Handbook

for the development of a policy framework on ICT/e-waste

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Acknowledgements

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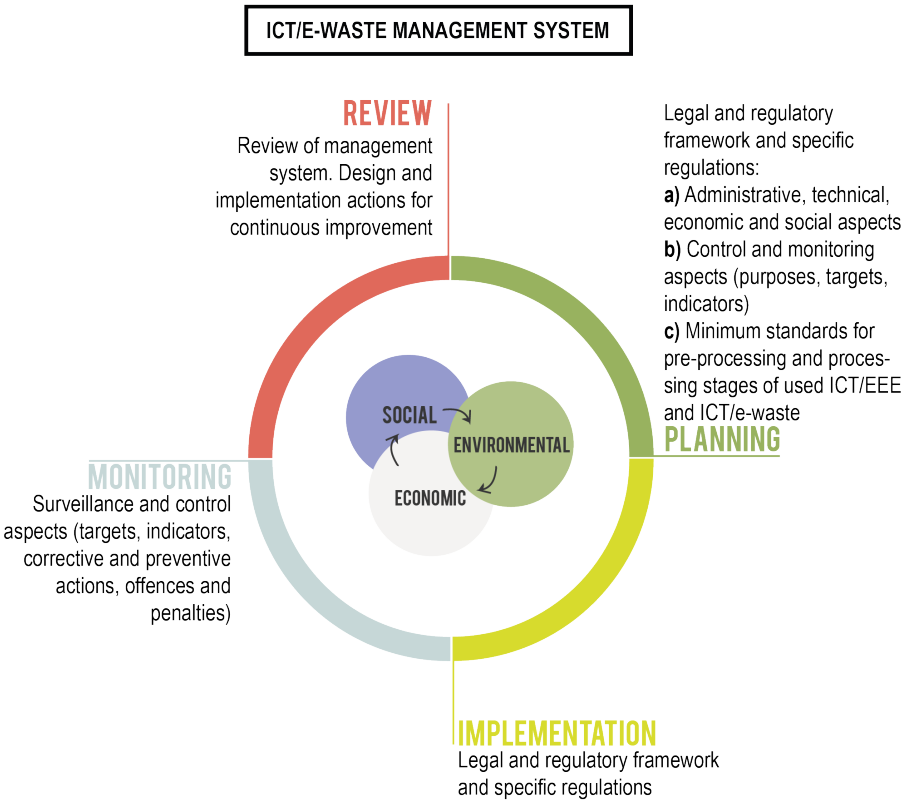
Executive Summary

In today's globalized world, telecommunications/ICTs are key catalysts for social, economic and environmental development. That being said, telecommunication/ICT devices and their electrical and electronic components are in general characterized by high demand and a relatively short lifespan. At the same time, the mounting volumes of end-of-life and near-end-of-life ICT equipment around the globe are becoming a matter of growing concern. If not properly treated, the chemical substances they contain are potentially harmful to both the environment and human health. On the other hand, the precious and rare elements contained in ICTs and WEEE should be recycled to avoid losing valuable resources.

The problem of e-waste is of particular concern in the world's least developed countries, which receive significant amounts of used EEE either legally for reuse or illegally (e.g. in transboundary shipments of non-usable equipment received in contravention of the Basel Convention or through dumping). Least developed countries often lack the policies, legal instruments, regulations, technology, and infrastructure needed for the environmentally sound management of e-waste recycling, and this, together with limited awareness of the adverse consequences of inadequate e-waste management, constitutes a challenge to their treatment of telecommunication/ICT-derived waste.

This is why it is so important for all countries to establish a legal, regulatory and policy framework allowing for the environmentally sound management of telecommunication/ICT-derived waste. Such a framework should cover both the design and organization of an e-waste management system and its enforcement on the basis of a set of stringent minimum standards.

