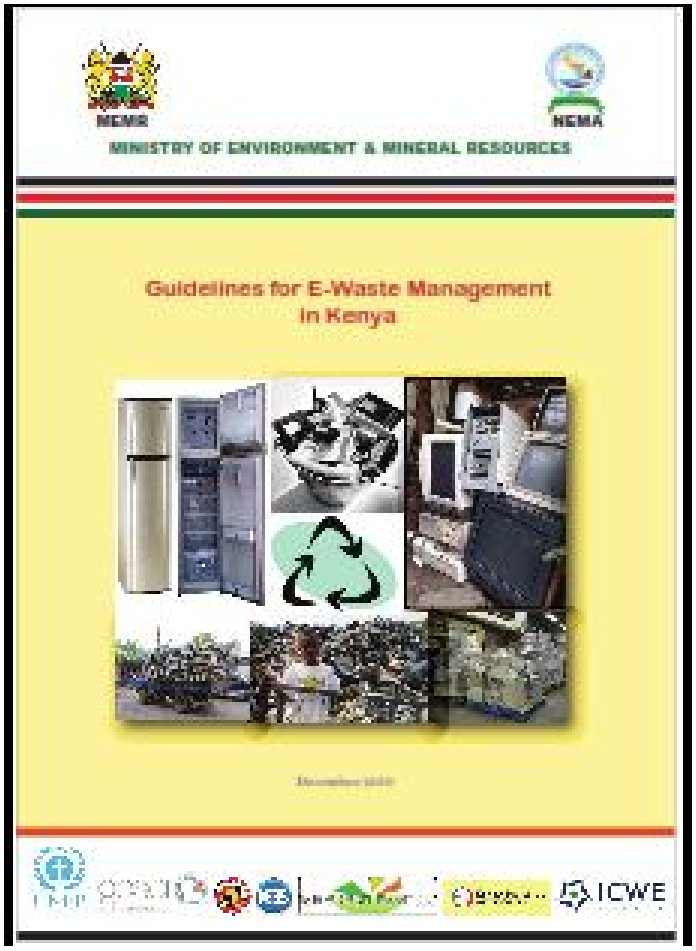
NEMA
MINISTRY OF ENVIRONMENT & MINERAL RESOURCES
Guidelines for E-Waste Management
In Kenya
ICWE

NATIONAL ENVIRONMENT MANAGEMENT AUTHORITY

Guidelines for E-Waste Management in Kenya

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TABLE OF CONTENTS

List of Tables

List of Figures

DEFINITION OF TERMS

Basel convention and Bamako conventions. The Conventions recommend that signatories ensure that the generation of hazardous waste and other waste within a country are reduced to a minimum, taking into account social, technological and economic aspects. Secondly, where a country exporting hazardous waste does not have the technical capacity, necessary facilities or suitable disposal sites to dispose of the waste in question in an environmentally sound and efficient manner, steps must be taken to minimise pollution and its consequences for health.
Chlorofluorocarbon (CFC) is a compound consisting of chlorine, fluorine, and carbon. CFCs are commonly used as refrigerants, solvents, and foam blowing agents.
Collector means a person who receives e-waste directly from a residence for recycling or processing for reuse. "Collector" includes, but is not limited to, manufacturers, recyclers, and refurbishers who receive e-waste directly from the public.
Electrical equipment includes any machine powered by electricity. They usually consist of an enclosure, a variety of electrical components, and often a power switch. Examples of these include: major appliance, microcontroller, power tool and small appliances. It also often refers only to the components part of the electrical distribution system such as: Electric switchboards, distribution boards, circuit breakers and disconnects, electricity meter and transformers.
Electronic Equipment is equipment that involves the controlled conduction of electrons (especially in a gas or vacuum or semiconductor) e.g. amplifier, audio and sound system, cassette player, CD player, Cathode Ray Oscilloscope, detector, equalizer, mixer, modem, telephone etc.
Environmental Audit (EA) is a systematic evaluation of activities and processes of an ongoing project to determine how far these activities conform to the Environmental Management Plan of that specific project and sound environmental management practices.
Environment Impact Assessment (EIA) is a systematic examination conducted to determine whether or not an activity or project will have any significant impacts on the environment, provide mitigation for the adverse impacts and optimize the positive impacts.
Extended Producer Responsibility (EPR) is an environment protection strategy that makes the producer responsible for the entire life cycle of the product, especially for take back, recycle and final disposal of the product.
E-waste is a term encompassing various forms of electrical and electronic equipment that are old, end-of-life electronic appliances that have ceased to be of any value to their owners. (definition by UNEP)
Hydrochlorofluorocarbon (HCFC) is a compound consisting of hydrogen, chlorine, fluorine, and

carbon. The HCFCs are one class of chemicals being used to replace the CFCs.
Polychlorinated biphenyls (**PCB**s) are a class of organic compounds with 1 to 10 chlorine atoms attached to a molecule composed of two benzene rings. They are widely used for many applications, especially as dielectric fluids in transformers, capacitors, and coolants. They are toxic and are classified as Persistent Organic Pollutants (POPs).
Producer Responsibility Organisation (PRO) is a delegated extended producer responsibility (EPR) by the producer to a third party, which is paid by the producer for spent-product management.
Recycler is a person who engages in treating or processing (of used or waste materials) to make them suitable for reuse.
Recycling is the processing of used materials (waste) into new products to prevent waste of potentially useful materials, reduce the consumption of fresh raw materials, reduce energy usage, reduce air pollution and water pollution by reducing the need for "conventional" waste disposal or producing a new product from a recyclable material.
Refurbisher means a person who renovates or processes e-waste for reuse, but does not include telecommunications carriers, telecommunications manufacturers, or commercial mobile service providers with an existing recycling programme.
Strategic Environmental Assessment (SEA) is a system of incorporating environmental considerations into policies, plans and programmes. It is sometimes referred to as Strategic Environmental Impact Assessment.

ACRONYMS

ARF	Advanced Recycling Fee
BAT	Best Available Technologies
CCK	Communication Commission of Kenya
CCN	City Council of Nairobi
CFCs	Chlorofluorocarbons
CFSK	Computer for Schools Kenya
CDF	Constituency Development Fund
CoP	Conference of Parties
CPU	Central Processing Unit
CRT	Cathode Ray Tube
CSR	Corporate Social Responsibility
EMCA	Environmental Management and Co-ordination Act
HCFCs	Hydrochlorofluorocarbons
ICT	Information and Communication Technologies
ICWE	International Conferences Workshops and Exhibitions
KEBS	Kenya Bureau of Standards
KRA	Kenya Revenue Authority
LCD	Liquid Crystal Display
LCF	Licensed collection facility
MEMR	Ministry of Environment and Mineral Resources
MoIC	Ministry of Information and Communication
MoLG	Ministry of Local Government
MOU	Memorandum of Understanding
NGO	Non Governmental Organisation
NEAP	National Environment Action Plan

NEMA	National Environment Management Authority
PC	Personal Computer
PCBs	Polychlorinated biphenyls
PVC	Polyvinyl chloride
PRO	Producer Responsibility Organisations
SWOT	Strengths, Weaknesses, Opportunities and Threats
ULF	Unified Licensing Framework
UNCED	United Nations Conference on Environment and Development
UNEP	United Nations Environmental Programme
UPSs	Uninterrupted Powers Supplies
USA	United States of America
WEEE	Waste Electrical and Electronic Equipment

FOREWORD

The environment sector is important in economic development of Kenya. This is because the sector provides raw materials to support various economic activities and livelihoods. However, the sector is also the recipient of waste products from production and disposal processes often becoming harmful to both human health and the environment. The situation has been escalated by the increasing population, changing consumption patterns and lifestyles leading to increased reliance on electrical and electronic equipments. The resulting e-waste generated by these appliances is a major concern to sound environmental management in the country.

While the use of electronics has greatly improved efficiency and quality of life for Kenyans, electronic and electrical appliances generate e-waste at their end of life. The e-waste is a new and emerging waste that is causing environmental degradation due to limited capacity on its handling and disposal. The generation of e-waste has escalated due to increased access to low quality electronic goods and subsequent high rates of obsolescence. The situation is escalated by obsolete donations especially from developing countries which add to the high generation of e-waste.

Kenya like other countries has embraced ICT in both public and private sectors. As such, the country is facing the challenge of accumulated e-waste whose handling and disposal has not been substantively addressed by the present environmental laws. An estimated 50 million tonnes of e-waste is produced globally each year with Kenya generating an average of 3,000 tonnes e-waste from computers, monitors, printers, mobile phones, fridges and batteries among others. Lack of segregation and poor disposal systems has led to mixing of e-waste with ordinary waste in our dumpsites.

The e-waste Guidelines have been developed to streamline the procedures of handling and disposal of e-waste generated by various sectors. The e-waste guidelines provide a framework for identification, collection, sorting, recycling and disposing of electrical and electronic waste (e-waste). The guidelines provide the basis for developing legal instruments to enhance enforcement to lay down procedures. We are therefore determined to address e-waste to encourage separation to enhance material recovery and promote recycling.

In addition the country will explore other available options and opportunities contained in international instruments which Kenya is a signatory. For instance, the Bamako as well as Basel Conventions prohibits the importation of any hazardous waste. Kenya welcomes the provisions to ship e-waste back to the country of origin whenever such consignments are detected

It is important to note that the management of e-waste is in-line with the provisions of Vision 2030 which calls for a clean and healthy environment for development. The Guidelines are also in line with the Vision of the Ministry of Environment & Mineral Resources that aspires for a clean, secure and sustainably managed environment and mineral resources to support national prosperity. The management of e-waste will therefore enhance the quality of the environment by controlling the quantities of e–waste generated.

Signed by:

Hon John N. Michuki, EGH, MP
Minister for Environment & Mineral Resources

PREFACE

A clean and healthy environment is of utmost importance to all citizenry whether in the public or private sector. With global development and innovations in technology, electronic devices are a constant feature of day-to-day life. In this regard, the Kenyan government has rolled out an e-government programme to promote use of information and communication technology (ICT) in all sectors. The resultant waste from their usage has over the years accumulated, and now poses a threat to our environment.

E-waste management is an emerging challenge that requires a comprehensive mechanism to address it effectively. All sectors use electronic and electrical appliances thus generating e-waste. Although the telecommunication sector has put in place preliminary systems for the collection and call back systems, there is need for a national coordination in the management of e-waste in the country. In addition, manufacturers of specific products will be tasked to bear costs related to the collection and disposal of waste associated with their respective products.

The Ministry of Environment and Mineral Resources through NEMA has developed the e-waste Guidelines to streamline the collection and disposal of e-waste. A comprehensive awareness will be conducted among various stakeholders to build their capacity in handling and disposing e-waste. The guidelines have identified the various types of e-waste and mode of handling including transportation, sorting, treatment, recycling, re-use and disposal. The guidelines were developed through elaborate consultations with relevant stakeholder thus ensuring ownership and effective implementation.

A clean and healthy environment is critical for all. As such, the Ministry is determined to put in place relevant programmes to promote a high quality of the environment. Although the use of electronic and electrical appliances is necessary across all sectors, the resulting e-waste has to be addressed in order to balance environmental conservation and development in-line with the principles of sustainable development.

Signed by:

Mr. Ali D. Mohammed
Permanent Secretary
Ministry of Environment and Mineral Resources

ACKNOWLEDGEMENT

On behalf of the National Environment Management Authority, I wish to acknowledge the technical officers drawn from key lead agencies who worked tirelessly to formulate the e-waste guidelines. The major institutions represented included, Ministry of Environment and Mineral Resources, Ministry of Information and Communication, Ministry of Education, Ministry of Forestry and Wildlife, Communications Commission of Kenya, Kenya Revenue Authority, Department of Resource Surveys and Remote Sensing, Meteorological Department, Mines and Geology Department and Kenya Bureau of Standards. I also wish to thank the universities that participated in the process namely, University of Nairobi and Africa Nazarene University.

