlag 2006, DOI 10.1007/s10163-005-0145-2
[8] MCIT (2003) Information technology annual report. Ministry of Communications and Information Technology, Department of Information Technology, India, p 1
[9] ICRA (2004) Consumer electronics: the Indian consumer electronics industry. ICRA, India, pp 5, 8–18, 28
[10] Toxics Link (2003) Scrapping the high-tech myth: computer waste in India. Toxics Link, India, p 13

6.2.2 Scope of this study

The study was limited to e-waste from PCs and TVs. It was carried out within the state boundaries of Delhi and selected areas in the National Capital Region (NCR) of Delhi. The scope of this study included an e-waste assessment, particularly applying an assessment methodology, its validation in a geographical region, and finally its application to all of India. This will facilitate total e-waste estimation for India for future planning of any intervention.

6.2.3 Approach and methodology

The first step in applying any approach and methodology is to establish the geographical boundaries of the study area. The study area included the state boundaries of Delhi, consisting of municipal boundaries, rural and urban areas, and selected areas of the NCR. The geographical boundaries were fixed considering the location of organized and unorganised markets, places where each item is unloaded, traded, transported, dismantled, recycled, reused, repaired, processed, and disposed of, starting from generation/production to its final end of life. These places were identified through a transect walk and preliminary surveys in the study area.

The two basic approaches applied for carrying out e-waste assessment in the study area involved quantification using material flow analysis (MFA) followed by site-specific validation. The MFA and site-specific validation help to establish the e-waste trade value chain. The fundamental e-waste trade value chain based on MFA in the study area is shown in Fig. 6.3.

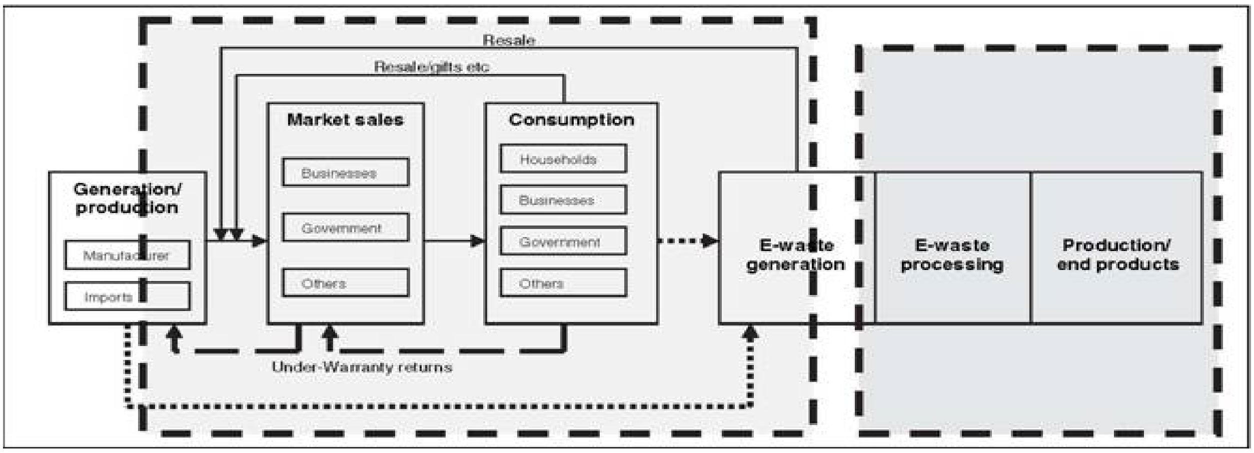


Figure 6.3: E-waste trade value chain

The last three stakeholders in the e-waste trade value chain, consisting of e-waste generation, e-waste processing, and e-waste production/end products, fall in the informal sector. E-waste processing involves primary dismantling of items from e-waste, e.g., the unscrewing of a PC monitor and removal of the CRT and printed circuit boards. E-waste production/end products involve processes consisting of secondary dismantling of items obtained as output of e-waste processing, e.g., the regunning of CRTs, extraction of metals, and others. The remaining stakeholders fall in the formal sector. This trade value chain has been developed considering that an electronic item "flows" through a region and on its way it is dismantled and processed in numerous steps until it rejoins the raw material streams or ends in final disposal. Some of the major stakeholders identified along the flow path include importers, producers/manufacturers, consumers (individual households, business sector), traders, retailers, scrap dealers, disassemblers, and dismantlers. At each step in the flow, business transactions define the movement of the electronic item in the flow. One of the ways to quantify the flow is through analysis of sales data of these business transactions.

In this study, sales data of electronic items have been applied to a market supply[11] calculation method to estimate the theoretical waste arising for each item. This market supply method has been used consideration taking into data limitations and the short duration of the study. Further, the findings of the field survey also verify the findings obtained from this method. This method is based on an assumption that 100% of electronic units sold in one particular year will become obsolete at the end of their average life. Sensitivity analysis was carried out assuming an average life for each item based on market trends and consumer behaviour. Sensitivity analysis for PCs was carried out using 5 years and 7 years as the average life. Sensitivity analysis for TVs was carried out using 10 years and 12 years as the average life. These average lifespans were fixed based on primary and secondary data from market research agencies and surveys. Further, externalities such as e-waste entering into the study area from outside based on a primary field survey conducted by IRGSSA[12] were factored into the final e-waste assessment analysis.

The average life of an electronic item assumed in the sensitivity analysis has been validated through site-specific surveys. The validation has focused on the last three steps, i.e., e-waste generation, e-waste processing, and the production/end products of the e-waste trade value chain as shown in figure 6.3.The basic approach in this validation is to first identify the waste stream, followed by the specific processes in the waste stream; this method included identification and complete tracking of one component in the waste stream. In this study, the Dismantling of a TV and PC monitor has been taken as the waste stream, in which dismantling the CRT and its regunning has been taken as a process. In this stream and process, the CRT was identified as one component, which was tracked along the material flow as shown in Fig. 6.4. Different products, by-products, and waste products handled by stakeholders along the material flow have been identified and quantified. The results obtained from this analysis have been compared with the assumptions to validate the average life of the electronic item.

6.2.4 Results and discussion

PC and TV sales data for the study area and India as a whole was obtained from the industry association. Comparative time series growth of the installed base and yearly additions of PCs from 1996 to 2004 and for TVs from 1983 to 2005 are shown in tables 6.1 and 6.2 respectively.

The market supply method was applied by assuming the average life of a PC to be 5 years and 7 years and the average life of a TV to be 10 years and 12 years. It was also assumed that 100% of electronic units sold in one particular year would become obsolete at the end of the average life. The amount of e-waste from PCs and TVs

[11] EPA (2001) Waste from electrical and electronic equipment in Ireland: a status report. EPA Topic Report, Cork Institute of Technology and Environmental Protection Agency, Ireland, pp 68–69

[12] IRGSSA (2004) Management, handling and practices of E-waste recycling in Delhi. IRGSSA, India

existing in the study area is given in Tables 6.3 and 6.4.

The average weight of a PC and a TV was taken as 27kg and 15 kg, respectively. These weights have been estimated based on average weights of different products and brands available in the Indian market during the primary survey. E-waste based on the sales figures/penetration rate has been adjusted for externalities, i.e., the number of trucks carrying e-waste from outside and entering the study area per day, considering 365 days in a year, during which dismantling occurs on 300 working days.

6.2.5 Validation

Qualitative and quantitative estimations were carried out with the identified stakeholders across the e-waste trade value chain. It was found that two types of stakeholders, dismantlers and CRT regunners, are involved in CRT handling. The field survey results from the dismantler revealed that out of the total CRTs received for dismantling, the regunning industry accepts 40%–45% of dismantled material; the remaining material is rejected. About 55%–60% of the rejected material goes for glass breaking. Further, out of the total 40%–45% accepted material (CRTs) for processing, 10% is found to be intact and is sent for resale, whereas the remaining 90% is regunned. The total number of regunning units operating in the study area is 15. The daily output (regunned CRTs) per unit is 120–140 CRTs. Therefore, the total output per day from all units in the study area is 1800–2100 CRTs. This range of CRT output per day was used to validate the average life of a PC and a TV based on scenario analysis using the market supply method.

The number of CRTs being regunned every day was estimated using data from tables 6.1 to 6.4. CRT fact sheets summarising the results considering an average life of 7 years for a PC and 12 years for a TV are shown in Tables 6.5 and 6.6.

The total number of CRTs being regunned per day is 2050, calculated on the basis of an average life of 7 years for a PC and 12 years for a TV. This number is within the range obtained from the survey of the CRT industry. Therefore, this market supply result validates the adopted approach. The total projected e-waste generation (TV and PC), calculated by using a power equation for the best fit of domestic market data in the study area based on the validated average life is shown in figure 6.5.

It is estimated that in 2010, e-waste generated from PCs and TVs in the study area will be more than 2 million units from the domestic market.