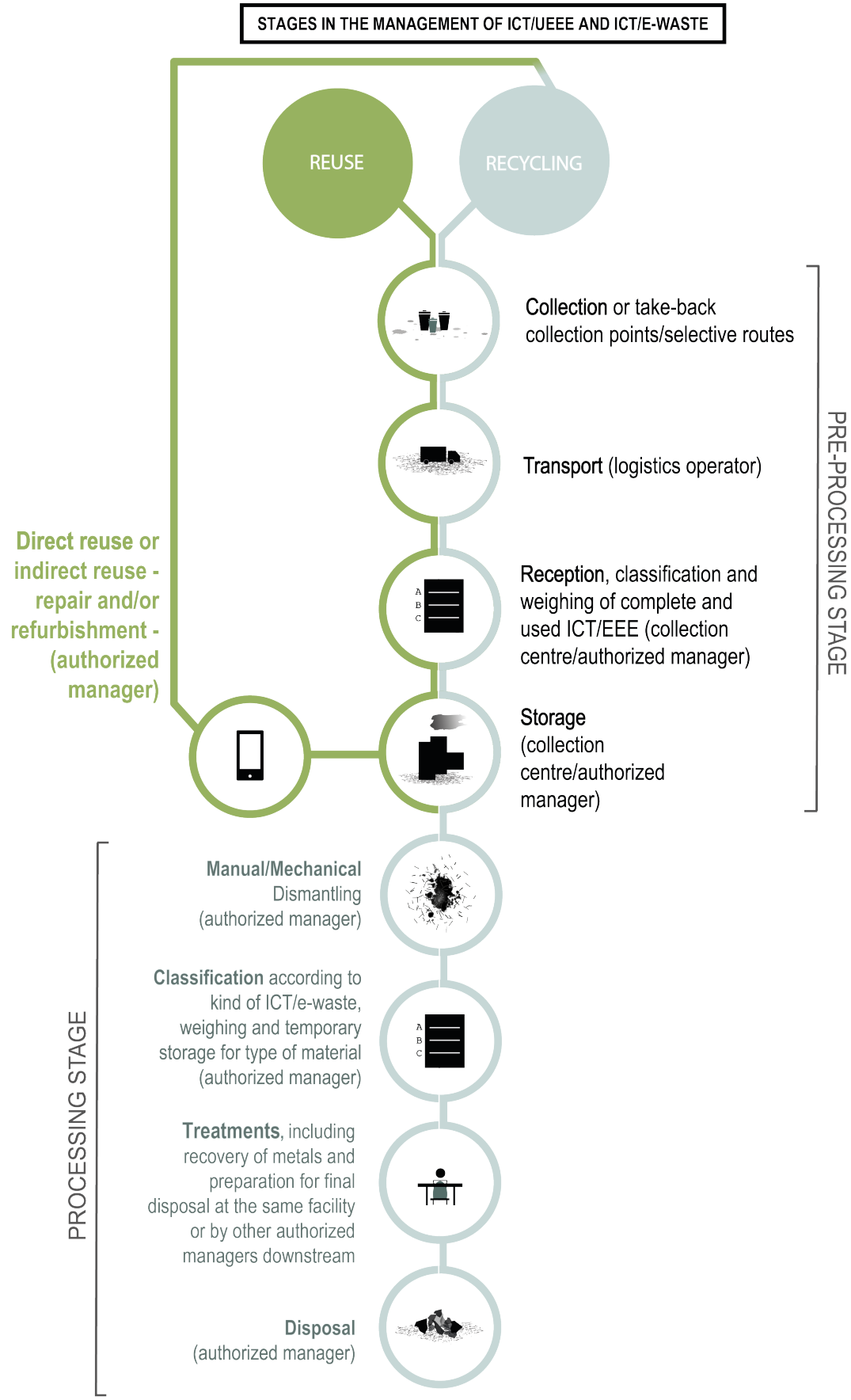
This Handbook provides guidance on the key aspects to be taken into account when designing, implementing and improving a legal, regulatory and policy framework on ICT/e-waste. The proposed framework is intended to facilitate the management of ICT/e-waste based on the concepts of sustainable development, green ICT and the circular economy. It is structured in four phases – planning, implementation, monitoring and review – summarized in the figure below.



Source: ITU

During the planning phase, a legal, regulatory and policy framework is defined that covers the administrative, technical, social and economic aspects key to the environmentally sound management of UEEE and ICT/e-waste.

In the next two phases, all stakeholders involved in the waste management chain apply the framework's different components. In order to ensure correct implementation, the government defines minimum standards enabling authorized managers to properly manage UEEE and e-waste through different stages leading to reuse or recycling (implementation), and to monitor and assess the process (monitoring).


STAGES IN THE MANAGEMENT OF ICT/UEEE AND ICT/E-WASTE
REUSE
RECYCLING
Collection or take-back collection points/selective routes
Transport (logistics operator)
Reception, classification and weighing of complete and used ICT/EEE (collection centre/authorized manager)
Storage (collection centre/authorized manager)
PRE-PROCESSING STAGE
Direct reuse or indirect reuse - repair and/or refurbishment - (authorized manager)
Manual/Mechanical Dismantling (authorized manager)
Classification according to kind of ICT/e-waste, weighing and temporary storage for type of material (authorized manager)
Treatments, including recovery of metals and preparation for final disposal at the same facility or by other authorized managers downstream
Disposal (authorized manager)
PROCESSING STAGE

Source: ITU

Depending on the results of the monitoring phase, the regulations are reviewed and adjusted, for example by increasing collection, reuse, recycling and recovery targets (review phase).