The technical support offered by international organizations such as, United Nations Environment Programme, Global e-Schools and Communities Initiative, International Conferences Workshops and Exhibitions (ICWE-Africa) is highly appreciated. In addition, local non-governmental organization namely, Computers for Schools Kenya and Masuro Consultants played an active role in the formulation of the e-waste guidelines.

Last but not least, I thank my own staff from NEMA who on top of being contributors to the formulation of the document also offered the Secretariat during the entire drafting process. The e-waste guidelines are therefore a product of broad consultations among relevant lead agencies which should make implementation easier.

It is my hope that these guidelines will provide practical strategies for the collection, handling and disposal of e-waste by various stakeholders. The guidelines will also form basis for the formulation of relevant e-waste regulations to facilitate the enforcement of standards and procedures stipulated for the appropriate to management of e-waste. The e-waste regulations will form part of the existing Waste Management Regulations (2006).

I am convinced that our concerted efforts will collectively enhance the quality of the environment.

DR. AYUB MACHARIA
AG. DIRECTOR GENERAL
NATIONAL ENVIRONMENT MANAGEMENT AUTHORITY

EXECUTIVE SUMMARY

Increased use of technology especially in ICT, low initial cost, and unplanned obsolescence of electrical and electronic equipment has led to an e-waste generation problem for Kenya. UNEP estimates the current e-waste generated annually in Kenya at 11,400 tonnes from refrigerators, 2,800 tonnes from TVs, 2,500 tonnes from personal computers, 500 tonnes from printers and 150 tonnes from mobile phones (Press Release UNEP, 2010). This high rate of accumulation of e-waste stems not only from the rapid pace of emerging technologies but also from e-waste disposal by developed countries in the form of used electronic equipment with short life-spans.

There are two key international conventions regulating waste management: the Basel and Bamako Conventions. The Conventions recommend that signatories ensure that the generation of hazardous wastes, and other wastes within a country, are reduced to a minimum, taking into account social, technological and economic aspects. Secondly, a country can export hazardous waste if it does not have the technical capacity, necessary facilities or suitable disposal sites to handle the waste in question in an environmentally sound and efficient manner. Steps must be taken to minimise pollution and its consequences for health as far as possible. It should, however, be noted that most developing countries are yet to legislate law and guidelines on e-waste and continue to act as dumping sites from developed countries.

The purpose of these guidelines is to assist the government, private sector, learning institutions and other stakeholders to manage electrical and electronic waste effectively to enhance environmental conservation. The development of these guidelines is one of the activities in the e-learning strategy for the environment sector. The e-learning strategy was developed in 2009 and adopted in April 2010. The guidelines have been developed through a consultative process involving various stakeholders in the environment sector as listed in Appendix 5.

The guidelines have been developed with the strategic objective of providing a framework for the development of regulations and policies in Kenya. Specific objectives of the guidelines include:

- To enhance environmental protection from e-waste.
- To establish a basis for a policy and regulatory frameworks on e-waste management.
- To raise public awareness on sustainable management of e-waste in Kenya.

Included in the guidelines are approaches to enhance environmental protection; policy and regulatory frameworks; environmental awareness; categories of e-waste and target groups; e-waste treatment technologies; and disposal procedures.

It is important to note that the guidelines are not a panacea for Kenya's e-waste problems, but will provide a basis for the development of e-waste regulations and an e-waste policy in Kenya. The following activities have been identified as necessary complementary to the development of the guidelines:

- The development of a regulatory framework to enable proper collection, recycling and to set the required standards for e-waste management. These guidelines will provide a basis for the development of this framework.
- The need to ensure that health and safety aspects of the people involved in the operations are protected, along with issues of emissions and waste emerging from such operations.
- The need to not only streamline the existing e-waste management systems from different stakeholders in the private and public sector but also to attract recyclers who could make the recycling process safe and efficient. This will create opportunities for employment through economically viable activities as a result of processing e-waste.
- Development of economic instruments by the Government such as land, financial subsidies etc., to ensure an efficient collection and recycling system and to attract would-be investors in this field

These guidelines have been divided into eight chapters. The background and rationale for the development of the guidelines are provided in Chapter 1. Chapter 2 presents the global and national context on the status of e-waste. In the same Chapter, there is provision for a SWOT analysis in which the strengths and opportunities of e-waste are identified. Chapter 3 elaborates on the legal and institutional framework on national laws and international conventions and agreements relating to environmental management. The different categories of e-waste that have been included in these guidelines are highlighted in Chapter 4. Guidelines for specific target groups are outlined in Chapter 5. The document ends with a discussion of the guidelines for collection and disposal systems, treatment technology for e-waste, and the establishment of integrated e-waste recycling and treatment as highlighted in chapters 6, 7 and 8 respectively.

CHAPTER ONE

1.0 BACKGROUND

The term e-waste is a generic term encompassing various forms of electrical and electronic equipment that are old, end-of-life electronic appliances, or have ceased to be of any value to their owners (UNEP). E-waste includes electronics which are destined for reuse, resale, salvage, recycling, or disposal. E-waste is the most rapidly growing problem in the waste stream due to its quantity, toxicity and carcinogenicity. Often, the toxic material is improperly disposed and thus poses a threat to human health and the environment.

Electrical and electronic waste (e-waste) poses one of the greatest environmental challenges globally and in particular to developing countries. Increased changes in technology especially in ICT, low initial cost, and high rates of obsolescence have resulted in a fast-growing surplus of e-waste generation in Kenya. UNEP estimates the current e-waste generated annually in Kenya at 11,400 tonnes from refrigerators, 2,800 tonnes from TVs, 2,500 tonnes from personal computers, 500 tonnes from printers and 150 tonnes from mobile phones (UNEP & UNU, 2009). This has resulted in e-waste management challenges that call for interventions.

It is in response to this need that these guidelines have been developed and will be key to the establishment of e-waste regulations and an e-waste policy for Kenya. Included in the guidelines are approaches to enhance environmental protection, policy and regulatory frameworks, environmental awareness, e-waste categories and target groups, e-waste treatment technologies, and disposal procedures.

1.1 Objectives

1.2.1 Strategic objective

To provide a framework for the development of regulations and policies with the participation of key stakeholders in the sustainable management of e-waste in Kenya.

1.2.2 Specific objectives

- To provide guidelines that will enhance environmental protection from e-waste
- To establish a basis for a policy and regulatory frameworks on e-waste management
- To raise public awareness on sustainable management of e-waste in Kenya.

1.2 Scope

These guidelines apply to the handling and management of the various categories and elements of e-waste in Kenya. The guidelines provide a clear mechanism for the management of e-waste

at various stages in the supply chain, the objective being to ensure the integrity of the environment is assured against the potential adverse impacts of e-waste and its elements.

1.3 Purpose

The purpose of these guidelines is to assist the government, private sector, learning institutions among others to manage e-waste in a manner that enhances environmental conservation.

1.4 Rationale

The guidelines will provide a regulatory framework to enable proper collection, recycling and to set the required standards for e-waste management. These guidelines will provide vital information to aid the development of a management framework. They will also ensure that health and safety aspects of the people involved in the operations are protected, along with issues of emissions and waste emerging from such operations. The existing e-waste management systems from different stakeholders will be streamlined and attract recyclers who make the recycling process safe and efficient. The guidelines will further enhance the development of economic instruments such as land, financial subsidies etc. to ensure an efficient collection and recycling system.

CHAPTER TWO

2.0 THE GLOBAL AND LOCAL CONTEXT ON E-WASTE

Increased economic growth has been facilitated by technology which has become an integral part of our daily life. Its use has generated opportunities, as well as challenges in the form of electrical and electronic waste (e-waste) and e-waste disposal. E-waste contains toxic and hazardous substances that pose a threat to human health and the environment. Different treatment and disposal systems have been used in various parts of the world.

2.1 The problem of e-waste

2.1.1 The global situation

Developed countries have various legislations and guidelines on e-waste. Their generated e-waste currently accounts for1% of total solid waste generation and is expected to grow to 2% by 2010. In the USA it accounts for 1% to 3% of total municipal waste generation. According to the European Community directive 2002/96/EC on Waste Electrical and Electronic Equipment (European Commission, 2010), e-waste is growing three times faster than average annual municipal solid waste generation. It is estimated that the total amount of e-waste generated in the 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 China and India however where annual generation per capita is less than 1 kg, it is growing at an exponential pace.

2.1.2 The Kenyan situation

The exact situation with regard to e-waste quantities in Kenya remains unclear due to the fact that a comprehensive baseline on e-waste in Kenya has never been undertaken. An assessment by UNEP (2009) estimates that Kenya generates 1,400 tonnes from refrigerators, 2,800 tonnes from TVs, 2,500 tonnes from personal computers, 500 tonnes from printers and 150 tonnes from mobile phones (UNEP, 2010). The mass flow study carried out in 2007 by Kenya ICT Action Network showed (Appendix 1) that 1,513 tonnes of electronics entered the market. The consumer in addition to receiving 1489.4 tonnes also received 151.3 tonnes from the second hand market. It was also revealed that consumers are likely to dispose 1,210.4 tonnes in the second-hard market, and 18.6 tonnes to collectors or as general waste which is sent to refurbishers. The consumer disposes a further 18.6 tonnes directly to recyclers. Refurbishers and recyclers then send 605.2 tonnes for disposal.

Although there have been initiatives by reputable firms to manage e-waste such Nokia through their recycling scheme and Computer for Schools through their refurbishment programme, the practices for managing e-waste are mostly handled by the informal sector (*Jua Kali*). Most of these operators have inadequate skills, are neither registered nor authorized and operate in a secretive manner. These operations are well connected to the supply chain processes of sourcing the raw material to finding markets for the recovered materials during post-recycling operations. The processes are highly toxic and impact adversely to both the environment and human health.

The lack of clear disposal mechanisms has resulted in excessive stocks being held by the consumer. The lack of well developed structures to handle e-waste disposal cause a 'drag' on waste volumes. A lot of the old technology is held in storage due to a lack of clear strategies and processes for disposal. Disposal options vary widely depending on the user. Government ministries and departments have to bond the computers and invite competitive tenders for disposal as scrap in line with procurement procedures. The process is slow and results in obsolete computers being held in government stores. Private sector corporations often donate the computers as charity to deserving users. Collectors, refurbishers and the recycling infrastructures are generally not developed and therefore the flow down the value chain has much lower volumes. Safaricom initiated a take back scheme which failed because of location of collection centres and lack of awareness and incentives for consumers.

2.2 Consequences of poor e-waste handling

The ecological, economic and social consequences resulting from poor handling and management of e-waste include:

Environmental consequences

- Air pollution, especially when e-waste is burnt
- Waste management problem of non-biodegradable equipment
- Toxicity and radioactive nature of e-waste to the human, water, soil and animals
- Blockage of water runoff channels
- Increased amount of waste
- Waste management disposal problem

Economic consequences

- Substantial public spending on health care
- Investments in complex and expensive environment remediation technologies
- Loss / waste of resources that can be recycled for re-use
- Opportunities for recycling industries and employment lost
- Ozone depletion has led to unpredictable weather conditions. Prolonged droughts and floods demand the use of resources which should be deployed for growth and development in other sectors

Social consequences

- E-waste affects people's health (e.g. lead poisoning and cancerous mercury).
- Growth of informal waste disposal centres in the neighbourhood
- Informal trade and management of e-waste
- Loss of appreciation for ICT

2.3 Swot Analysis

The ecological, economic and social consequences from e- waste could be turned into opportunities for the good of society as shown in Table 1.