6.2.6 Conclusions

The market supply method can be easily applied to e-waste estimation in the Indian context, considering constraints in data collection as a result of the informal nature of the e-waste trade. The application of this method is highly dependent on the estimation of the average life or obsolescence rate of an electronic item. Since the average life is an indicator of consumer behaviour, it includes elements of active usage, reuse, and storage of an electronic item before its recycling and final disposal. Sensitivity analysis using different average life spans for an electronic item can factor elements of active usage, reuse, and storage into the assumption that 100% of electronic units sold in one particular year will become obsolete at the end of the average life. Further, sensitivity analysis also factors in the dynamic nature of consumer behaviour. This has been validated for PCs and TVs in the study area.

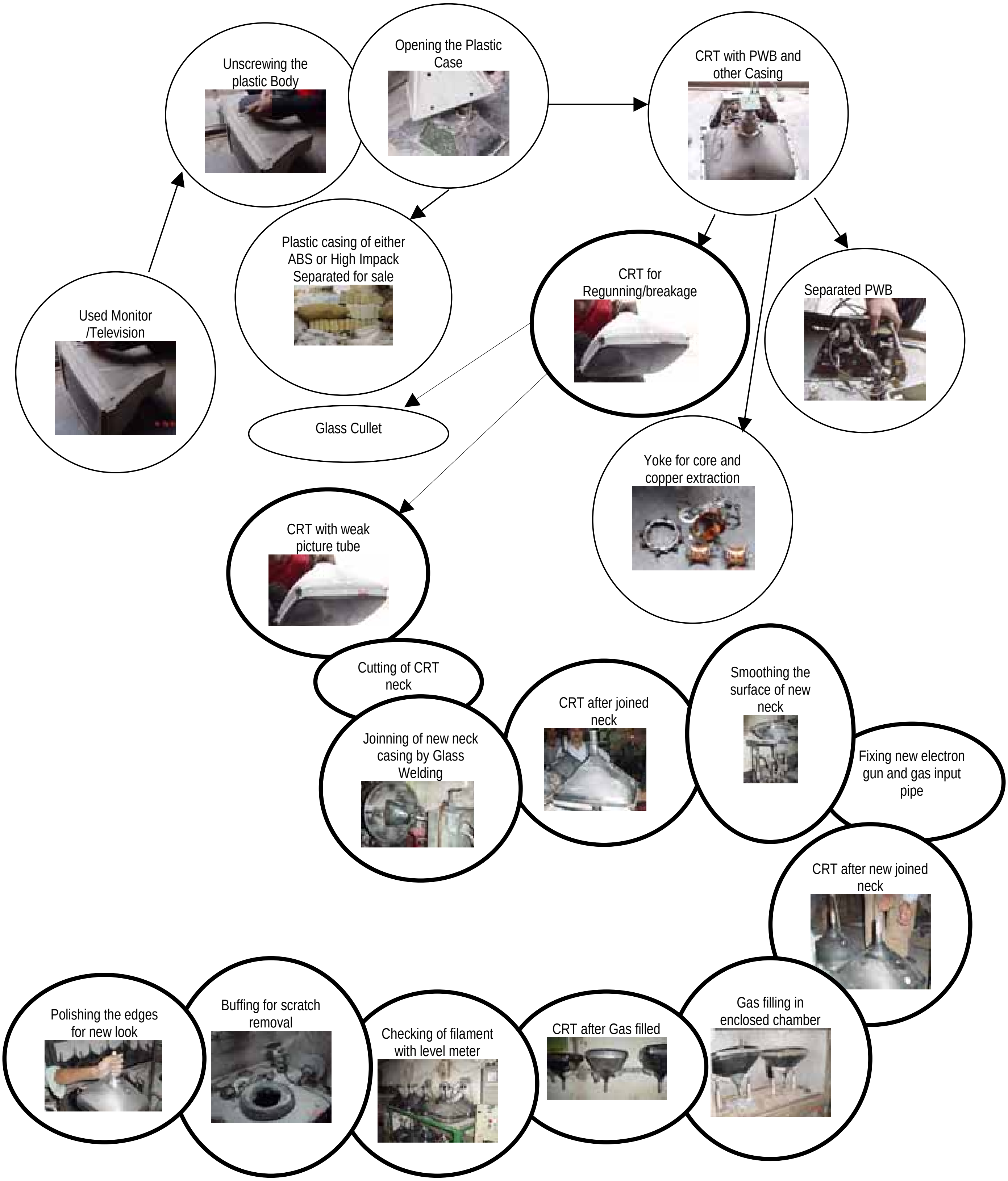


Figure 6.4: Dismantling of Monitor / Television, extraction of components and Regunning of Cathode Ray Tube (CRT)

Table 6.1: Growth of installed base and yearly additions of personal computers (PCs) in India and the study area

Year	Personal Computer Penetration Per 1000 Population	Population of India	India		Study Area	
			Installed Base (Units)	Yearly Addition (Units)	Installed Base (Units)	Yearly Addition (Units)
1996	0.7	934300000	654010	600000	163503	150000
1997	1.4	949900000	1329860	800000	332465	200000
1998	2.1	965600000	2027760	1000000	506940	250000
1999	3.1	981300000	3042030	1400000	760508	350000
2000	4.5	997000000	4486500	1740000	1121625	435000
2001	6.3	1012400000	6378120	1796434	1594530	449109
2002	8	1027600000	8220800	2434408	2055200	608602
2003	9	1043500000	9391500	3298948	2347875	824737
2004	11	1060000000	11660000		3172612	

Source: MAIT[13] and Census of India
Note: Delhi Share @25% of India (Source: MAIT)

Table 6.2: Growth of installed base and yearly additions of televisions in India and the study area

Domestic Market - Television									
			Market Size (India) (in Million)		Market Share (inches)				Delhi Market Size (in Million)
	Year	Market Size (India) (in Million)	B&W	Colour	14"	20"	21"	Large	
	1985	2.00	1.40	0.60	0.40	0.80	0.74	0.06	0.21438
	1986	2.80	2.00	0.80	0.56	1.12	1.04	0.08	0.268367994
	1987	3.60	3.00	0.60	0.72	1.44	1.33	0.11	0.345044563
	1988	4.40	3.50	0.90	0.88	1.76	1.63	0.13	0.421721133
	1989	5.20	4.00	1.20	1.04	2.08	1.92	0.16	0.552624
	1990	4.90	3.70	1.20	0.98	1.96	1.81	0.15	0.469643989
	1991	4.53	3.50	1.03	0.91	1.81	1.68	0.14	0.434181075
	1992	4.22	3.39	0.83	0.84	1.69	1.56	0.13	0.404468905
	1993	5.18	3.90	1.28	1.04	2.07	1.92	0.16	0.4579792
	1994	6.03	4.64	1.39	1.21	2.41	2.23	0.18	0.5414286
	1995	7.74	5.99	1.75	1.55	3.10	2.86	0.23	0.7027297
	1996	7.92	5.95	1.97	1.58	3.17	2.93	0.24	0.7938809
	1997	8.96	6.03	2.93	1.79	3.58	3.32	0.27	0.8427516
	1998	9.98	6.11	3.87	2.00	3.99	3.69	0.30	0.8983316
	1999	10.70	5.70	5.00	2.14	4.28	3.96	0.32	1.025549119
	2000	9.50	4.50	5.00	1.90	3.80	3.52	0.29	0.910534264
	2001	9.20	3.90	5.30	1.84	3.68	3.40	0.28	0.881780551

[13] MAIT, India The hardware opportunity. Ernst and Young, MAIT, MCIT, India, pp 1.1–1.5, 3.5, B.1–B.5

Domestic Market - Television									
			Market Size (India) (in Million)		Market Share (inches)				
	Year	Market Size (India) (in Million)	B&W	Colour	14"	20"	21"	Large	Delhi Market Size (in Million)
	2002	10.25	3.50	6.75	2.05	4.10	3.79	0.31	0.982418548
	2003[a]	11.00	3.00	8.00	2.20	4.40	4.07	0.33	1.054302832
	2004	11.75	2.50	9.25	2.35	4.70	4.35	0.35	1.126187116
Present	**2005**	12.50	2.00	10.50	2.50	5.00	4.63	0.38	1.1980714
	2006	13.75	1.50	12.25	2.75	5.50	5.09	0.41	1.31787854
	2007	15.50	1.00	14.50	3.10	6.20	5.74	0.47	1.485608536

Source: MAIT[13], ICRA[14], NCAER[15], and Survey Findings
a The base year was 2003; B&W, black and white

Table 6.3: Sensitivity analysis for personal computers in the study area

Description	Average Life 5 Years	Average Life 7 years
Study area's Share to e-waste (number of PCs /Year) @300 days/year	250000	150000
Equipment Weight (Kg)	27.21	27.21
Total Waste (tonnes)/year	6803	4082
Total Waste (tonnes) entering from outside the study area/ year	3600	3600
Grand total (tones)/ year	10403	7682
Total Number of PCs handled/day	1274	941