A review of some of the most comprehensive existing standards for the environmentally sound management of ICT/e-waste (Chapter 3 and Annex 2) and of the legal, regulatory and policy frameworks adopted by five countries (Annex 3) brought to light a number of key issues. Chapter 4 draws on this review to formulate a set of recommendations for key points to be covered by a model legal, regulatory and policy framework for the management of ICT/e-waste.

The model framework must take account of the national context and any existing legal, regulatory and policy framework. Despite differences in national contexts, the Handbook proposes a standardized framework for ICT/e-waste management in line with the concepts of sustainable development, green ICT and the circular economy.

Some of the general aspects are summarized hereunder.

Legal, regulatory and policy framework: general aspects

In the planning and implementation phases, a number of preparatory steps need to be taken: it is crucial to assess the country's situation in terms of waste management, including ICT/e-waste; ICT/e-waste needs to be classified as a special category of waste and the e-waste management system defined in the light, for example, of the national situation in terms of e-waste management, infrastructure and possible funding mechanisms.

- As regards the administrative aspects, some of the overarching principles to consider are protection of the environment and human health, environmentally sound management, the 3Rs, the waste hierarchy and EPR. Consideration should also be given to authorizations and licences; the definition of realistic targets for collection, reuse, recycling and recovery; the regulation of import/export of ICT/UEEE and ICT/e-waste, based on the principles enshrined in the Basel Convention; the identification of clear roles and responsibilities for all stakeholders in the supply chain (producers, consumers, managers, etc.). An information system should also be designed and administered, by a designated public entity.
- As regards the social aspects, the framework should encourage the creation of jobs related to reuse and recycling, the adoption of strategies for training and the inclusion of the informal sector. Awareness of responsible technology consumption should also be promoted.
- As regards the technical aspects, the framework should request adequate and sufficient capacities for the management of used ICT and ICT/e-waste; provide support for eco-design; and promote the application of the circular economy. Manufacturers should be requested to provide detailed information on e-waste to consumers.
- Finally, as regards the economic aspects, there exist a number of economic models for financing waste management systems, including by producers or consumers, the public or private sector, or international organizations. Often a combination of different models ensures the system's sustainability.

In the monitoring phase, the government should designate public entities to supervise and control the stakeholders in the used ICT and ICT/e-waste management system. Different kinds of sanctions should be applied (administrative, criminal or disciplinary). The entities concerned should verify indicators at local and regional level.

In the review phase, the government should apply the preventive, corrective and improvement measures proposed in the previous phase, in order to ensure and develop environmentally sound management.

Suggested minimum standards

Certain minimum standard requirements are common to all four phases (planning, implementation, monitoring and review); they relate to general aspects such as pre-requisites, principles, authorizations and licences, and general legal considerations. In addition, there are cross-cutting requirements relating to infrastructure, human skills, equipment and documentary support, information systems, and awareness and communication.