Table 2.1: SWOT Analysis

Strengths	Weakness
• Kenya has identified the problem of e-waste and key stakeholders are involved • Potential employment creation and revenue generation source • MENR concept paper being developed • MoLG is developing a solid waste management policy. • CCK has developed solid waste management into licensing conditions • CCN is developing an integrated solid waste management strategy in conjunction with UNEP • Significant level of refurbishment is already taking place	• Lack of coordinated approach across the Ministries to deal with e-waste • Lack of awareness of the need for the e-waste management system • No mechanism to implement the policy intentions (e.g. MoIC policy statement) • Limited national capacity to process e-waste • Lack of a mechanism to separate e-waste from solid waste and a structured system of e-waste collection • None or limited extended producer/supplier responsibility • Lack of affordability of new IT • Lack of collection systems leads to e-waste being stockpiled at homes, office and repair shops • No national e-waste policy in Kenya • Lack of formal training in e-waste management
Threats	**Opportunities**
• Dumping of e-waste by developed nations • Hazardous nature of e-waste • No regulatory and policy structures to safeguard health, environment and social consequences of e-waste • Limited capacity of MENR, NEMA and other government agencies to deal with e-waste • Significant amount of second-hand equipment in the market with short remaining lifespan	• Willingness by stakeholders to contribute to e-waste management • CCN has allocated land to CFSK to build a national e-waste recycling centre • Employment opportunities • Informal business in recycling found around dumpsites can be formalized • Capacity in formal business can be developed • Some manufacturers e.g. (Sony Ericsson, LG) and suppliers and service providers (e.g. Safaricom) are implementing take back schemes • Funds available that can be used by small entrepreneurs (e.g. CDF, Youth and Women Fund)

2.4 Converting the challenges into opportunities

Despite the problem of e-waste, its proper management using environmentally sound systems, presents numerous socio-economic opportunities that can stimulate entrepreneurship, employment and enhancement of livelihoods.

a. **Recycling level**. Organisations and individuals that will be licensed to recycle will either create job opportunities or self-employ themselves. Experiences across the world indicate that the scale of operation for recycling e-waste is growing at viable and potentially profitable rates.

b. **Dismantling and refurbishing level**. The refurbisher extends the functional life of electronic or electrical equipment by breaking apart the end of use equipment and selling the parts that can still be used. This process, besides creating job opportunities, saves the environment by diverting large volumes of e-waste from energy-intensive down cycling processes where the equipment is reverted to raw materials for use in manufacturing. The environmental and social benefits of refurbishing and reuse include diminished demand for new products and virgin raw materials and diminished use of landfills.

c. **Collection level.** Through the Producer Responsibility Organization (PRO) and *take back* systems those who collect e-waste and hand it over to recyclers, refurbishers and treatment plants are paid a *take back* fee which in away provides for livelihoods.

d. **Creation of artificial mines.** It is a fact that e-waste contains hundreds of tonnes of various metals. These metals can be isolated, treated and made available for use in new forms. This is done by establishing metal separation facilities at landfills or e-waste deposits. This process not only creates employment but also reduces metal loading on e-waste deposit sites and hence reduces the risk of soil contamination, besides making available new metals for use

CHAPTER THREE

3.0 LEGAL AND INSTITUTIONAL FRAMEWORK

There are no specific national environmental laws or Guidelines for e-waste. None of the existing environmental laws make any direct reference to the handling of electronic and electrical waste. However provisions made for Environmental Management and Coordination (Waste Management Regulations) regulations 2006, may apply to electronic waste where they can be classified as hazardous waste.

3.1 Existing policy

3.1.1 International instruments

Kenya is a signatory to many agreements and conventions on environmental management. These include support for the provisions of Agenda 21 amongst other declarations and statements of principle, such as the Rio Declaration in 1992 on Environment and Development. Kenya is also party to the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal.

Kenya also supported the Nairobi Declaration on the Environmentally Sound Management of Electrical and Electronic Waste at the Conference of the Parties (CoP 8) meeting in Nairobi, 2007. The declaration sought to develop a work plan for the environmentally sound management of electrical and electronic waste (e-waste), focusing on the needs of developing countries and countries with economies in transition.

3.1.2 Sessional Paper No 6 of 1999 on Environment and Development

In 1999 the Government of Kenya produced the Sessional Paper No 6 on Environment and Development. The overall goal of the policy was to integrate environmental concerns into the national planning and management processes and provide guidelines for environmentally sustainable development. The policy paper identified areas requiring action which included development of comprehensive waste management policy, guidelines, and standards.

3.2 Legislation

The Environment Management and Coordination Act of 1999 is an ACT of Parliament that provides for the establishment of an appropriate legal and institutional framework for the management of the environment. The act allows the minister in charge of environment to gazette standards, regulations and guidelines for the proper management, conservation and protection of the environment.

The Environmental Management and Co-ordination (Waste Management) Regulations 2006, is the government's legal instrument that deals with waste management in Kenya. Although there is no direct provision for e-waste, the Waste Management Regulations 2006 apply to electronic waste by virtue of their composition which includes several of the substances listed as hazardous waste.

The Environment Management and Coordination (Controlled Substances) Regulations 2007, deals with management and control of substances that deplete the Ozone. However, the

regulations provide a list of hazardous substances but do not detail how they should be handled in relation to e-waste management.

3.3 Institutional framework

The Ministry of Environment and Mineral Resources

The Ministry of Environment and Mineral Resources (MEMR) is responsible for the environment at policy level. One of its key functions is the full implementation of the Environmental Management Coordination Act (EMCA) 1999 which defines hazardous waste, pollutants and pollution. To achieve this objective, the Ministry's role is to create an enabling environment through policy, legal and regulatory reforms for environmental and natural resources management.

The National Environment Management Authority

The National Environment Management Authority (NEMA) is the principal instrument of Government in the implementation of all policies relating to the environment. In the NEMA strategic plan 2010-12, key objectives include universal compliance and enforcement of environmental regulations, developing guidelines and standards and the prosecution of offenders failing to meet the provisions of the EMCA 1999. The lead agencies that are also pertinent to e-waste management include the Ministry of Information and Communication, Communication Commission of Kenya (CCK), Kenya Bureau of Standards (KEBS), Kenya Revenue Authority (KRA), Ministry of Education, Ministry of Local Government (MoLG) and City Council of Nairobi (CCN).

Ministry of Information and Communication

The Ministry of Information and Communication (MoIC) has recognised the potential challenge posed by e-waste and has included a clause in its 2006 policy document that specifically addresses the issue.

Communications Commission of Kenya

The CCK is working on issues of enforcement through the Unified Licensing Framework (ULF).

Ministry of Local Government

The Ministry of Local Government (MoLG) is developing a solid waste management policy and the CCN is developing an integrated solid waste management strategy in conjunction with UNEP.

3.4 Efforts towards development of an e-waste policy

MoIC has a clause that addresses e-waste in the 2006 policy. CCK is also working on the enforcement through the Unified Licensing Framework (ULF). MoLG is developing a solid waste management policy while CCN is developing an integrated solid waste management strategy in conjunction with UNEP. The development of these guidelines is expected to integrate the above developments to manage e-waste in the country effectively.

CHAPTER FOUR

4.0 E-WASTE CATEGORIES

This chapter describes the different categories of electronic and electrical appliances, the e-waste resulting from them and their levels of toxicity. It's important to note that these elements may be found in combination with others. The objective of this section is to understand different types of electrical and electronic equipment so that they may be disposed of appropriately through sorting, collection, dismantling, treatment and disposal. There are two broad categories of e-waste based on mode of operation and function and based on elemental composition.

NB: The list below is not exhaustive, but a guideline.

4.1 Categorization based on mode of operation and function

The classification of equipment is based on the mode of operation and function. It reveals the composition of physical components before dismantling in order to facilitate sorting. Table 2 shows some of e-waste categories

Table 4.1: E-waste categories

Type of e-waste	Examples of equipment
ICT and Tele-communications equipment	Mainframes, Printers, Personal computers (CPU, mouse, screen and keyboard included), Laptop computer, Networking equipment, Scanners, Mobile phones, CD / DVDs / Floppy Disks, UPSs, Radio sets, Television sets, Video cameras, Video recorders, Hi-fi recorders, Audio amplifiers and Musical instruments.
Office electronics	Photocopying equipment, Electrical and electronic typewriters, Pocket and desk calculators, Facsimile and Telephones.
Large Household Appliances	Refrigerators, Freezers, Washing machines, Dish washing machines, Cooking equipment, Microwaves, Electric heating appliances, Electric hot plates, Electric radiators, Electric fans, Air conditioner appliances, exhaust ventilation and conditioning equipment, large appliances for heating beds, rooms and seating furniture.
Small Household Appliances	Vacuum cleaners, Carpet sweepers, Water dispensers, Toasters, Fryers, Appliances for hair-cutting, hair drying, brushing teeth, shaving and massage; Electric knives, Clocks, Appliances used for sewing, knitting and weaving.
Consumer Equipment.	Equipment for turning, milling, sanding, grinding, sawing, cutting, shearing, drilling, punching, folding, bending or processing 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. Tools for mowing or other gardening activities,

Type of e-waste	Examples of equipment
	Sewing machines etc.
Toys, leisure and sports equipment	Electric trains or car racing sets, Hand-held video game, Video games, Computers for biking, diving, running, rowing, etc., Sports equipment with electric or electronic components.
Lighting	Fluorescent tubes, Compact fluorescent lamps, High intensity discharge lamps, including pressure sodium lamps and metal halide lamps; Low pressure sodium lamps, Other lighting or equipment for the purpose of spreading or controlling light with the exception of filament bulbs.
Medical equipment	Scanners, Operating equipments, Stethoscopes, Radiotherapy equipment, Cardiology, Dialysis, Pulmonary ventilators, Nuclear medicine equipment, Laboratory equipment for in-vitro diagnosis, Analysers, Freezers, Fertilization tests. Other appliances for detecting, preventing, monitoring, treating, alleviating illness, injury or disability.
Automatic dispensers	Automatic dispensers for hot drinks, Automatic dispensers for hot or cold bottles or cans, Automatic dispensers for solid products, Automatic dispensers for money, and other appliances which deliver automatically all kind of products.
Monitoring and control instruments	Smoke detectors, Heating regulators, Thermostats, Measuring, weighing or adjusting appliances for household or as laboratory equipment and other monitoring and control instruments used in industrial installations (e.g. in control panels).
Batteries	Lead Batteries, Nickel and Cadmium batteries etc.

4.2 Categorization based on element composition

This category is based on the physical, chemical and gaseous components found in the electrical and electronic appliances. They include epoxy resins, fiber glass, Polychlorinated biphenlys (PCBs), (polyvinyl chlorides) (PVC), chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), thermosetting plastics, lead, tin, copper, silicon, beryllium, carbon, iron and Aluminium. They also vary in quantity:

4.2.1 Elements found in small amounts

They include cadmium, mercury, and thallium.

4.2.2 Elements found in trace amounts

They include americium, antimony, arsenic, barium, bismuth, boron, cobalt, europium, gallium, germanium, gold, indium, lithium, manganese, nickel, niobium, palladium, platinum, rhodium, ruthenium, selenium, silver, tantalum, terbium, thorium, titanium, vanadium, and yttrium etc.

Almost all electronics contain lead and tin (as solder) and copper (as wire and printed circuit board tracks), though the use of lead-free solder is now being promoted all over the world. These substances can be divided further based on their level of toxicity to humans and the environment.

4.2.3 Hazardous elements

This category includes those elements that are harmful to the environment and human health; Table 3 below shows some hazardous elements in electrical and electronic equipment

Table 4:2: Hazardous elements in electrical and electronic equipment

Element	For example found in electrical and electronic equipment such as:
Americium	Smoke alarms (radioactive source).
Mercury	Fluorescent tubes (numerous applications); tilt switches (pinball games, mechanical doorbells, thermostats).
Sulfur	Lead-acid batteries.
PCBs	Prior to ban, almost all 1930s–1970s equipment, including capacitors, transformers, wiring insulation, paints, inks, and flexible sealants used PCBs.
Cadmium	Light-sensitive resistors, corrosion-resistant alloys for marine and aviation environments and nickel-cadmium batteries.
Lead	Old solder, CRT monitor glass, lead-acid batteries and formulations of PVC.
Beryllium oxide	Filler in some thermal interface materials such as thermal grease used on heat sinks of CPUs and power transistors, magnetrons, X-ray-transparent ceramic windows, heat transfer fins in vacuum tubes, and gas lasers
Polyvinyl chloride	PVC contains additional chemicals to change the chemical consistency of the product. Some of these additives can leach out of vinyl products e.g. plasticizers that are added to make PVC flexible.