Source: IRGSSA[11]

Table 6. 4: Sensitivity analysis for televisions in the study area

Description	Average life 10 years	Average life 12 years
Study area's Share to e-waste (number of PCs /Year) @300 days/year	702730	457979
Equipment Weight (kg)	15	15
Total Waste (tonnes)/year	10541	6870
Total Waste (tonnes) entering from outside the study area/ year	16810	16810
Grand total (tonnes)/ year	13610	9940
Total Number of televisions handled/day	5410	4594

[14] ICRA (2003), Industry watch series – the Indian consumer durables industry. ICRA, India, pp 25–45
[15] NCAER (2002) Indian market demographics report. National Council of Applied Economic Research, India, annex 3, 4

Table 6.5: Cathode ray tube (CRT) fact sheet for PCs in the study area

Descrition	Units (Nos.)
Total CRT being regunned/day	350
CRT breaking (not regunned)	544
CRT found to be intact and returned to market for resale	52 %
Total CRT's being regunned /day (including externality+ domestic market)	350

Source: IRGSSA[11]

Table 6.6: CRT fact sheet from Television in Study Area

Description	Units (Nos.)
Total CRT being re gunned/day in Delhi	1700
CRT broken and not regunned	2640
CRT found intact and returned to market for resale	254 %
Total CRTs being regunned /day (including externalities+ domestic market)	1700

Source: IRGSSA[11]

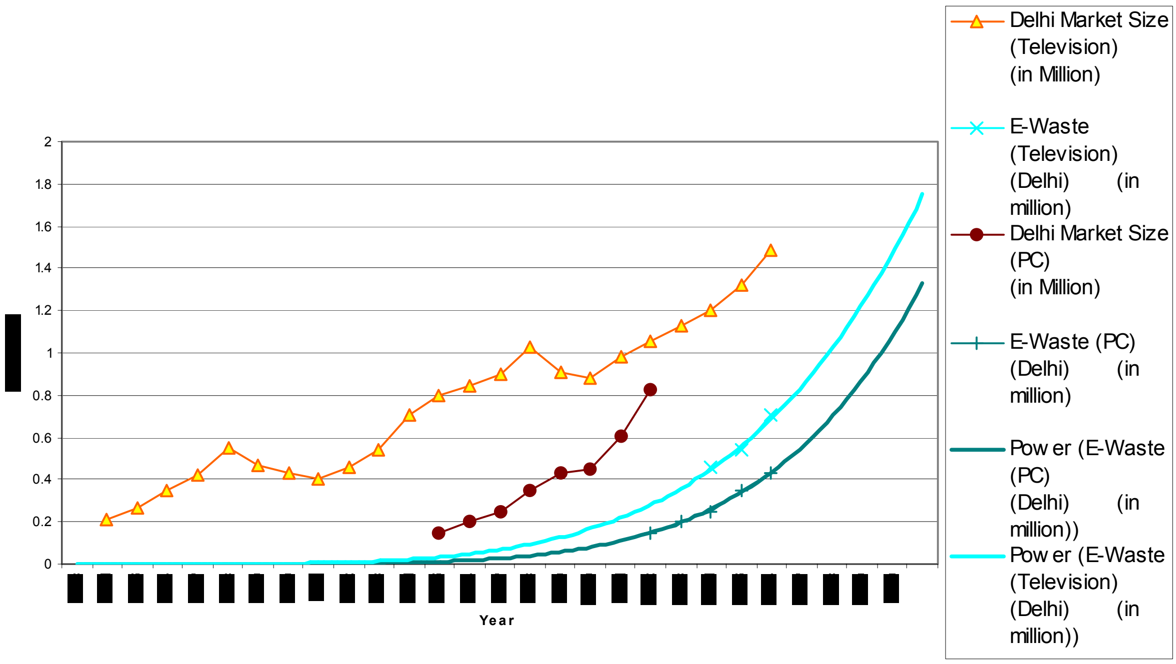


Figure 6.5: Delhi market size and electronic waste (e-waste) generation for personal computers (PCs) and televisions (TVs). *Triangles*, market for TVs; *circles*, market for PCs; *multiply signs*, e-waste for TVs; *plus signs*, e-waste for PCs

Appendix 1

Information Guide

1.0 Introduction

This information guide has been prepared as a reference guide to seek information from different stakeholders identified along the WEEE/E-waste trade value chain for each electrical and electronic item. Different questionnaires, semi-structured/ structured interview guide and checklists can be prepared for the study area using this reference material.

2.0 Personal Computers (PCs)

2.1 Target Group: Manufacturers/ Assemblers/ Retailers/ Importers

The following information needs to be obtained from secondary sources and discussions with the target group.

Products & industry

- Product category definitions – Desktops and notebooks, types of monitors and old and new product lines.
- Industry structure, major players from component manufacture to disposal.
- Current major manufacturers / importers / suppliers.

Market information

- Current market segmentation – sales across various product lines, i.e. desktops and notebooks.
- Current market value in the country.
- Current market size.
- Current market growth rate (%).
- Current market shares across major players.
- Branded market Vs gray market.
- Buyer/user segments within urban and rural (high, middle and low income groups)
- Market differentiation, first time Vs replacement / upgradation (percentage breakdown).
- Estimate of the personal computers population base (bulk and individual home installations).
- Future market projections.
- Imports of new, working second hand as well as non-working waste PCs.
- Views of major manufacturers on the future PCs markets and projected increase in sales.
- Views of major manufacturers on the assemblers (grey) market, if any, and vice versa –the nature of the competition between the branded and grey markets.
- Views of major manufacturers about the reuse (used product) market and whether or not major manufacturers face competition from such products in the urban market.

Product replacement trends

- Replacement frequency - Bulk installations (company policies) and individual home installations - the cycle for an average urban household for PCs - Is it 2-3 years or 4-5 years?
- Estimation of lifetime for branded PCs and "grey" PCs.
- Estimation of lifetime for desktops and notebooks.

Recycling & waste-related

- Post-use component classification – identifying those for reuse, those for recovery and those for disposal – from desktops and notebooks.
- Identification of the recycling chain – auctioneers, middlemen / stockists and those undertaking physical collection.
- Types of recyclers (reuse and recovery) – in-company (buy-back schemes), formal and informal.
- Methods for recycling (reuse and recovery)
- Environmental impacts of recovery operations.
- Types of recovery operations done, e.g. segregation, re-gunning of cathode ray tubes, extraction and burning.
- Estimates of the quantity and market value of the recycling (reuse and recovery) market.
- Estimates of the percentage and time period for a typical PC to find its way for reuse, recovery and disposal.
- Manufacturer’s estimation of lifespan for branded PCs and gray PCs.
- Manufacturer’s estimation of lifespan for desktops and notebooks.
- Views of major manufacturers of the problems and opportunities in coordinating organized recycling through buy-back schemes.
- Views on the major components that have value for reuse and recovery.
- Views on best practices for recovery, wherever it is being practiced.
- Retailer’s replacement cycle for an average PC.
- Retailer’s estimation of lifespan for branded PCs and grey PCs.
- Retailer’s estimation of lifespan for desktops and notebooks.
- Retailer’s estimates of the quantity and market value of the recovery market that PCs generate.

Others

- Government policies pertaining to the industry.
- Government policies pertaining to wastes generated by the industry.
- Census survey information on population and other statistics pertaining to PCs.

2.2 Target Group: Consumer / End User

The consumers / end users range from large volume / multiple installations to single installations. The large volume consumers / end users are software companies and business processing organisations (BPOs), whereas the single installations are those in individual homes. The following information needs to be obtained from secondary sources and discussions with consumers / end users.

Bulk installation

- Frequency of replacement
- Methods for discarding / disposal – is physical destruction undertaken?

- Views on preferences between desktops and notebooks – current and future trends.
- Views on purchases from branded, grey and used PCs market

Single installation

- Frequency of replacement – across different income segments.
- Views on exchange schemes and their level of attractiveness
- Views on upgrading to new technology, i.e. better chip / faster processing capacity.
- Views on purchases from branded, grey and used PCs market, particularly in the middle and low-income segment.
- User's lifetime estimation for branded PCs and grey market PCs.
- User's lifetime estimation for desktops and notebooks.
- Disposal practices adopted for old PCs, i.e. store in the attic or donation or exchange scheme or give-away or junk in the dustbin.

2.3 Target Group: Service Centre / Repair / Reuse

There are two types of service centres: (a) company-owned and (b) local. The following information needs to be obtained from secondary sources and discussions with service centres for repairs and reuse.

Service scenario

- Estimate of the number of PC service centre in the study area.
- Views on the viability of repair taking into consideration the cost of new components and new PCs.
- Estimate of the number of PCs that have been received for repair – percentage of those that are returned after proper repair – percentage of the remaining that can be stripped for components, used for recovery and finally disposed.