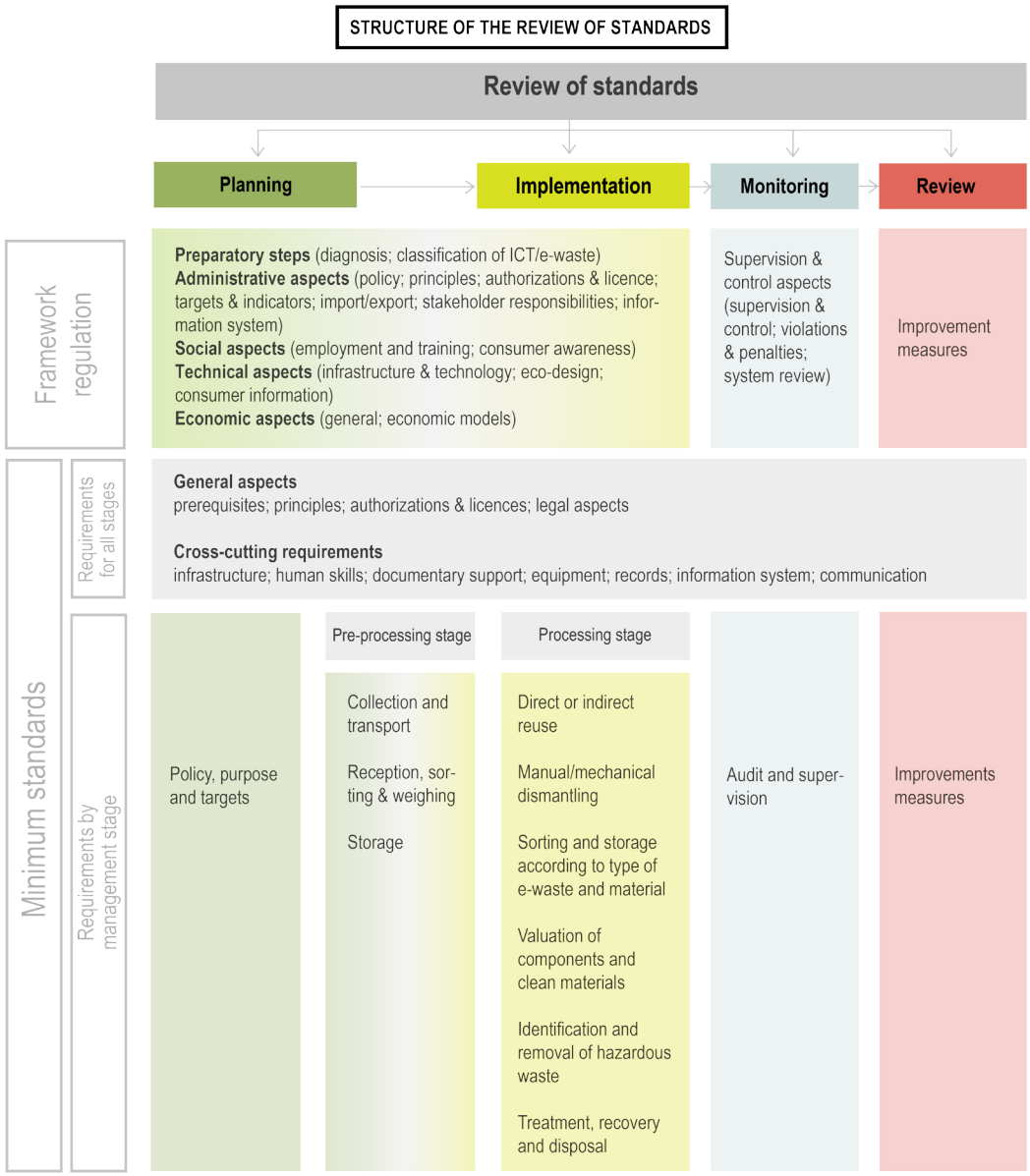
Moreover, the minimum standards should reflect the following:

- in the planning phase, authorized managers should follow an environmental, health and safety policy stipulating a commitment to control the risks originating from used ICT and ICT/e-waste management.
- in the implementation phase, pre-processing should include minimum requirements for the collection and transport (a critical step), reception/sorting and weighing of ICT/e-waste, and for storage, including of infrastructure and dedicated equipment and machinery.

In terms of the actual processing of e-waste, the framework should contain clear indications for direct and indirect reuse, including the possible repair and refurbishment of products. By way of example, it should stipulate compliance with all applicable laws in case of export/import; sanitization of data; the availability of proper labeling and documentation; and traceability. The government should provide clear instructions for manual and mechanical dismantling (types of document needed and how to record information), and for the correct sorting and storage of ICT/e-waste based on composition (if there are hazardous components).

Lastly, in terms of treatment and disposal, the minimum requirements should cover both general aspects and more specific ones, such as the infrastructure (facilities, laboratories, etc.), specific tools, equipment and information to be included in the records (treatment and disposal methods, kinds of material obtained, possible transboundary movements, etc.).

- In the monitoring phase, audits should be conducted by first, second and third parties, following objective and impartial criteria and involving all the operators in the recycling chain.
- In the review phase, the government should implement preventive, corrective and improvement measures to ensure that the e-waste management system is continuously improved.


STRUCTURE OF THE REVIEW OF STANDARDS
Review of standards
Planning
Implementation
Monitoring
Review
Framework regulation
Preparatory steps (diagnosis; classification of ICT/e-waste)
Administrative aspects (policy; principles; authorizations & licence; targets & indicators; import/export; stakeholder responsibilities; information system)
Social aspects (employment and training; consumer awareness)
Technical aspects (infrastructure & technology; eco-design; consumer information)
Economic aspects (general; economic models)
Supervision & control aspects (supervision & control; violations & penalties; system review)
Improvement measures
Minimum standards
Requirements for all stages
General aspects
prerequisites; principles; authorizations & licences; legal aspects
Cross-cutting requirements
infrastructure; human skills; documentary support; equipment; records; information system; communication
Requirements by management stage
Policy, purpose and targets
Pre-processing stage
Collection and transport
Reception, sorting & weighing
Storage
Processing stage
Direct or indirect reuse
Manual/mechanical dismantling
Sorting and storage according to type of e-waste and material
Valuation of components and clean materials
Identification and removal of hazardous waste
Treatment, recovery and disposal
Audit and supervision
Improvements measures