4.2.4 Generally non hazardous elements

This category includes materials that are not harmful. They can be extracted from the used electrical and electronic appliances and applied elsewhere. They include;

Table 4.3 Non hazardous elements in electrical and electronic equipment

Element	For example found in electrical and electronic equipment such as:
Tin	Solder, coatings on component leads.
Copper	Copper wire, printed circuit board tracks, component leads.
Aluminium	Nearly all electronic goods using more than a few watts of power, including electrolytic capacitors.
Iron	Steel chassis, cases, and fixings.
Germanium:	1950s–1960s transistorized electronics (bipolar junction transistors).
Silicon	Glass, transistors, ICs, printed circuit boards.
Nickel	Nickel-cadmium batteries.
Lithium	Lithium-ion batteries.
Zinc	Plating for steel parts.
Gold	Connector plating, primarily in computer equipment.

CHAPTER FIVE

5.0 GUIDELINES FOR TARGET GROUPS IN E-WASTE MANAGEMENT

There is no system to manage the various groups involved in the management of e-waste in Kenya. E-waste has to be managed through a carefully organised system and existing actors should be part of the proposed system. The target groups do have a collective responsibility for managing the e-waste at different stages in its life-cycle.

5.1 Guidelines for producers / manufacturers

There are very few (if any) manufacturers of electronic equipment in Kenya. Most companies have their production plants in Asia, where they have specialised equipment and methods to recover useful raw materials from scrap. Producers need to:

- Establish channels to collect the waste at the end of its life-cycle.
- Implement individual take-back schemes or get organised into sectoral or sub-sector Producer Responsibility Organisations (PRO) that encompass Extended Producer Responsibility (EPR).
- Clearly label products for easy identification and to show the constituents of the product.
- Comply with Kenya standards in the manufacture of electronic goods.
- Build in the cost of product take back and disposal into the purchase product price.

5.2 Guidelines for importers

Importers of electronic and electric equipment are divided into two categories; importers of new units and importers of used units. Importers need to:

- Specify standards for products on the expected remaining lifespan of the equipments and electrical appliances.
- Notify NEMA for consent to transport e-waste through Kenya subject to stated conditions
- State the number of years a computer has been in use before donation. The specifications should be stated according to the regulations on importation of pre-owned hand electronic equipment.
- Ensure used electrical and electronic goods reach the pre-destined end users. A record of customers should be kept to facilitate waste collection e.g. schools.
- Indicate an envisaged lifespan of used units when importing used equipment and bear responsibility for this by ensuring that take back mechanisms are in place.
- Desist from importing hazardous e-waste.

5.3 Guidelines for assemblers

Assemblers need to:

- Clearly label products for easy identification of product constituents.
- Clearly indicate Extended Producer Responsibility on electrical and electronic equipment.
- Comply with Kenyan standards on the assembly of electronic goods.

5.4 Guidelines for refurbishers

The refurbisher extends the functional life of equipment and feeds it into the second-hand market. Refurbishers need to:

- Ensure unusable material should go to a licensed disposer
- Ensure waste plucked out of the equipment will go to the recycler
- Provide incentives to the consumer to donate used devices

5.5 Guidelines for recyclers

These are organisations and individuals who dismantle, separate fractions and recover material from e-waste after the lifespan of the equipment. Recyclers need to;

- Establish recycling infrastructure and environmentally sound technologies to manage electrical and electronic waste
- Ensure that dismantling is done in an environmentally safe manner.
- Provide recycling processes to be approved and licensed by NEMA
- Ensure that revenue generated through sales of the materials recovered will support the administrative, plant and machinery and other overheads

5.6 Guidelines for government organisations

These are the organisations that are involved in the formulation and enforcement of regulations regarding generation, handling and disposal of e-waste. They include MEMR, Ministry of Local Government, KEBS, NEMA, KRA and CCK. Government organisations need to:

- Prepare a framework with appropriate legislation to support e-waste management
- Monitor the processes of e-waste handling regularly
- Create a management plan with responsibilities for different target groups
- Provide incentives to entrepreneurs to set up e-waste collection and treatment facilities
- Regulate / control the number of e-waste facilities within a geographical area
- Approve innovative e-waste management technologies that are environmentally sound
- Form multi-stakeholder monitoring committees to oversee the implementation of the e-waste management guidelines
- Create awareness among all the stakeholders through the legislative frame work of e-waste management
- Develop standards to prevent the importation and donations of useless or harmful e-waste
- Determine the impact of and come up with strategies for managing technology changes such as analogue-to-digital television equipment and deciding the procedure for Strategic Environmental Assessments

5.7 Guidelines for consumers

The consumer can either be an individual or a corporate organisation that owns a device which falls into one of the e-waste categories and which is considered to have ceased to be of any value. Consumers need to:

- Separate e-waste from other wastes to facilitate collection, treatment and recycling
- Dispose e-waste generated to the e-waste collection centres
- Sell or donate e-waste to licensed refurbishers
- Take back equipment to the manufacturer, importer or assembler, if they allow it
- Dump e-waste at the licensed dumping site specified for the e-waste
- Be responsible for following recommended disposal methods or procedures especially dates of expiry or end of usage period of the product

5.8 Guidelines for learning institutions

Learning institutions can be those associated with basic education or higher education. They are recipients of electrical and electronic goods. Unfortunately, most of the second hand products are not inspected before they are donated. Coupled with poor handling and use, their lifespan becomes shorter resulting in huge amounts of e-waste in most learning institutions. In order to manage e-waste, learning institutions need to:

- Create awareness and conduct sensitization campaigns on responsible e-waste management
- Develop Memorandum of Understandings (MoUs) with PROs for take-back, recycling and refurbishing of e-waste at life-end
- Develop mechanisms to ensure that inspection certificates clearly specify end-of-life date and who bears responsibility thereafter
- Develop and mainstream e-waste education in curricula

5.9 Guidelines for transporters

Transporters need to:

- Ensure e-waste is properly stored
- Ensure vehicles transporting e-waste obtain a waste transport license from NEMA.
- Ensure e-waste is disposed in licensed dumping sites

5.10 Guidelines for disposal authorities

Disposal authorities need to:

- Develop disposal standards for each type of toxic waste, including procedures for disassembling and recycling
- Provide efficient transport for e-waste
- Develop proper infrastructure for e-waste collection and disposal
- Set manageable fees to sustain e-waste management

5.11 Guidelines for informal sector e-waste collectors

- Informal sector e-waste collectors will only need to acquire a license if they collect e-waste from various sources

5.12 Guidelines for people living near dumpsites

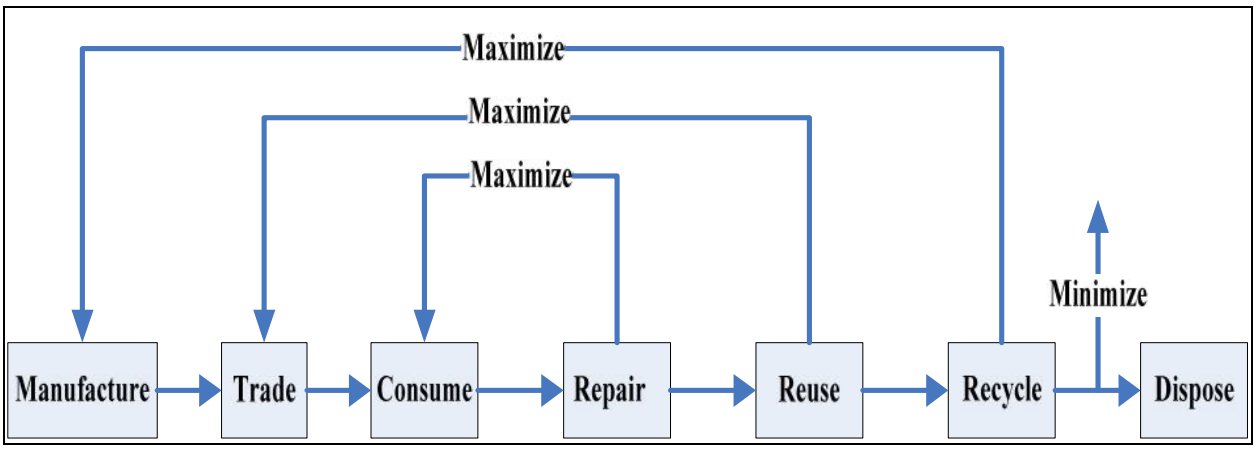
- People living near dumpsites need to be educated on how to detect potential health hazards, through organised workshops by the e-waste management stakeholders and environmental health practitioners

CHAPTER SIX

6.0 GUIDELINES FOR COLLECTION SYSTEMS

These guidelines seek to implement the 4Rs, (Reduce, Repair, Reuse and Recycle) to effectively minimise e-waste. The proposed recommendations are presented in figure 1.

Figure 6.1: Cradle to cradle electronic and electric management



Source: E-Waste Assessment in South Africa: A case study in Gauteng Province

6.1 General guidelines

- Collection mechanisms for e-waste in terms of packaging, labelling and transportation shall be as per the existing Waste Management Regulations 2006.
- Collection centres shall be established by producers/dealers, manufacturers, importers and distributors. They shall seek approval from NEMA and Local Authorities and their details shall be publicised for public use.
- Collection centres shall store the e-waste after sorting it into various categories for easier access by downstream users as well as to facilitate record keeping on the quantities of various categories of waste.
- Producers / dealers, manufacturers, importers and distributors have to enrol in an e-waste collection scheme by virtue of the fact that they introduce electrical and electronic equipment into the environment.
- Producers / dealers, manufacturers, importers and distributors should have the extended producer/manufacturer responsibility to ensure that at the end-of-life span of the equipment, the disposal is managed responsibly.
- National Environment Management Authority (NEMA) with other relevant key government stakeholders will regulate the collection, recycling, refurbishing and disposal of e-waste.
- Records of licensed facilities as well occupational health and safety concerns of various facilities will be monitored by NEMA.
- Awareness creation on delivery mechanisms of waste to these centres shall be the responsibility of the producers, local authorities, distributors and importers.

6.2 Guidelines for selection of collection channels / method

These collection systems have been described in terms of the collection channels and infrastructure required to make these channels operational. The commonly used collection channels are municipal collection sites, retailer take-back, and producer take-back. The collection mechanisms are described below.

6.2.1 Retailer take back and storage

- Consumers take back e-waste to retail stores that distribute similar products
- Consumers may give back the product at the retail store depending upon purchase of a new product, or without any purchase required
- Distributors may also provide take back schemes to ensure availability and accessibility of free of charge of designated collection facilities
- Take back fees may be included in the cost of sale and refunded on delivery/return

6.2.2 Producer take back and storage

- It usually applies to larger commercial equipment and operates on the principle of "new equipment replacing the old ones"
- E-waste is taken back by producers either directly at their facilities or designated collection centres that fed into the e-waste system
- The collected waste is stored on site to be transported for treatment elsewhere or on the site

6.2.3 Municipal collection and storage

- Consumers and businesses should be able to leave e-waste at municipal sites
- Sorting containers should be provided at Municipal collection site
- The collected waste should be stored on-site or directly fed into the e-waste treatment system

6.2.4 Other collection points

- E-waste can be dropped at specially created sites or centres
- There can be specialised sorting centres controlled such as Producer Responsibility Organisation (PRO) or third party sites, whose operators may be remunerated for the provision of space

6.3 Guidelines for establishing collection and storage infrastructure

The operation of a collection system described above requires storage and transportation infrastructure. Collection infrastructure requires establishment of e-waste collection points and storage areas. The following are guidelines for establishing collection points and storage areas:

- Collection points and storage areas should provide sorting infrastructure to effectively separate e-waste from other municipal waste
- Collection facilities should be available and accessible taking into account the population density.