Recycling & waste-related

- Estimate of waste quantity, i.e. old PCs and components, sold annually and the price obtained for them in the different service centres.
- Estimate of waste quantity likely to be generated from all the service centres in the study area
- Disposal practices adopted for old PCs and components e.g. use of middlemen or junk in the dustbins.
- Information on whether or not the old PCs and components go outside of study area. If so, what is the extent and why?
- Visual inspection of the storage area of old, unusable PCs and components to determine whether segregation is done.
- Information on good practices and bad practices of the recovery recycling that is being done elsewhere in study area.

2.4 Target Group: Importer

The following information needs to be obtained from importers, custom agencies and port authorities:

Material sourcing

- Quantity of imports of used and waste PCs, import category number, country of origin, final destination of bulk WEEE/E-waste cargo.

2.5 Target Group: Waste Market

The following information needs to be obtained from secondary sources and discussions with waste traders – both formal and informal. This covers both importers, scrap dealers / agents (large and small) and traders:

Material sourcing

- Different sources of their material i.e. waste PCs and components, only domestic or imported as well.
- Quantity of wastes from manufacturing factories and post consumer waste.
- Quantity from auctions, imports, percentage of working and non working PCs
- Trends in the availability of their material.

2.6 Target Group: Recovery Recycler

This covers auctioneers, scrap dealers / agents (large and small) and those involved in the physical recovery operations. The following information needs to be obtained from secondary sources and discussions with recovery recyclers – both formal and informal recyclers:

Raw material sourcing

- Different sources of their raw material, i.e. unusable PCs and components – only domestic or imported waste as well – rejects from the hardware manufacturing units, discards from software companies / BPOs and discards from individual installations – possible breakdown among the various sources.
- Trends in the availability of their raw material for resource recovery

Recovery operations

- Components of a PC that have the maximum potential for reuse and for recovery.
- Types of recovery operations done, e.g. segregation, re-gunning of cathode ray tubes, extraction and burning – what are the materials that are retrieved?
- Environmental impacts of these recovery operations.
- Good practice and bad practice information on the methods and operations adopted.
- Views on the size of the recovery operations.
- Information on the financial viability of these recovery operations.

Final recovered products

- Different final applications of their produce. Good and bad practice information associated with those methods and operations.

Recovery market information

- Estimate of the size of the recovery market based on unusable PC sets and components in study area.
- Information on whether or not the unusable PCs and components after recovery go outside of study area. If so, which locations? To what extent and why?

2.7 Target Group: Disposal

The following information needs to be obtained from secondary sources, visit to the dump yards and discussions with representative-in-charge of the dump sites:

- Estimate of the quantity of WEEE/ E-waste received in the particular dump site.
- Estimate of the total quantity of WEEE/ E-waste reaching all the dump sites.
- Information on whether rag pickers are collecting WEEE/ E-waste in these dump site.

3.0 Televisions (TVs)

3.1 Target Group: Manufacturers/ Assemblers/ Retailers/ Importers

The following information needs to be obtained from secondary sources and discussions with target group.

Product & industry

- Product category definitions – B&W and Colour TVs – types of colour TVs – old and new product lines.
- Industry structure – major players – from component manufacture to disposal.

Market information

- Current market segmentation – sales across various product lines.
- Current market value.
- Current market size.
- Current market growth rate (%).
- Current major manufacturers / importers / suppliers.
- Current market shares across major players.
- Buyer / user segments – urban and rural, and within urban (high, middle and low income groups).
- Market differentiation – first time Vs replacement/up gradation – percentage breakdown relevant to study area.
- Current market penetration in urban and rural (%) i.e. no. of televisions per 100 people and estimation of the number of TVs in study area.
- Estimate of the TV population base in study area.
- Existence of a grey (assembled, not recycling) markets in TVs and what percentage of the total TV market?
- Future market projections.
- Imports of working secondhand as well as non-working waste TVs. Views of major manufacturers on the future TV industry and projected increase in sales.
- Views of major manufacturers on the assemblers (grey) market, if any.
- Views of major manufacturers about the reuse market and whether or not major manufacturers face competition from such products in the urban market.

Product replacement trends

- Replacement cycle for an average urban household?
- Estimation of the lifespan of a typical TV.

Recycling & waste-related

- Post-use component classification – identifying those for reuse, those for recovery and those for disposal.
- Identification of the recycling chain – middlemen, stockists and those undertaking physical recovery.
- Types of recyclers (reuse and recovery) – in-company (buy-back schemes), formal and informal.
- Methods for recycling (reuse and recovery)
- Environmental impacts of recovery operations.
- Types of recovery operations done, e.g. segregation, re-gunning of cathode ray tubes, extraction and burning.
- Estimates of the quantity and market value of the recycling (reuse and recovery) market.
- Estimates of the percentage and time period for a typical television to find its way for reuse, recovery and disposal.
- Views of major manufacturers of the problems and opportunities in coordinating organized recycling through buy-back schemes.
- Quantity of waste generated and disposed from the manufacturing facilities directly.
- Views on the major components that have value for reuse and recovery.
- Views on best practices for recovery, wherever it is being practiced.
- Estimate of the breakdown between first time buyers and replacement buyers
- Replacement cycle for an average household.
- Estimates of the quantity and market value of the recovery market that TVs generate.

Others

- Government policies pertaining to the industry.
- Government policies pertaining to wastes generated by the industry.
- Census survey information on population and other statistics pertaining to TVs.

3.2 Target Group: Consumer / End User

The following information needs to be obtained from secondary sources and discussions with consumers / end users:

- Views of the frequency of replacement cycle across different income segments
- Views on exchange schemes and their level of attractiveness
- Views on upgrading to new technology, e.g. flat screen.
- Whether priority given to TVs in relation to other consumer electrical and electronic items such as refrigerators, microwave ovens and washing machines.
- Views on purchases from grey and used TVs market, particularly in the middle and low-income segment.
- Disposal practices adopted for old TVs, i.e. store in the attic or exchange scheme or give-away or junk in the dustbin.

3.3 Target Group: Service Centre / Repair / Reuse

There are two types of service centres: (a) company-owned and (b) local. Both these have to be covered. The following information needs to be obtained from secondary sources and discussions with service centres for repairs and reuse.

Service scenario

- Estimate of the number of service centres in study area.
- Views on the viability of repair taking into consideration the cost of new components and new TVs.
- Estimate of the number of TVs that have been received for repair – percentage of those that are returned after proper repair – percentage of the remaining that can be stripped for components, used for recovery and finally disposed.

Recycling & waste-related

- Estimate of waste quantity, i.e. old TVs and components, sold annually and the price obtained for them in the different service centres.
- Estimate of waste quantity likely to be generated from all the service centres
- Disposal practices adopted for old TVs and components e.g. use of middlemen or junk in the dustbins.
- Information on whether or not the old TVs and components go outsideof study area. If so, what is the extent and why?
- Visual inspection of the storage area of old TVs and components to determine whether segregation is done.
- Information on good practices and bad practices of the recovery recycling that is being done elsewhere in study area.

3.4 Target Group: Importer

The following information needs to be obtained from importers, custom agencies and port authorities:

Material sourcing

- Quantity of imports of used and waste TVs, import category number, country of origin, final destination of bulk WEEE/E-waste cargo

3.5 Target Group: Waste Market

The following information needs to be obtained from secondary sources and discussions with waste traders – both formal and informal traders. This covers both importers, scrap dealers / agents (large and small) and traders:

Material sourcing

- Different sources of their material i.e. waste TVs and components, only domestic or imported as well.
- Quantity of wastes from TV manufacturing factories, end users.
- Quantity from auctions, imports, % of working and non working TVs
- Trends in the availability of their material.

3.6 Target Group: Recovery Recycler

The following information needs to be obtained from secondary sources and discussions with recovery recyclers – both formal and informal recyclers. This covers both the scrap dealers / agents (large and small) and those involved in the physical recovery operations:

Raw material sourcing

- Different sources of their raw material i.e. waste TV sets and components, only domestic or imported waste as well.
- Quantity of wastes from TV manufacturing factories reaching recovery recycling.
- Trends in the availability of their raw material.

Recovery operations

- Types of recovery operations done, e.g. segregation, re-gunning of cathode ray tubes, extraction and burning.
- Environmental impacts of these recovery operations.
- Good practice and bad practice information on the methods and operations adopted.
- Views on the size of the recovery operations.
- Information on the financial viability of these recovery operations.

Final recovered products

- Different final applications of their produce. Good and bad practice information associated with those methods and operations.

Recovery market information

- Estimate of the size of the recovery market based on waste TV sets and components in study area.
- Information on whether or not the old TVs and components after recovery go outside of study area. If so, which locations? To what extent and why?

3.7 Target Group: Disposal

The following information needs to be obtained from secondary sources, visit to the dump yards and discussions with representative-in-charge of the dump sites:

- Estimate of the quantity of WEEE/ E-waste received in the particular dump site.
- Estimate of the total quantity of WEEE/ E-waste reaching the entire dump site.
- Information on whether rag pickers are collecting WEEE/ E-waste in these dump site.

4.0 Refrigerators/ Washing Machine

4.1 Target Group: Manufacturers/ Assemblers/ Retailers/ Importers

The following information needs to be obtained from secondary sources and discussions with target group.

Product & industry

- Product category definitions, refrigerators/ washing machines, old and new product lines.
- Industry structure, major players, from component manufacture to disposal.

Market information

- Current market segmentation – sales across various product lines.
- Current market value
- Current market size
- Current market growth rate (%).
- Current major manufacturers / importers / suppliers
- Current market shares across major players
- Buyer / user segments – urban and rural, and within urban (high, middle and low income groups)
- Market differentiation – first time Vs replacement / upgradation – percentage breakdown relevant to study area.
- Current market penetration in urban and rural (%)
- Estimate of the refrigerator/ washing machine population base in study area
- Existence of a grey (assembled, not recycling) markets in refrigerator/ washing machine and what percentage of the total refrigerator/ washing machine market?
- Future market projections
- Imports of working second hand as well as non-working waste refrigerator/ washing machine. Views of major manufacturers on the future refrigerator/ washing machine industry and projected increase in sales.
- Views of major manufacturers on the assemblers (grey) market, if any.
- Views of major manufacturers about the reuse market and whether or not major manufacturers face competition from such products in the urban market.

Product replacement trends

- Replacement cycle for an average urban household?
- Estimation of the lifetime of a typical refrigerator/ washing machine.

Recycling & waste-related

- Post-use component classification – identifying those for reuse, those for recovery and those for disposal.
- Identification of the recycling chain – middlemen, stockists and those undertaking physical recovery.
- Types of recyclers (reuse and recovery) – in-company (buy-back schemes), formal and informal.
- Methods for recycling (reuse and recovery).
- Environmental impacts of recovery operations.
- Types of recovery operations done, e.g. segregation, re-gassing of compressor/ rewinding of motor, extraction and burning.

- Estimates of the quantity and market value of the recycling (reuse and recovery) market.
- Estimates of the percentage and time period for a typical refrigerator/ washing machine to find its way for reuse, recovery and disposal.
- Views of major manufacturers of the problems and opportunities in coordinating organised recycling through buy-back schemes.
- Quantity of waste generated and disposed from the manufacturing facilities directly.
- Views on the major components that have value for reuse and recovery.
- Views on best practices for recovery, wherever it is being practiced.
- Estimate of the breakdown between first time buyers and replacement buyers
- Replacement cycle for an average household.
- Estimates of the quantity and market value of the recovery market that refrigerator/ washing machine generate.

Others

- Government policies pertaining to the industry
- Government policies pertaining to wastes generated by the industry
- Census survey information on population and other statistics pertaining to refrigerator/ washing machine.

4.2 Target Group: Consumer / End User

The following information needs to be obtained from secondary sources and discussions with consumers / end users:

- Views of the frequency of replacement cycle across different income segments.
- Views on exchange schemes and their level of attractiveness
- Views on upgrading to new technology, e.g. from ODS to non ODS based compressors.
- Whether priority given to refrigerators/ washing machines in relation to other consumer electrical and electronic items such as TV/microwave ovens.
- Views on purchases from grey and used refrigerators/ washing machines market, particularly in the middle and low-income segment.
- Disposal practices adopted for old refrigerators/ washing machines i.e. store in the attic or exchange scheme or give-away or junk in the dustbin.

4.3 Target Group: Service Centre / Repair / Reuse

There are two types of service centres: (a) company-owned and (b) local. Both these have to be covered. The following information needs to be obtained from secondary sources and discussions with service centres for repairs and reuse.

Service scenario

- Estimate of the number of service centres in study area.
- Views on the viability of repair taking into consideration the cost of new components and new refrigerator/ washing machine.
- Estimate of the number of refrigerators/ washing machines that have been received for repair – percentage of those that are returned after proper repair – percentage of the remaining that can be stripped for components, used for recovery and finally disposed.

Recycling & waste-related

- Estimate of waste quantity, i.e. old refrigerators/ washing machines and components, sold annually and the price obtained for them in the different service centres.
- Estimate of waste quantity likely to be generated from all the service centres.
- Disposal practices adopted for old refrigerators/ washing machines and components e.g. use of middlemen or junk in the dustbins.
- Information on whether or not the old refrigerator/ washing machine and components go outside of study area. If so, what is the extent and why?
- Visual inspection of the storage area of old refrigerators/ washing machines and components to determine whether segregation is done.
- Information on good practices and bad practices of the recovery recycling that is being done elsewhere in study area.

4.4 Target Group: Importer

The following information needs to be obtained from importers, custom agencies and port authorities:

Material sourcing

- Quantity of imports of used and waste refrigerators/ washing machines, import category number, country of origin, final destination of bulk WEEE/E-waste cargo

4.5 Target Group: Waste Market

The following information needs to be obtained from secondary sources and discussions with waste traders – both formal and informal traders. This covers importers, scrap dealers / agents (large and small) and traders:

Material sourcing

- Different sources of their material i.e. waste refrigerator/ washing machine and components, only domestic or imported as well.
- Quantity of wastes from refrigerator/ washing machine manufacturing factories, end users.
- Quantity from auctions, imports, percentage of working and non working refrigerator/ washing machine
- Trends in the availability of their material.

4.6 Target Group: Recovery Recycler

The following information needs to be obtained from secondary sources and discussions with recovery recyclers – both formal and informal. This covers both the scrap dealers / agents (large and small) and those involved in the physical recovery operations:

Raw material sourcing

- Different sources of their raw material i.e. waste refrigerator/ washing machine and components, only domestic or imported waste as well.
- Quantity of wastes from refrigerator/ washing machine manufacturing factories reaching recovery recycling.
- Trends in the availability of their raw material.

Recovery operations

- Types of recovery operations done, e.g. segregation, re-gassing of compressors/ rewinding of motors, extraction and burning.
- Environmental impacts of these recovery operations.
- Good practice and bad practice information on the methods and operations adopted.
- Views on the size of the recovery operations.
- Information on the financial viability of these recovery operations.

Final recovered products

- Different final applications of their produce. Good and bad practice information associated with those methods and operations.

Recovery market information

- Estimate of the size of the recovery market based on waste refrigerator/ washing machine and components in study area.
- Information on whether or not the old refrigerator/ washing machine and components after recovery go outside of study area. If so, which locations? To what extent and why?

4.7 Target Group: Disposal

The following information needs to be obtained from secondary sources, visit to the dump yards and discussions with representative-in-charge of the dump sites:

- Estimate of the quantity of WEEE/ E-waste received in the particular dump site.
- Estimate of the total quantity of WEEE/ E-waste reaching the entire dump site.
- Information on whether rag pickers are collecting WEEE/ E-waste in these dump site.

5.0 Cellular Phones

5.1 Target Group: Manufacturers/ Assemblers/ Retailers

The following information needs to be obtained from secondary sources and discussions with target group:

Products & Industry

- Industry structure – major players – from product importers, retailers, service providers, users, service centres and disposal.
- Product category definitions – GSM and CDMA – B&W and colour - Price range.

Market information - mobile

- Current market segmentation – sales across various product lines.
- Current market value.
- Current market size.
- Current market growth rate (%).
- Market differentiation – first time Vs replacement (%) – Changing trends in the split between first time and replacement - Lifespan of a typical mobile handset.

- Current major companies / importers / suppliers (market shares across these companies).
- Grey market size, comparison with the regular market, trends in the grey market, i.e. increasing or shrinking – price differentials vis-à-vis products of the regular market.
- Future of the cellular phone industry, market trends and total projected sales increase
- Future plans to establish manufacturing of cellular phones in study area.
- Imports of working second hand as well as non-working waste cellular phones. Views of major companies on the future cellular phone industry and projected increase in cellular phone sales and users in urban and rural area.
- Views of major companies on the gray market and the competition from this market.
- Views of major companies about the reuse market and whether or not major players face competition from such products in the urban and rural market.

Market information - subscribers

- Major service providers in study area, their market shares and total subscriber base with respect to time.
- Monthly increase in the subscriber base in rural and urban area.

- Buyer / user segments in urban and rural area (high, middle and low income groups).
- Current market penetration in urban and rural area (%).
- Future of the cellular phone subscriptions – market trends – total projected increase.

Recycling & waste-related

- Post-use component classification – identifying those for reuse, those for recovery and those for disposal.
- Identification of the recycling chain – middlemen, stockists and those undertaking physical recovery.
- Types of recyclers (reuse and recovery) – in-company / retail (exchange schemes), formal and informal.
- Methods for recycling (reuse and recovery)
- Types of recovery operations done, e.g. segregation, extraction and burning.
- Environmental impacts of recovery operations
- Estimates of the quantity and market value of the recycling (reuse and recovery) market.
- Estimates of the percentage and time period for a typical Cellular Phone to find its way for reuse, recovery and disposal. Views of major companies of the

problems and opportunities in coordinating organized recycling through buy-back schemes.