- Collection and transport of separated e-waste should be done in such a way that enables reuse and recycling of those components or whole appliances.
- Sites for storage of e-waste prior to their treatment should have impermeable surface for appropriate areas with the provision of spillage collection facilities and where appropriate, decanters and cleanser-degreasers.
- Sites for storage of e-waste prior to their treatment should have weatherproof covering for appropriate areas.

6.4 Guidelines for design and technical specifications of e-waste collection points

A Licensed Collection Facility (LCF) should:

- Enable household e-waste to be collected from the LCF in streams of either large household appliances other than cooling appliances and display equipment containing CRTs amongst other waste.
- Be accessible to members of the public.
- Have signs to direct members of the public to deposit e-waste to the relevant container or area prevent mixing of e-waste with other waste or allow contamination with hazardous material
- State the maximum quantity that can be deposited on the site.
- Have impermeable surface with a sealed drainage and impermeable drains which do not leak to ensure that all liquids are in a sealed sump except where they may be lawfully discharged.
- Have a weatherproof cover
- Have a Collection Point and Storage Facility adequate to serve the geographical area and the volume of separated e-waste tonnage captured.
- Have adequate collection points and storage facilities to serve the population size.
- Be located where it meets the requirements of the collection option identified (i.e. retailer take back collection centre, municipal collection centre or other) and able to handle the number of trucks or trailers of different capacities required to transport the e-waste.

6.5 Guidelines for operation of Producer Responsibility Organisations

Producer Responsibility Organisations are committees that take the responsibility for the end-of-life disposal of products being manufactured or assembled. They can be established with the support of all manufacturers largely responsible for the management of e-waste in an environmentally sound manner. Manufacturers should implement take-back policies for used devices to ensure that they do not turn into e-waste.

6.5.1 About the PRO Structure

- The PRO will be expected to operate as a non-profit committee built on the ethos of Corporate Social Responsibility (CSR) and be an active participant in this sector.

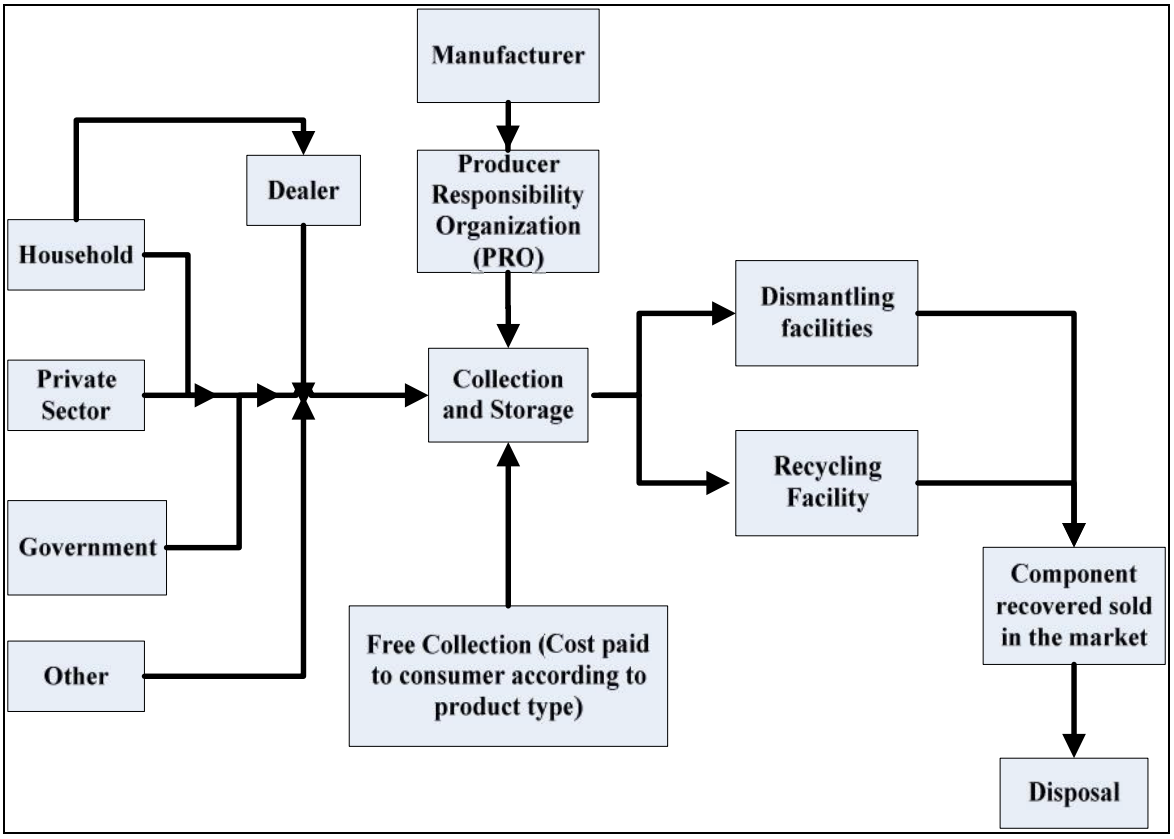
- The cost of establishing these structures shall be supported by the manufacturers. The details on the contribution made by individual companies can be worked out through detailed deliberation. A part of revenue can also be generated through the sale of the e-waste by the recycler.
- The PRO should operate with all stakeholder participation (including representatives of the informal sector) and with full operational transparency to ensure efficacy in its implementation.

6.5.2 Roles of Producer Responsibility Organisation

- The Producer Responsibility Organisation will have overall responsibility for the complete recycling process of e-waste with different levels of engagement in various processes.
- The PRO will take on direct responsibility of collection and storage of all waste resulting from electrical and electronic equipments generated across the country and then passes this on to the dismantler/recycler for a price.
- The nature of goods being classified as e-waste, have an intrinsic material value and this value is key to the complete financial plan of this structure. It is a globally accepted fact that e-waste has a material value assigned and all recyclers, big or small, procure electronic wastes at a price and then make profits by selling the recovered materials.
- This structure suggests provision of incentives to the manufacturers to be active participants and streamline the storage and collection system to an authorised agency that will handle the e-waste.
- The PRO will pay the manufacturers for the material collected and provide free collection system. The dynamic fee system for different end-of-life products will be fixed by the PRO and will be open to review at periodic intervals. This will give an option to vary the monetary value attached to it according to the prevailing market values of the materials extracted.
- The revenue generated by PRO through sales of this e-waste to the recyclers will be utilised for financing the take back process from the consumers (cost paid for the e-waste) as well as the collection and storage of the waste.
- Dealers selling such household products will have to take back the old products and the household manufacturers will get a discount on new purchase of electrical and electronic goods (the end-of-life cost can be fixed according to product type). These products will be then transferred back to the PRO with proper reporting.

The flow chart below shows a systematic flow of managing e-waste that result when most of the products reach their end of life.

Figure 6.2: Proposed e-waste management flow structure



Source: Sinha S. And Mahesh P (2007)

CHAPTER SEVEN

7.0 GUIDELINES FOR TREATMENT TECHNOLOGY FOR E-WASTE

The presence of hazardous elements and compounds in e-waste offers potential for increasing the intensity of their discharge in the environment due to land-filling and incineration. Therefore, a recommended approach to treating e-waste is to first reduce the concentration of these hazardous chemicals and elements and finally dispose e-waste fractions through either incineration or land-filling or a combination of both.

The e-waste treatment options should include the following unit operations:

a. *Decontamination or Dismantling:* This is done manually and will includes;
   i. Removal of parts containing hazardous/ dangerous substances (CFCs, Mercury (Hg), switches, PCBs).
   ii. Removal of easily accessible parts containing valuable substances (cables containing copper, steel, iron, and precious metals, e.g. contacts)
   iii. Segregation of hazardous/ dangerous substance and removal of easily accessible parts

b. *Segregation of ferrous metals, non-ferrous metals and plastics:* This separation is generally carried out after shredding and is followed by a mechanical and magnetic separation process.

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

d. *Treatment or disposal of dangerous materials and waste:* Shredded light fractions are disposed of in landfill sites or sometimes incinerated, CFCs are treated thermally, Poly Chlorinated Biphenyls (PCBs) are incinerated or disposed of in underground storages, Mercury (Hg) is often recycled or disposed of in underground landfill sites

7.1 Guidelines for development of e-waste treatment technology

An e-waste treatment process should include the following components;

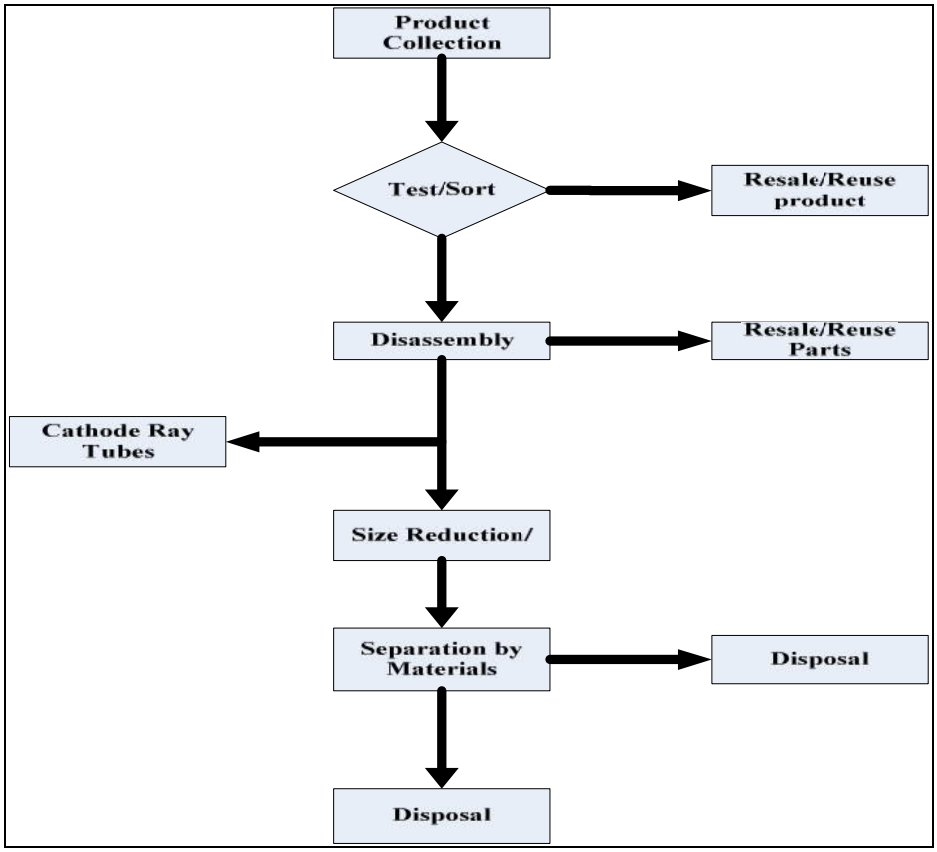
- Testing of e-waste product in order to sort reusable and non-reusable e-waste separately.
- Disassembling non-reusable e-waste and sorting e-waste fractions into reusable and non reusable parts.
- Size reduction, separation and recovery of different materials from non-reusable e-waste.
- Disposal of the remaining e-waste fractions.

A detailed e-waste treatment system falls in a hierarchy of three levels:

- First level treatment
- Second level treatment and
- Third level treatment.

All the three levels of e-waste treatment systems are based on material flow from first level to third level treatment. Each level treatment consists of unit operations where e-waste is treated and the output of first level treatment serves as input to second level treatment. After the third level treatment the residues are disposed off either in hazardous waste landfill or incinerated. The simplified flow diagram for e-waste treatment is given in figure 3.

Figure7.1: E-waste treatment process



Source: Hai-Yong Kang, Julie M. Schoenung (2005)

7.1.1 Guidelines for development of first level e-waste treatment

- Inputs: They include e-waste items like TVs, refrigerators and Personal Computers (PCs).

- Unit Operations: There are three unit operations at first level of e-waste treatment. These are:
  1. *Removal of all liquids and gases*: The first treatment step is to decontaminate e-waste and render it non hazardous. This involves removal of all types of liquids and gases under negative pressure, their recovery and storage.