- Views on the major components in a typical Cellular Phone that have value for reuse and recovery.
- Views on best practices for recovery.

Others

- Government policies pertaining to the industry
- Government policies pertaining to wastes generated by the industry
- Census survey information on population and other statistics pertaining to Cellular Phones

5.2 Target Group: Mobile service providers

The following information needs to be obtained from secondary sources and discussions with mobile service providers:

- Major service providers their market shares and total subscriber base in the current month
- Monthly increase in the subscriber base in study areas.
- Buyer / user segments (high, middle and low income groups)
- Current market penetration (%)
- Future of the Cellular Phone industry, market trends, total projected increase in subscribers.

5.3 Target Group: Consumer / End User

The following information needs to be obtained from secondary sources and discussions with consumers / end users:

- Views of the frequency of replacement across different income segments, i.e. high, medium and low income
- Views on exchange schemes and their level of attractiveness
- Views on upgrading to new technology – of the different consumer items, are Cellular Phones most likely to be upgraded when new technology becomes available?
- Views on purchases from gray and used Cellular Phones market, particularly in the low-income segment.
- Disposal practices adopted for old Cellular Phones, i.e. store at home or exchange scheme or give-away to others or junk in the dustbin.

5.4 Target Group: Service Centre / Repair / Reuse

There are two types of service centres: (a) company-owned and (b) local. Both these have to be covered. The following information needs to be obtained from secondary sources and discussions with service centers for repairs and reuse.

Service scenario

- Estimate of the number of service centers in study area.
- Views on the viability of repair taking into consideration the cost of new Cellular Phones.
- Estimate of the number of Cellular Phones that received for repair, percentage of those that are returned after proper repair, percentage of the remaining that can be stripped for components, used for recovery and finally disposed.

Recycling & waste-related

- Estimate of waste quantity, i.e. unusable Cellular Phones and components, generated annually. Are these sold locally? If so, what's the price obtained for them in the different service centres? Are these sent back to the manufacturers?
- Estimate of waste quantity likely to be generated from all the service centres.
- Disposal practices adopted for unusable Cellular Phones and components e.g. use of middlemen or junk in the dustbins.
- Information on whether or not the unusable Cellular Phones and components go outside of study area. If so, what is the extent and why?
- Visual inspection of the storage area of unusable Cellular Phones and components to determine whether segregation is done.
- Information on good practices and bad practices of the recovery recycling that is being done elsewhere in study area.

5.5 Target Group: Importer

The following information needs to be obtained from importers, custom agencies and port authorities:

Material sourcing

- Quantity of imports of used & waste Cellular Phones, import category number, country of origin, final destination of bulk WEEE/E-waste cargo

5.6 Target Group: Waste Market

The following information needs to be obtained from secondary sources and discussions with waste traders (both formal and informal traders). This covers importers, scrap dealers / agents (large & small) and traders:

Material sourcing

- Different sources of their material i.e. waste Cellular Phones and components, only domestic or imported as well.
- Quantity of wastes from Cellular Phones manufacturing factories, end users.
- Quantity from auctions, imports, % of working and non working Cellular Phones
- Trends in the availability of their material.

5.7 Target Group: Recovery Recycler

The following information needs to be obtained from secondary sources and discussions with recovery recyclers (both formal and informal recyclers). This covers both the scrap dealers / agents (large & small) and those involved in the physical recovery operations.

Raw material sourcing

- Different sources of their raw material, i.e. unusable Cellular Phones and components, only domestic or imported waste as well.
- Quantity of waste from the Cellular Phone manufacturing facilities reaching the areas recycling sector.
- Trends in the availability of their raw material

Recovery operations

- Types of recovery operations done, e.g. segregation, extraction and burning.
- Environmental impacts of these recovery operations

- Good practice and bad practice information on the methods and operations adopted.
- Views on the size of the recovery operations
- Information on the financial viability of these recovery operations.

Final recovered products

- Different final applications of their produce. Good and bad practice information associated with those methods and operations.

Recovery market information

- Estimate of the size of the recovery market based on unusable Cellular Phones and components in study area
- Information on whether or not the unusable Cellular Phones and components after recovery go outside of study area. If so, which locations? To what extent and why?

5.8 Target Group: Disposal

The following information needs to be obtained from secondary sources, visit to the dump yards and discussions with representative-in-charge of the dump sites:

- Estimate of the quantity of WEEE/ E-waste received in the particular dump site.
- Estimate of the total quantity of WEEE/ E-waste reaching the entire dump site.
- Information on whether rag pickers are collecting WEEE/ E-waste in these dump site.

Appendix 2

Example Proforma No.1

Dated	Date/ Month/ Year
Survey Type	Computer Vendor Survey
Area	Main Market
Name of Shop	ABC Computers
Number of persons	3
Area of establishment	10*15 feet
Repair facility	In house and sublets to local repair shops in markets
Waste Generation	Once in two years
Waste Quantity	5-10 kgs
Who purchase the waste	Scrap Vendors in market
Type of Business	Sale purchase of old laptops/ PC
Source of Material supply	Local markets and imports from X, Y, Z etc.
Major Findings: Selling Rates: □ 486:$ X □ P1: $ Y □ P2: $ Z □ P3: $W No warranty provided Purchase cost: □ 486: $X1 □ P1: $Y1 □ P2: $Z1 □ P3: $W1 Based on condition of the laptop	
Next Steps	More detailed study of scrap dealers and local repair shops

Example Proforma No.2

Dated	Date/ Month/ Year
Survey Type	Scrap Vendor Survey/ Collector
Area	Main Market
Name of Shop	Payment Dweller
Number of persons	1
Area of establishment	
Repair facility	
Waste Generation	Daily
Waste Quantity	5-10 kgs
Who purchase the waste	Scrap Vendors in Dismantler Market
Type of Business	Scrap purchase, sorting, selling the useable components to repair or old system shops, remaining sold to scrap dealers in dismantler market
Source of Material supply	Repair shops in main market, old system shops, direct walk in customer, annual maintenance contractor's establishment as well as MNC etc.
Major Findings: Selling cost of products Individually: Hard disk: $X2 Lan card: $Y2 Cable: $Z2 Fan (SMPS): $W2 Fan (CPU): $W3 Total waste as observed: Hard disk: $X3 LAN card: $Y3 Cable: Z3 Fan (SMPS): W4 Fan (CPU): X3Y3	
Next Steps	More detailed study of scrap dealers in main market and dismantling market and local repair shops

Example Proforma No.3

Dated	Date/ Month/ Year
Survey Type	Scrap Vendor Survey
Area	Dismantling Market
Name of Shop	XYZ Scrap Dealer, Street No.
Number of persons	5
Area of establishment	10*15
Repair facility	
Waste Collection	Daily
Waste Quantity collected	25-50 kgs
Who purchase the waste	Metal Extractor in Extraction Market and glass sold to trader X in Market X and CPU gold sold to trader in Market Y
Type of Business	Segregation, physical removal of ICs from wire board and then selling component wise
Source of Material supply	Scrap vendors in main market sometime direct dealing with companies
Major Findings: Selling price: Plastic: PVC: $ X/kg Plastic ABS: $Y/kg Process: Crushed, heated, cooled, then shredded to make plastic grains used for manufacturing of new products CPU: Gold Extraction in Market Y CPU: $ X to Y/piece Material recovered: $Z ICS: after heating on stove physically plucked out with pluckers Large ICs: $A / kg Medium: $B/ kg Small: $C/kg CRT: Re-gunning and sold to TV manufacturer for B/W TV CRT: $D/piece Those CRT which have no use are crushed and sold to glass dealers in glass market. Motors are physically separated from printer and CD Rom for usage in toy manufacture. Motor: either $/ kg or per piece Total quantity of waste stored: E kg Component wise: Printer: Numbers Mother board: Numbers CPU: Numbers Cabinet: Numbers Monitor: Numbers Hard disk: Numbers Casing (Plastic): kg Cable: kg Keyboard: Numbers Mouse: Numbers Batteries: Numbers	
Next Steps	More detailed study of scrap dealers and metal extractors

Example Proforma No.4

Dated	Date/ Month/ Year
Survey Type	Computer Repair shop Survey
Area	Main Market
Name of Shop	
Number of persons	4
Area of establishment	10*12
Repair facility	In house
Waste Generation	Once in two years
Waste Quantity	5-10 kgs
Who purchase the waste	Scrap Vendors in Main Market
Type of Business	Repair Shop
Source of Material supply	Walk in customers, AMC, Old computer shop, other establishments
Major Findings: Repair costs: □ Mother Board: $ X □ SMPS: $ Y □ Hard Disk: $ Y □ CD Rom: $Z Process is to replace the faulty component by identifying the fault by electronic meter. Faulty components are arranged from the old components lying with the vendor. Stock in house: Kg/ Numbers Hard Disk: Numbers Mother Board: Numbers SMPS: Numbers CD Rom: Numbers	
Next Steps	More detailed study of scrap dealers and local repair shops