2. *Dismantling (manual or mechanised breaking):* The decontaminated e-waste or the e-waste requiring no decontamination are dismantled to remove the components from the used equipments. The dismantling process could be manual or mechanised requiring adequate safety measures to be followed in the operations.
3. *Segregation:* After dismantling the components are segregated into hazardous and non hazardous components of e-waste fractions to be sent for third level treatment.
   All the three unit operations are dry processes, which do not require usage of water.

- Outputs from First level e-waste treatment are:
  - Segregated hazardous wastes like CFCs, Hg, Switches, batteries and capacitors.
  - Decontaminated e-waste consisting of segregated non-hazardous e-waste like plastics, CRTs, circuit boards and cables.
  - Emissions that include air, water, noise

7.1.2 Guidelines for development of second level e-waste treatment

These are:

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

- Unit Operations: There are three unit operations at second level of e-waste treatment;
  1. Hammering: Size reduction
  2. Shredding : Size reduction
  3. Special treatment processes comprising of;
     - CRT treatment consisting of separation of funnels and screen glass (Appendix 4).
     - Electromagnetic separation (Appendix 5)
     - Eddy current separation (Appendix 5)
     - Density separation using water

- Outputs: Materials from the second level treatment technology include.
  - Ferrous metal scrap (secondary raw material)
  - Non ferrous metal scrap mainly copper and aluminium
  - Precious metal scrap mainly silver, gold and palladium
  - Plastic consisting of sorted plastic, plastic with flame retardants and plastic mixture.

7.1.3 Guidelines for development of third level e-waste treatment

This is carried out mainly to recover ferrous and non-ferrous metals, plastics and other items of economic value. The major recovery operations focus on ferrous and non ferrous metal recovery, which is either geographically carried out at different places or in an integrated facility.

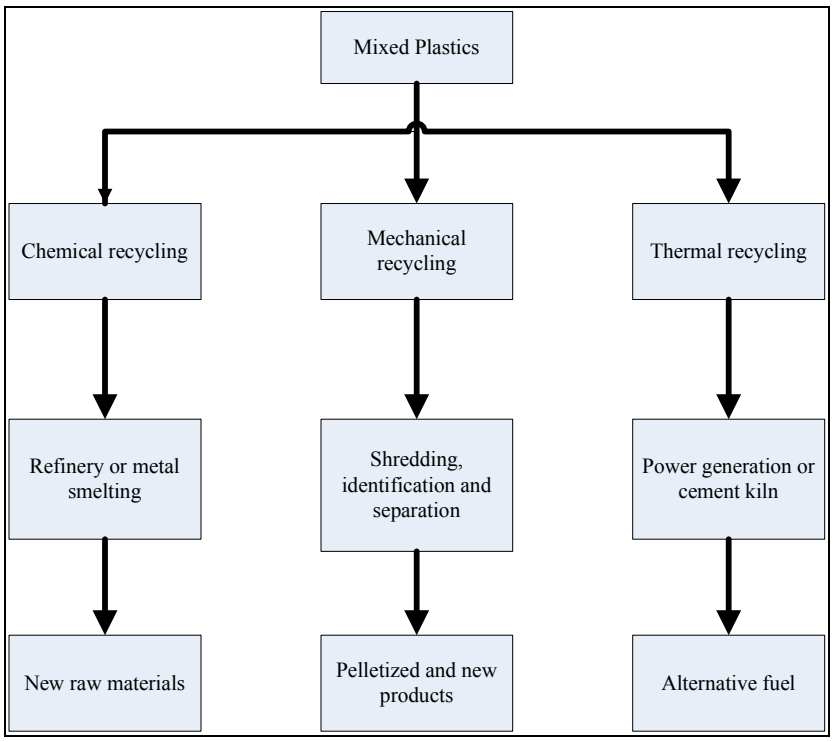
7.1.3.1 Plastic recycling

There are three different types of plastic recycling options i.e. mechanical recycling chemical recycling, and thermal recycling.

- In chemical recycling process, waste plastics are used as raw materials for petrochemical processes or as reductant in a metal smelter.
- In mechanical recycling process, shredding and identification process is used to make new plastic products.
- In thermal recycling process, plastics are used as alternative fuel.

The two major types of plastic resins, which are used in electronics, are "thermo sets" and "thermoplastics". Thermo sets are shredded and recycled because they cannot be re-melted and formed into new products, while thermoplastics can be re-melted and formed into new products. Recycling options for managing plastics from end of life electronics are shown in figure 4.

Figure7.2: Recycling options for managing plastics from end-of-life electronics



Source: Hai-Yong Kang, Julie M. Schoenung (2005)

7.1.3.2 Mechanical recycling process

- The first step is the sorting process, where contaminated plastics such as laminated or painted plastics are removed.
- Shear-shredder and hammer mills are generally used for size reduction and liberation of metals (coarse fraction) followed by granulation and milling for further size reduction.
- Magnetic separators are used for ferrous metals separation, while eddy current separators are used for non ferrous metals separation.

- Air separation system can be used to separate light fractions such as paper, labels and films.
- Resin identification can be carried out by using a number of techniques like turboelectric separator, high speed accelerator and X-ray fluorescence spectroscopy.
- X-ray fluorescence spectroscopy is effective in identifying heavy metals as well as flame retardants.
- After identification and sorting of different resins, they are extruded and palletized.

7.1.3.3 Chemical recycling process

Mixed plastic waste is de-polymerized, dehalogenated, metals removed and hydrogenated to produce high quality products like off gas and syncrude obtained by hydrotreatment, which are sent to the petrochemical process.

7.1.3.4 Thermal recycling process

Plastics recovered in the second level treatment are used as fuel to provide energy. Since plastics have high calorific value, which is equivalent to or is greater than coal, they can be combusted to produce heat energy in cement kilns.

7.1.3.5 Metals recycling

Metal recycling includes lead recycling, copper recycling and precious metals recycling. After sorting of metal fractions at second level e-waste treatment, they are sent to metal recovery facilities.

CHAPTER EIGHT

8.0 GUIDELINES FOR ESTABLISHMENT OF UNIT TREATMENT FACILITY, AN INTEGRATED PROCESSING TREATMENT FACILITY AND DISPOSAL SITES FOR E-WASTE

The establishment of e-waste Recycling & Treatment Facilities in Kenya shall be in line with the existing Environment Management and Coordination Act (EMCA) 1999 and Waste Management Regulations (2006) requirements applicable for establishing and operating Recycling, Treatment and Disposal Facilities. The e-waste facility should meet the following guidelines:

8.1 General Guidelines for setting-up and management of a unit treatment facility or an integrated e-waste facilities

Any processing and recycling facilities that receive designated materials must ensure:

- Facility is fully licensed by all appropriate governing authorities.
- An Environment Impact Assessment (EIA) is undertaken and an EIA license issued.
- Facility is registered as a recycler under the Waste Management Regulations, 2006.
- Facility should have obtained approvals under the Water Quality Regulations, 2006, Noise and Excessive Vibration Control Regulations 2009 and Air Pollution (Control & Prevention, Occupational Safety and Health Act amongst others).
- Facility takes sufficient measures to safeguard occupational and environmental health and safety.
- Facility has a regularly-implemented and documented monitoring and recordkeeping program that tracks key process parameters, compliance with relevant safety procedures, effluents, emissions, stored incoming and outgoing materials and waste.
- Facility has an adequate plan for closure. The need for closure plans and financial guarantees is determined by applicable laws and regulations, taking into consideration the level of risk.

8.2 Guidelines for facility operation requirements

The facilities can exist as a separate unit operation or as an integration of all unit operations under one roofing. The key facility operation units include;

- An effective collection channel and infrastructure.
- Adequate storage area.
- An elaborate dismantling and segregation section.
- A recycling plant / unit.
- A Treatment and Disposal unit.

8.2.1 Guidelines for collection systems for e-waste

- The collection systems shall be in line with the guidelines provided in Chapter 6.
- The individual producers can have direct contact with dismantlers or recyclers to get back the re-usable components from their obsolete equipments for use in production.

- The system may charge fees, provide free collection or provide discount on purchase of new items.

8.2.2 Guidelines for storage areas

- The location can be within the facility (on site) or outside the facility (off site).
- It should be well covered to store waste until it is recycled or treated.
- The covering should be weatherproof to minimise the contamination of clean surface and rain waters. It will also facilitate the reuse of whole appliances and components intended for recycling and to assist in the containment of hazardous materials and fluids.
- The type of weatherproof covering required will depend on the types and quantities of waste and the storage and treatment activities undertaken.
- E-waste items should be separated and kept in appropriate well marked containers.
- The storage area should have impermeable surfaces and a sealed drainage system. This will ensure that no liquid will run off the pavement and all liquids entering the system are collected in a sealed sump.
- Spillage collection facilities should be provided. They should include the impermeable pavement and sealed drainage system as the primary means of containment.
- An appropriate storage site should be provided for disassembled spare parts (e.g. motors and compressors) that contain oil or other types of fluids. They should be stored in containers that are secured that will not allow oil and other fluids to escape with an impermeable surface and a sealed drainage system.
- Components and residues arising from the treatment of e-waste should be contained for disposal or recovery. If they contain hazardous substances they should be stored on impermeable surfaces and in appropriate containers or bays with weatherproof covering.
- Containers should be clearly labelled to identify their contents and must be secure from liquids and rainwater seepage.
- Components should be segregated having regard to their eventual destinations and the compatibility of the component types.
- Batteries should be handled and stored with a clear knowledge of their potential fire risk.

8.2.3 Guidelines for dismantling and segregation of dismantled parts

Dismantling and segregation are the first steps towards recycling of the e-waste. These are cost effective and labor intensive activities and are mostly carried out in the informal sector which needs to be brought into mainstream recycling.

E-waste segregation involves separation of equipment according to its level of difficulty to to dismantle, and its hazardousness. Segregation can be done either before the equipment is dismantled or after.

- Dismantling of e-waste may be carried out manually or mechanically depending upon the scale of operations and the e-waste being handled.

- Manual dismantling should only involve used electronic and electrical equipments where there is no likelihood of contact with hazardous substances.
- An integrated facility should provide a mechanical dismantling facility to dismantle e-waste containing hazardous substances.
- Sorting of waste is encouraged at source to enable easier identification and access to particular waste streams.
- Identification will be carried out in three categories;
    1. Items in good condition that can be reused
    2. Items that can be repaired/refurbished
    3. Items for dismantling for recovery or disposal
- Dismantling shall be carried out after verification that items are no longer usable.
- The electrical components are dismantled, classified and broken apart.
- Removal of parts containing dangerous substances; removal of easily accessible parts containing valuable substances (cable containing copper, steel, iron, precious metal containing parts, e.g. contacts).
- Useful parts can be recovered and sold to the second hand market for some profit (or donated) as refurbished.
- Occupational health and safety concerns of facilities for storage and dismantling of the equipment shall be as per the stipulated Occupational Safety and Health Act (OSHA), 2007.
- NEMA shall monitor the facilities through control environmental audits to determine the handling facilities in terms of physical status and mitigation measures in place to ensure safety of workers as well as protection of the environment.

8.2.4 Guidelines for recycling and recovery of e-waste

Recycling is encouraged at a formal level where all institutions shall ensure that e-waste is collected and delivered to the designated collection centres. E-waste recycling is expensive and the costs are not necessarily covered by the resale of recovered materials.

- NEMA in collaboration with relevant lead agencies shall register and recognise collection schemes as well as recycling centres for regulation through licensing.
- NEMA in collaboration with the Kenya Revenue Authority (KRA) may have to introduce an Advanced Recycling Fee (ARF) for products which will eventually become part of the e-waste stream as part of import levy.
- This fee will be submitted by the supplier to KRA which will in turn dispatch to the association to run collection centres as well as partly fund end–of–life recycling. Certain items, such as CRTs, may attract a higher ARF due to greater recycling costs.
- The supplier will be required to supply records of the amounts collected for this purpose to the government.
- An integrated e-waste recycling facility should opt for the Best Available Technologies (BAT) and provide the state of the art facility complying with all the environmental laws in the terms of emissions, effluents, noise, waste treatment and disposal amongst others.