Appendix 3

Process No.1

Visited Processing Site Name, Address, Contact Person — Area/ Market/ Street

Date: Date/ Month/ Year

Person Responsible for Survey

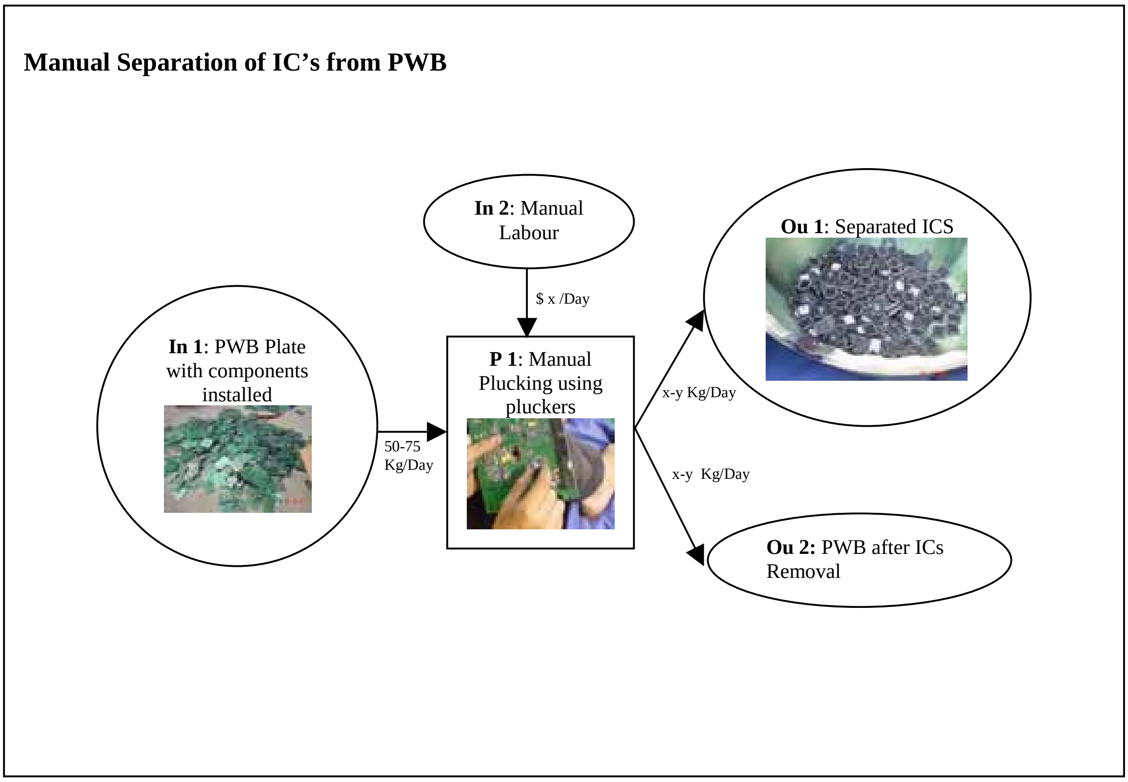
Coordinate (GPS) — Lat/ Long

Type of Processed Material — IC's Extraction from PWB

Quantity of Processed Material — X-Y Kgs/day

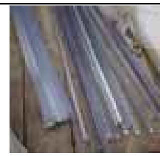
Number of Employees/ Working Hours — 5; 9 A.M. to 5 P.M. even beyond depending on material

Process Flow



Process				
	Name	**GPS**	**Description** Detailed Description of the Technologies applied; thermal recovery, landfill, environment, open burning, transport (Vehicle Type, Distance) 1. Health and Safety Measures 2. Labour intensity (Persons*hours/Processed Material) 3. Average Wages of employees, taxes paid to public authorities, cost of equipments, etc	**Photo Documentation**
P 1	Manual Plucking of IC's		Small pluckers are used to remove IC's from the plate Input Material Comes in boxes comes through rickshaws or autorickshaws from supplier Labour Intensity: =X man hours/Kg of processes material Average Wage: @ $ X /Day	 

Input				
	Material/Energy	**Price $/Unit**	**Description** Supplier, Specification	**Photo Documentation**
In 1	PWB	$ X-Y/Kg	Manufacturing companies and imports	
In 2	Manual Labour	$ X-Y/Kg of processed material	Belonging to a particular area/ socio-economic section/ strata	

Output				
	Material/Energy	**Price $/Unit**	**Description** Costumer, Specification	**Photo Documentation**
Ou 1	ICs	Different ICs different rates some time per kg sometime per piece	Manufacturing companies, Tv or Deck Assemblers etc $ X-Y/Kg $ X-Y/piece of IC	  
Ou 2	PWB without ICs	$ X-Y/Kg	For removal of capitor etc it will go to people who heat the PWB and remove the material, located in the same area close by	

Process No.2

Visited Processing Site Area/ Market/ Street
Name, Address, Contact Person

Date: Date/ Month/ Year

Person Responsible for Survey

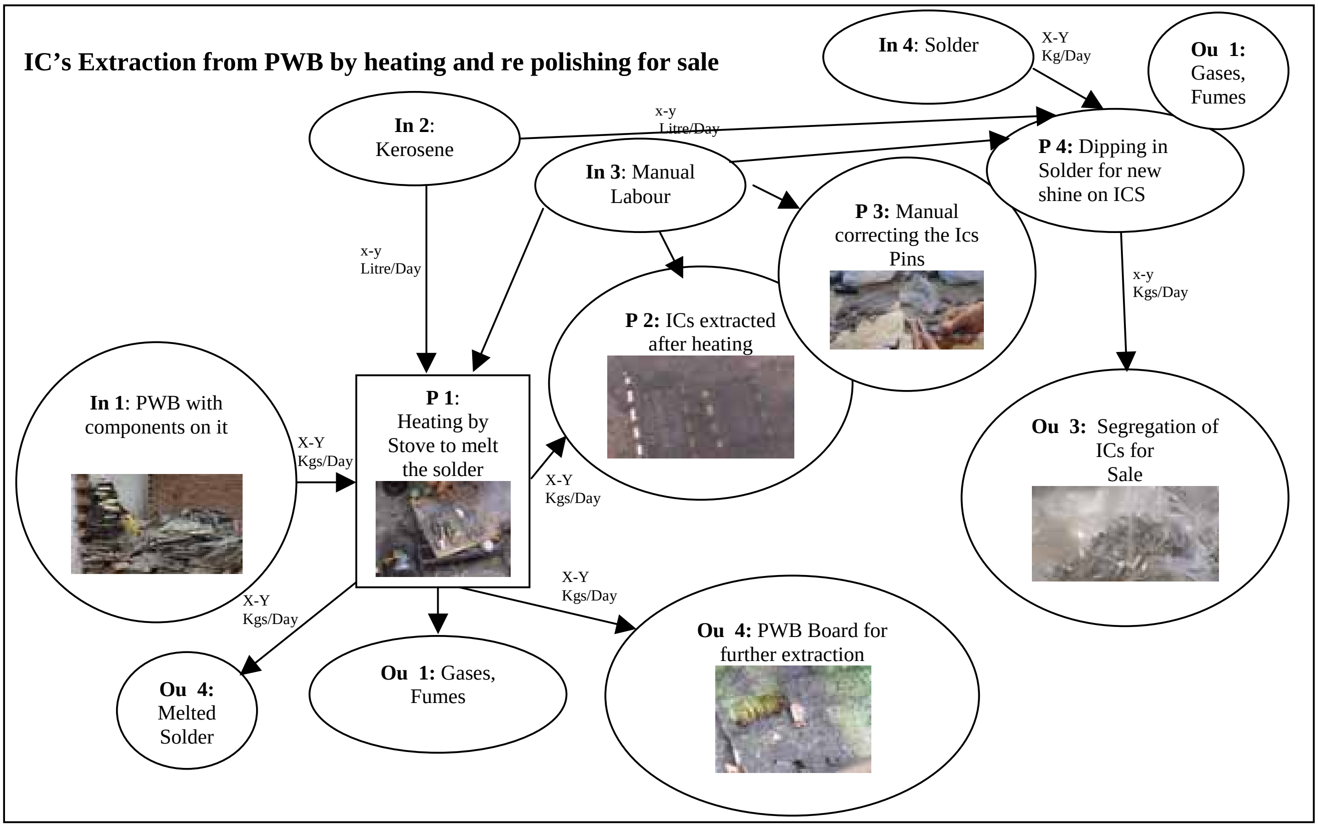
Coordinate (GPS) Lat/ Long

Type of Processed Material IC's Extraction from PWB by heating and re polishing for sale