8.2.5 Guidelines for developing a treatment and disposal unit

- Provisions should be made of equipment for the treatment of water, including rainwater, in compliance with health and environmental regulations. Operators of treatment facilities should take appropriate steps to minimise the contamination of clean waters.
- Impermeable surfaces should be provided for appropriate areas. The impermeable surface should be associated with a sealed drainage system and may be needed even where weatherproof covering is used.
- Spillage collection facilities that include the impermeable pavement and sealed drainage system as the primary means of containment should be provided. However, spill kits to deal with spillages of oils, fuel and acids should be provided and used as appropriate.
- Records should be maintained on the treated waste to inform on e-waste entering a treatment facility and components and materials leaving each site (together with their destinations).

8.3 Guidelines for e-waste disposal sites

- Disposal should be done in specialised cells or sections in a licensed landfill site.
- Owners / operators of disposal sites shall be licensed by NEMA and Local Authorities.
- Owners / operators must demonstrate technical knowledge and understanding of the hazardous nature of e-waste.
- Disposal sites shall be published after licensing for the general public is aware of the existence of the same.
- Disposal shall be paid for and the disposer shall be issued with a certificate of safe disposal.
- Disposers shall keep a record of the amounts and categories of waste which NEMA may access upon request or during inspection of e-waste handling facilities.
- Incineration of unusable disposable parts is not recommended in the country due to the unsuitability of existing incineration facilities. In future, development of incinerators will include compulsory installation of waste gas purification systems to deal with dioxins and furans in incineration flue gas.
- Burying is strictly prohibited as contaminants may easily leach into the soil and pollute both soil and groundwater resources.

APPENDICES

Appendix 1: Hazardous Substances that can occur in e-waste

Hazardous Substance	Use	Risk	Regulatory requirements with threshold quantities
Short Chain Chloro Paraffins, Alkanes, C_{10-13}	Amounts less than 1% by weight of SCCP are present in mid chain chlorinated paraffin's (MCCP). Used as secondary plasticizer and flame retardant for PVC and chlorinated rubber in cable insulation.	Very toxic to aquatic organisms. It may cause long term effects in the aquatic environment.	Halogenated Aliphatic Compounds >=0.5%
Antimony trioxide	The major use is as a flame retardant synergist in plastics etc. It increases the flame retardant effectiveness of halogenated flame retardant compounds thereby minimising their level.	Limited evidence of a carcinogenic Effect	Antimony and antimony Compounds >=0.005%
Beryllium metal	Chassis, rotating mirrors in laser printers; windows for X-ray generators and detectors for research and medical purposes.	Very toxic on inhalation and may cause cancer by inhalation	Beryllium and cadmium Compounds >=0.005%
Beryllium oxide	Used in heat sink electrical insulators for electrical and electronic systems and devices. It has very high thermal conductivity; very high electrical resistivity; low dielectric constant; low loss factor; high breakdown voltage; and chemically inert.	Very toxic by inhalation. It may cause cancer by inhalation	Beryllium and cadmium compounds >=0.005%
Cadmium	Part of the negative electrode material in nickel-cadmium (NiCd) batteries, as an electrodeposited, vacuum deposited or mechanically deposited coating on iron, steel, aluminium-base materials, titanium-base alloys or other non-ferrous alloys, and as an alloying element in low-melting brazing, soldering and other specialty alloys.	Very toxic by inhalation. It may cause cancer.	
Cadmium oxide	Part of the negative cadmium electrode in nickelcadmium and some silver-cadmium military Batteries. Also part of silvercadmium oxide (Ag-CdO) electrical contact alloys.	May cause cancer by inhalation. Toxic by inhalation. Toxic if swallowed. Danger of serious damage to health by prolonged exposure Harmful if swallowed	

Cadmium sulphide	Serves as the basis compound for a series of pigments and semiconducting compounds.. Used in red, orange and yellow pigments for plastics, glasses, ceramics, enamels and artists colours, cadmium sulphide Also used for phosphors in x-ray fluorescent screens, cathode ray tubes and electronic devices	Limited evidence of a carcinogenic effect Toxic by inhalation. and if swallowed. Danger of serous damage to health by prolonged exposure It may cause long term effects in the aquatic environment.	>=0.005%
Chromium VI	Used as pigments (e.g. lead chromate) and as corrosion inhibitor (sodium dichromate) in circulating water systems e.g. absorption heat pumps and (industrial) heat exchangers in freezers and refrigerators. Electrical shielding material for certain sheet metals	Toxic if swallowed by inhalation. It may cause heritable genetic damage and cancer by inhalation. Very toxic to aquatic organisms and may cause long term effects in the aquatic environment.	>=0.005%
Copper beryllium alloys	Used in electrical connector terminations; switch components; relay springs; electromagnetic radiation seals.	Toxic by inhalation	>=0.005%
Decabromodiphenylether (DBDE)	Used as a flame retardant in electrical and electronic plastics.	Potential for forming brominated dibenzodioxins or furans (PBDD/F) in uncontrolled thermal processes, and possibility that higher PBDEs could debrominate to form the tetra and penta BDEs found in marine environment food chain	>=0.005%
Lead	Used in batteries, solders, alloying element for machining metals, printed circuit boards, components, incandescent light bulbs, and weighting	Lead compounds, are all classified as dangerous substances.	>=0.5%
Lead oxide	Occurs in leaded glass in cathode ray tubes, light bulbs and photocopier pastes. Lead oxide is also used in batteries.	May cause harm to the unborn child Harmful by inhalation/harmful if swallowed	>=0.5%
Liquid Crystals	Commercially available liquid crystals (LC) are mixtures of 10 to 20 substances, which belong to the group of substituted phenycyclohexanes,	No indications of carcinogenic potential and acute oral toxicity have been found	

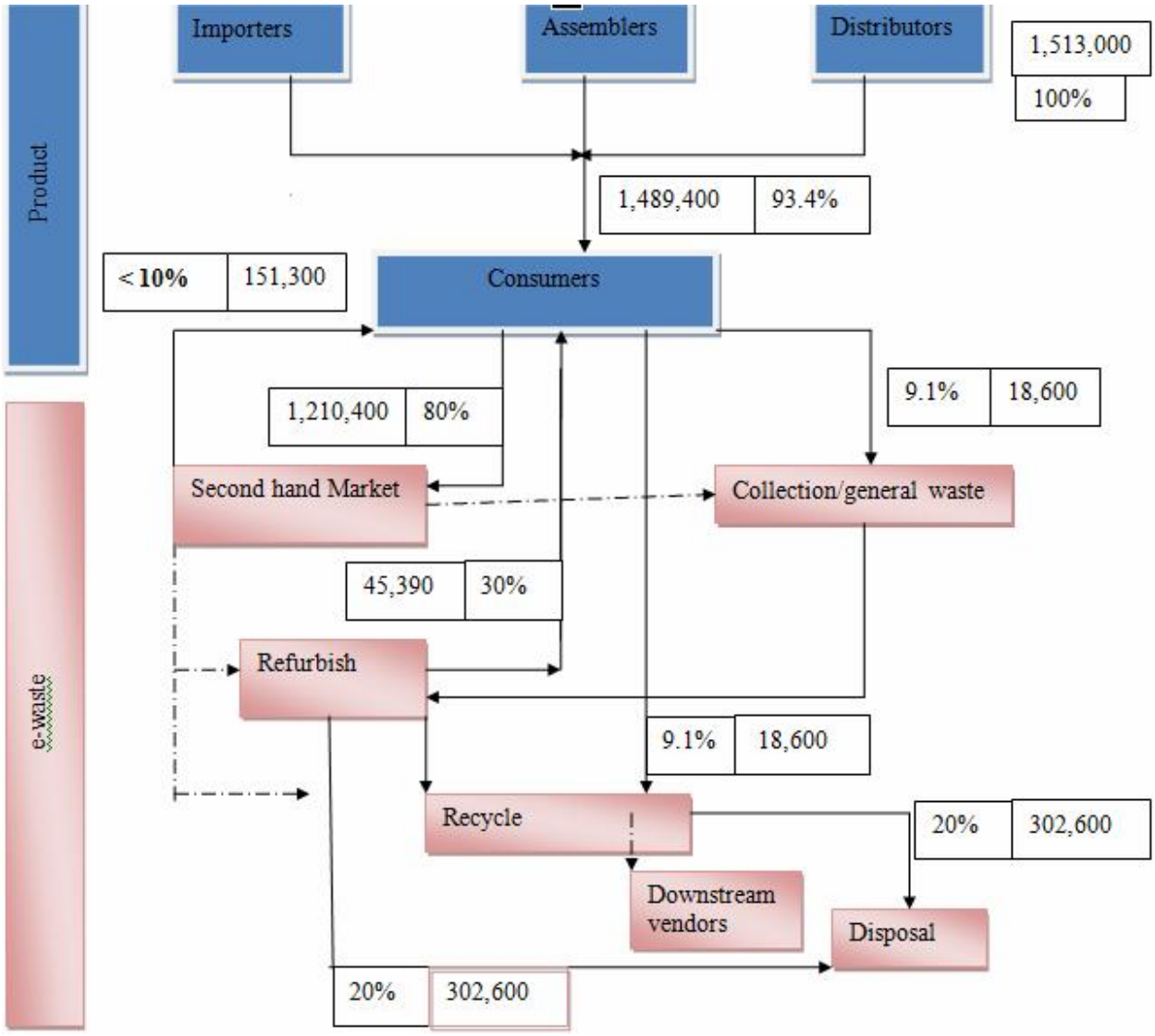
	alkylbenzenes and cyclohexylbenzens. Liquid crystal mixture are used as electroactive layer in liquid crystal display (LCD).		
Mercury	It is used in thermostats, sensors, relays and switches, discharge lamps etc	Very toxic to aquatic organisms and may cause long term effects in the aquatic environment and the central nervous system (CNS) the kidney in humans Toxic by inhalation	>=0.005%
Mineral Wool	Man-made vitreous (silicate) fibers with random orientation with alkaline oxide and alkali earth oxide ($Na_2O+K_2O+CaO+MgO+BaO$) content greater than 18 % by weight]	Limited evidence of carcinogenic effect Irritating to the skin	
Octabromodiphenylether (OBDE)	Flame retardant in plastics used for electrical and electronic equipment	Possible risk of harm to the unborn child	>=0.005%
Polychlorobiphenyls	Extensively used in capacitors and transformers. Found in refrigerators, cookers, washing machines, air-conditioners, dishwashers.	Very toxic to aquatic organisms and may cause long term effects in the aquatic environment	50mg/kg (0.005%)
Refractory Ceramic Fibers:	[Man-made vitreous (silicate) fibers with random orientation with alkaline oxide and alkali earth oxide	May cause cancer by inhalation. Irritating to the skin	
Tetrabromobisphenol-A (TBBPA)	It is used as a reactive (primary use) or additive flame retardant in polymers. and printed writing boards.	Potential to form brominated dioxins/furans in thermal processes. Potential for endrocrine modulating effects (hormone disrupter). substances"	>=.005%