Quantity of Processed Material X-Y Kgs/day

Number of Employees/ 2
Working Hours 9 A.M. to 3 P.M. even beyond depending on material

Process Flow



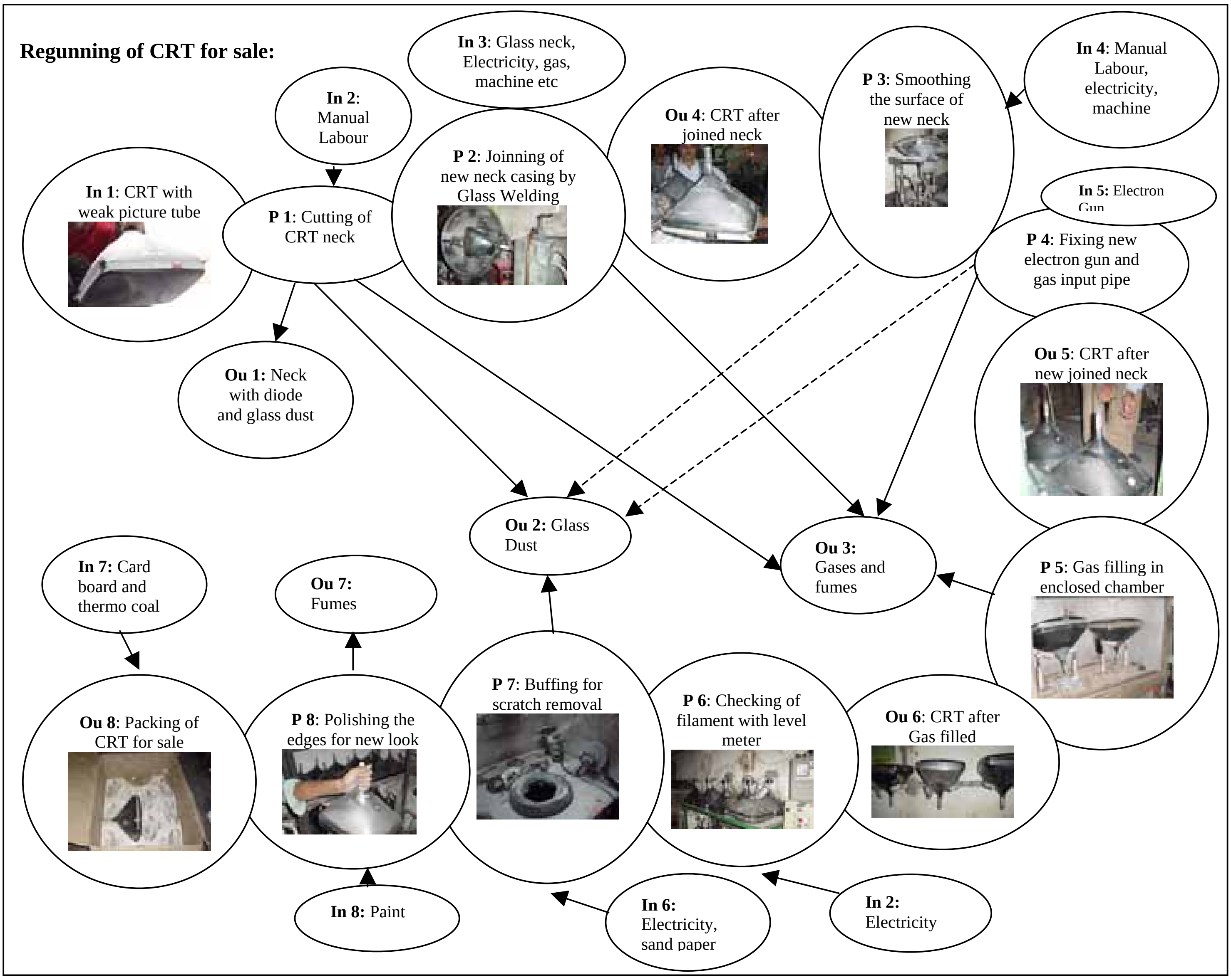
Process No.3

Visited Processing Site Area/ Market/ Street
Name, Address, Contact Person

Date: 17th November, 2003

Person Responsible for Survey
Coordinate (GPS) Lat/ Long
Type of Processed Material Regunned CRT's
Quantity of Processed Material X-Y Piece/day
Number of Employees 9-10
Working Hours 10 A.M. to 4 P.M. even beyond depending on material

Process Flow



Process				
Code	**Name**	**GPS**	**Description** Detailed Description of the Technologies applied; thermal recovery, landfill, environment, open burning, transport (Vehicle Type, Distance) 1. Health and Safety Measures 2. Labor intensity (Persons*hours/Processed Material) 3. Average Wages of employees, taxes paid to public authorities, cost of equipments, etc	**Photo Documentation**
For complete Process			Labor Intensity: X hours/piece Average Wage: $ X /Day	
P 1	Cutting of CRT neck		In this process with the help of diamond cutter the existing neck is removed. This process results is release of gases, glass dust and broken glass.	
P 2	Joining of new neck casing by Glass Welding		In this process the CRT tube after neck removal is placed on a machine which revolves and new neck is closely placed with a machine arm which holds it close to CRT, a three way flame is pointed for joining the new neck glass to the CRT. This process results in gases, heat and fumes.	
P 3	Smoothing the surface of new neck		In this process CRT is placed inverted on a machine with neck downwards then a small rod equivalent to the size of the neck internal diameter is inserted and revolved so as to smooth the welded portion of the glass. Generation of glass dust.	
P 4	Fixing new electron gun and gas input pipe		In this process the new electron gun is fixed into the neck glass (it get fixed like a cork) and made ready for gas filling.	

Process Code	Name	GPS	Description	Photo Documentation
			Detailed Description of the Technologies applied; thermal recovery, landfill, environment, open burning, transport (Vehicle Type, Distance) 1. Health and Safety Measures 2. Labor intensity (Persons*hours/Processed Material) 3. Average Wages of employees, taxes paid to public authorities, cost of equipments, etc	
P 5	Gas filling in enclosed chamber		In this process the gas is filled into the CRT through new gas filling pipe attached along with electron gun which is later on removed after gas filling, in enclosed chamber where the pressure and temperature both are maintained through external meters attached to it. Release of gas, fumes and heat.	
P 6	Checking of filament with level meter		After gas filling the CRT are attached to a filament meter which helps in checking the resistivity which helps to judge whether picture output from the newly filled CRT will be ok or not.	
P 7	Buffing for scratch removal		In this process the front screen of CRT is rubbed with sand paper through a mechanical arm which revolves and peel off a layer of glass from the screen so as to give a fresh look to CRT. Generation of Glass dust.	
P 8	Polishing the edges for new look		In this process black paint is painted along the side walls of CRT. Paint fumes.	

Input				
Code	**Material/Energy**	**Price $/Unit**	**Description** Supplier, Specification	**Photo Documentation**
In 1	CRT with weak picture tube	Black and white: $/piece Colour: $/Piece	Monitor Dissemblers	
In 2	Manual Labour	$/day	Belonging to a particular area/ section	
In 3	Glass neck , Electricity and Gas	Neck + Electron gun: 1. Colour: $/Piece 2. B/W: $/Piece Elec: $/unit X-Y Units /day Gas: 1-2 Cylinder /Day Cost:	Foreign Country Grid Supply Local Market	
In 5	Electron gun with gas pipe	Neck + Electron gun: 1. Colour: $/Piece 2. B/W: $/Piece	Foreign Country	
In 6	Sand Paper	$/Paper 10 papers	Local Market	
In 7	Card Board and Thermocol	Number boxes $/Box with thermocol	Local Market	
In 8	Black Paint	$ X-Y/Liter	Local Market	

Outputs				
Code	**Material/Energy**	**Price $/Unit**	**Description** Costumer, Specification	**Photo Documentation**
Ou 1	Neck with diode and glass dust	Nil	WEEE/ E waste Fraction	
Ou 2	Glass Dust	Nil	WEEE/ E Waste Fraction	
Ou 3	Gases and Fumes	Nil	WEEE/ E Waste Fraction	
Ou 8	CRT after Regunning	B/W: $X-Y /Piece Colour: $X-Y/Piece	Wholesale electronic market	

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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.
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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

UNEP

This book is the first volume of E-waste manual to build the capacity of practitioners and policy makers for preparing WEEE/E-waste inventory. The objective of the manual is to identify E-waste as an environmental issue and to quantify its extent.

This manual summarises the available legislations on WEEE/E-waste in different countries and provides a methodology to design and use E-waste inventory assessment studies/projects.

Furthermore, E-waste management chain (starting from electrical and electronic equipment manufacture, production, import, consumption, E-waste generation, treatment and disposal) has been discussed to identify the "mechanism of trading" and related socio-economic and environmental risks.

Methodologies for E-waste inventory assessment in a city/ geographical area/country have been elaborated with reference to developing countries.

This manual also provides case studies from developing countries.

DTI/0989/PA