Appendix 2: Volumes entering the market of the stakeholders

Equipment imported/ assembled	**2007**	**2006**	**2005**	**2004**	**Total units**	**Ratio to PC**	**Wt/unit (kg)**	**Ratio wt (kg)**
Desktop computers (including monitor)	15,130	6,885	6,530	6,400	34,945	29.26	1.00	29.26
Notebook computers	8,288	5,760	5,660	5,600	25,308	0.72	3.51	2.54
Monitors	13,660	5,417	5,415	5,400	29,892	0.86	15.87	13.58
Flat screens	3,775	2,335	2,315	2,300	10,725	0.31	7.72	2.37
Printers	1,455	30	27	0	1,512	0.04	11.7	0.51
Photocopiers	5,010	5,010	5,010	5,000	20,030	0.57	90.96	52.14
Fax machines	13	13	17	0	43	0.00	-	-
Modems	8,255	20	25	0	8,300	0.24	-	-
UPS	1,790	1,020	1,020	1,000	4,830	0.14	-	-
Total	57,376	26,490	26,019	25,700	135,585	3.88		100.39
Equipment supplied/ distributed	**2007**	**2006**	**2005**	**2004**	**Total units**	**Ratio to PC**	**Wt/unit (kg)**	**Ratio wt (kg)**
Desktop computers (including monitor)	14,894	6,885	6,530	6,400	34,709	0.99	29.26	29.06
Notebook computers	7,972	5,760	5,660	5,600	24,992	0.72	3.51	2.51
Monitors	13,544	5,417	5,415	5,400	29,776	0.85	15.87	13.52
Flat screens	1,651	335	315	300	2,601	0.07	7.72	0.57
Printers	1,559	30	27	0	1,616	0.05	11.7	0.54
Photocopiers	5,010	5,010	5,010	5,000	20,030	0.57	90.96	52.14
Fax machines	13	13	17	0	43	0.00	-	-
Modems	8,019	20	25	0	8,064	0.23	-	-
UPS	1,770	1,020	1,020	1,000	4,810	0.14	-	-
Total								**98.35**

Source: Waema T. and Murethi M. (2008)

Appendix 3: Mass flow diagram



Source: Waema T. and Murethi M. (2008)

Appendix 4: CRT treatment technology

Input: CRT segregated after first level e-waste treatment

Unit operations:

1. Dismantling: CRT is manually removed from plastic/ wooden casing.
2. De-pressurization and Splitting:
   Picture tube is split and the funnel section is then lifted off the screen section and the internal metal mask can be lifted to facilitate internal phosphor coating. Different types of splitting technology used are given below.
   - *NiChrome hot wire cutting:* A NiChrome wire or ribbon is wrapped round a CRT and electrically heated for at least 30 seconds to cause a thermal differential across the thickness of the glass. The area is then cooled (e.g. with a water-soaked sponge) to create thermal stress which results in a crack. When this is lightly tapped, the screen separates from the funnel section.
   - *Thermal shock:* The CRT tube is subjected to localised heat followed by cold air. This creates stress at the frit line where the leaded funnel glass is joined to the unleaded panel glass and the tube comes apart.
   - *Laser cutting:* A laser beam is focused inside and this heats up the glass. It is immediately followed by a cold water spray that cools the surface of the glass and causes it to crack along the cut line.
   - *Diamond wire method:* In this method, a wire with a very small diameter, which is embedded with industrial diamonds, is used to cut the glass as the CRT is passed through the cutting plane.
   - *Diamond saw separation*: Diamond saw separation uses either wet or dry process. Wet saw separation involves rotating the CRT in an enclosure while one or more saw blades cut through the CRT around its entire circumference. Coolant is sprayed on to the surface of the saw blades as they cut. This is to control temperature and prevent warping.
   - *Waterjet separation:* This technology uses a high-pressure spray of water containing abrasive, directed at the surface to be cut. The water is focused through a single or double nozzle-spraying configuration set at a specific distance.
3. Cleaning: Internal phosphor coating is removed by using an abrasive wire brush and a strong vacuum system to clean the inside and recover the coating. The extracted air is cleaned through an air filter system to collect the phosphor dust.
4. Shredding

Outputs: Metals, Plastic and Glass Cullet

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

Appendix 5: Electromagnetic, Eddy current and Density Separation Using Water

Electromagnetic and eddy current separation utilises properties of different elements like electrical conductivity, magnetic properties and density to separate ferrous, non ferrous metal and precious metal fractions.

Plastic fractions consisting of sorted plastic after 1st level treatment, plastic mixture and plastic with flame retardants after second level treatment, glass and lead are separated during this treatment. The efficiency of this treatment determines the recovery rate of metal and segregated E-waste fractions for third level treatment.

The salient features of this treatment technology and process are given below.

1. The proposed technology for sorting, treatment, including recycling and disposal of e-waste is fully based on dry process using mechanical operations.
2. The pre-comminuting stage includes separation of Plastic, CRT and remaining non CRT based e-waste. Equipments like hammer mill and shear shredder will be used at comminuting stage to cut and pulverise e-waste and prepare it as a feedstock to magnetic and eddy current separation.
3. A heavy-duty hammer mill grinds the material to achieve separation of inert materials and metals.
4. After separation of metals from inert material, metal fraction consisting of Ferrous and Non-Ferrous metals are subjected to magnetic current separation. After separation of Ferrous containing fraction, Non-ferrous fraction is classified into different non-metal fractions, electrostatic separation and pulverisation.

5. The ground material is then screened and dusted subsequently followed by separation of valuable metal fraction using electrostatic, gravimetric separation and eddy current separation technologies to recover fractions of Copper (Cu), Aluminum (Al), residual fractions containing Gold (Au), Silver (Au) and other precious metals.

   This results in recovery of clean metallic concentrates, which are sold for further refining to smelters. Sometimes water may be used for separation at last stage.

6. Electric conductivity-based separation separates materials of different electric conductivity (or resistivity) mainly different fractions of non-ferrous metals from e-waste. Eddy current separation technique has been used based on electrical conductivity for non ferrous metal separation from e-waste.

   Its operability is based on the use of rare earth permanent magnets. When a conductive

particle is exposed to an alternating magnetic field, eddy currents will be induced in that object, generating a magnetic field to oppose the magnetic field.

The interactions between the magnetic field and the induced eddy currents lead to the appearance of electro dynamic actions upon conductive non-ferrous particles and are responsible for the separation process.

7. The efficacy of the recycling system is dependent on the expected yields / output of the recycling system. The expected yields / output from the recycling system are dependent on the optimisation of separation parameters. These parameters are given below:
   - Particle size
   - Particle shape
   - Feeding rate/ RPM
   - Optimum operations

8. Particle shape is dependent on comminuting and separation. Since hammer mills and screens will be used in the proposed technology, the variations are expected to be the same as that of Best Available Technology (BAT).

9. The feeding rate can be optimised based on the speed and width of the conveyor.

Appendix 6: List of stakeholders who took part in developing the e-waste guidelines

NAME	INSTITUTION
Paul P. Olando	Ministry of Environment and Mineral Resources
Ben Mugambi	Ministry of Environment and Mineral Resources
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Anne Nderitu	Ministry of Environment and Mineral Resources
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David Ong'are	National Environment Management Authority
Vicky Onderi	National Environment Management Authority
Hildegard Wambayi	National Environment Management Authority
Betty Nzioka	National Environment Management Authority
Felix Mugambi	National Environment Management Authority
Maureen Kwamboka	National Environment Management Authority
Richard Okeyo	National Environment Management Authority
Carol Mbatia	National Environment Management Authority
Frederick Nambisia	National Environment Management Authority
Wilkister Magangi	National Environment Management Authority
John Mumbo	National Environment Management Authority
Samuel Munene	National Environment Management Authority
John Mumbo	National Environment Management Authority
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Jeremiah Mugambi	National Environment Management Authority
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Lois Bosire	Ministry of Information
Ibrahim Longlomoi	Ministry of Public Works
Dr. Osoro Nyakweba	Ministry of Wildlife
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Washington Okoth	Kenya Bureau of Standards
Amos Wambua	Kenya Bureau of Standards

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Wesley K. Ondieki	Bomango Environmental Initiatives
Tom Musili	Computers For Schools Kenya
Stephen Kahara	Computers For Schools Kenya
Henry Ongaga	Eco-Watch
Terry Njoroge	International Conference Workshops and Events
Rachel Ibukah	Jomo Kenyatta University of Agriculture & Technology
Esther Mwiyeria Wachira	Global E-Schools and Communities Initiative
Lina Palmer	Global E-Schools and Communities Initiative
Roxana Bassi	Global E-Schools and Communities Initiative
Senthil Kumar	Global E-Schools and Communities Initiative
Dan Njiriri	Kenya ICT Trust Fund
Maurice Mbegera	Masuro Consultants
Benjamin Ombati	Masuro Consultants
Dickson Mokua	Masuro Consultants
Mike K. Bill	Mindgem Concepts
Caleb Ouma	United Nations Environment Programme
Dr. Ludgard Coppens	United Nations Environment Programme
Gerard Cunningham	United Nations Environment Programme
Elias Ayiemba	University of Nairobi
Dr. Isiah Nyandega	University of Nairobi

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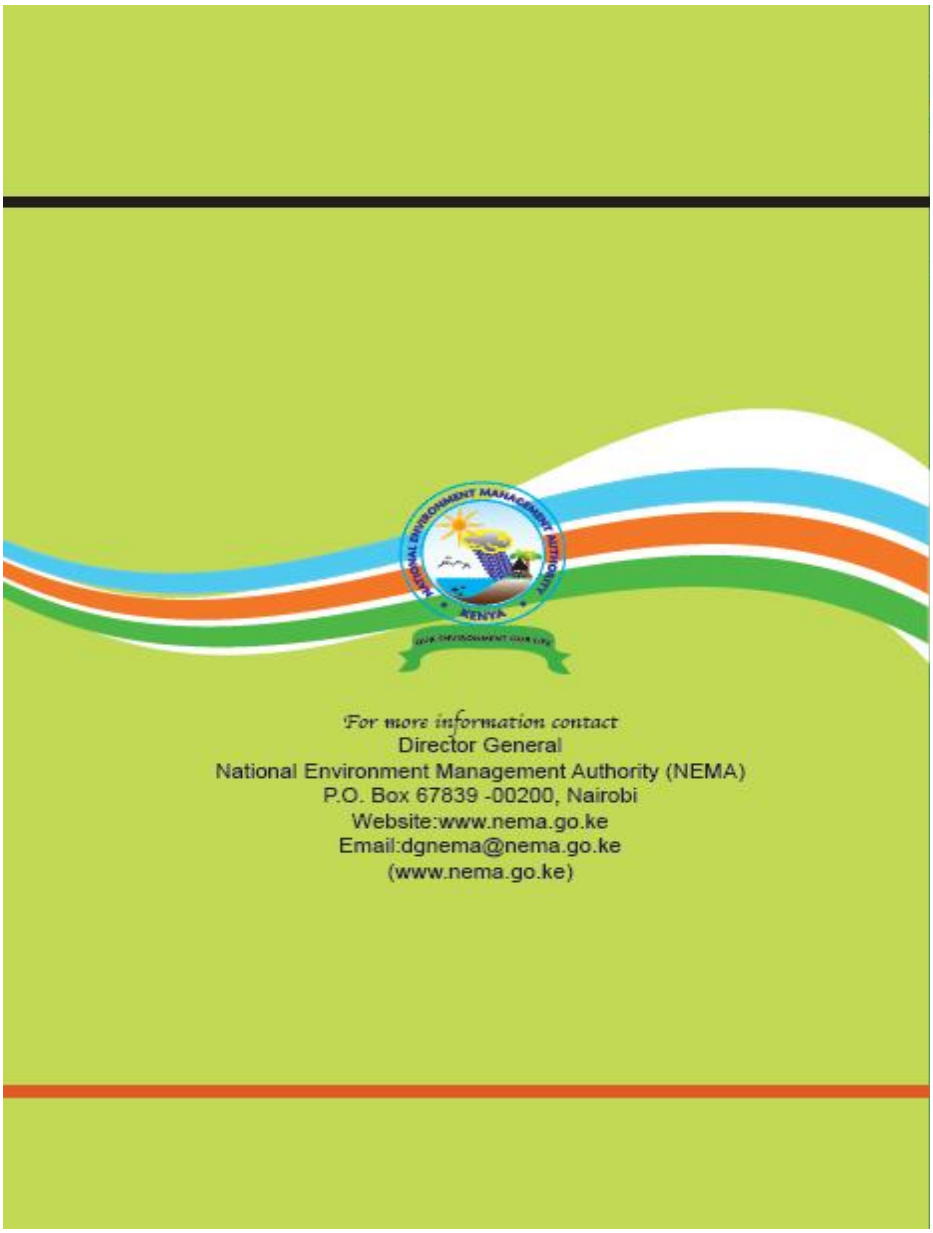

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