Source: ITU

Introduction

In today's globalized world, ICTs are key catalysts for social, economic and environmental development. That being said, the mounting volumes of end-of-life and near-end-of-life ICT equipment around the globe are becoming a matter of growing concern. More electrical and electronic devices are being discarded – often prematurely – to acquire the latest update, without due consideration being given to the hazardous substances or precious and rare metals or elements they contain. If not properly treated, these substances have the potential to harm both the environment and human health. On the other hand, the precious and rare elements contained in ICT electrical and electronic devices should be recycled to avoid losing valuable resources.

In many countries, e-waste is disposed of along with ordinary waste, discarded in public areas, or collected by informal recyclers who – having limited or no knowledge of the appropriate techniques – may follow practices affecting the environment and human health, such as burning cables or using acid baths to recover precious metals.

The problem is of particular concern in the world's least developed countries, which receive significant amounts of UEEE, either legally for reuse, or illegally (e.g. transboundary shipments of non-usable equipment received in contravention of the Basel Convention). Least developed countries often lack the technology, regulations and infrastructure needed for the environmentally sound management of e-waste recycling, and this, together with limited awareness of the adverse consequences of inadequate e-waste management, constitutes a challenge to their treatment of ICT-derived waste.

Technological advancement and development should be achieved while limiting any adverse impact on the environment. Three key concepts have been developed over the years to strike a balance between development and environmental protection: sustainable development, green ICT and the circular economy. According to the United Nations report *Our Common Future* (1987), sustainable development (see Glossary) entails "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". The application of green ICT (see Glossary), which is derived from the sustainable development concept, "benefits the environment by improving energy efficiency, lowering greenhouse gas emissions, using less harmful materials, and encouraging reuse and recycling" (CEPIS, 2016). In the same vein, within a circular economy (see Glossary), products "are designed from the start for reuse, and products subject to rapid technological advance are designed for upgrade" (World Economic Forum, 2016).

The implementation of these three concepts implies environmentally sound management of used ICT equipment and ICT-derived waste. A critical step in this direction is the adoption of a legal, regulatory and policy framework establishing an environmentally sound e-waste management system like the one discussed in this Handbook.

ITU work on e-waste

ITU attaches great importance to the environmentally sound management of ICT/e-waste; it has implemented a number of actions and initiatives to support countries in this regard. These include work by the ITU Development and Standardization Sectors and their study groups. During the Study Period 2017-2020, ITU-T Study Group 5 on "Environment, Climate Change and Circular Economy" is working on circular economy including e-waste within Q7/5, and during the Study Period 2014-2017, ITU-D Study Group 2 considered strategies and policies for the proper disposal or reuse of telecommunication/ICT waste material, under Question 8/2. In October 2017, the World Telecommunication Development Conference restated the mandate of the ITU Development Sector to properly assess the scope of e-waste as an important step towards addressing the e-waste challenge, and to advise countries on how to achieve the environmentally sound management of e-waste and to build a circular economy. A new Study Group Question (6/2) on ICTs and the environment was approved, to continue the study of e-waste. In addition, ITU provides direct assistance for the planning and implementation of e-waste management methods and promotes innovative ICT solutions in the domain of e-waste.

Last but not least, ITU Members reaffirmed their commitment to tackling the challenges of e-waste when, as part of the ITU Connect 2020 Strategic Goals and Targets, they adopted Target 3.1 on reducing the amount of e-waste.[1]

Objective and structure of the Handbook

Multiple documents provide instructions on the proper techniques for managing e-waste in an environmentally sound manner (e.g. UNEP, 1992; StEP, 2014 and 2016; UNU, 2015). This Handbook aims to supplement those instructions with guidance on the key aspects to be taken into account when establishing an effective legal, regulatory and policy framework on ICT/e-waste. It focuses on ICT/e-waste, but a number of the aspects and recommendations it discusses apply to electrical and electronic waste and/or waste in general.

The Handbook comprises four chapters and three annexes. Chapter 1 deals with the social and economic benefits of ICT and the main challenges posed by ICT/e-waste. Chapter 2 covers the importance of designing and implementing e-waste regulations based on the concepts of sustainability and green ICT. It also describes the steps involved in designing and implementing an e-waste management system. Chapter 3 reviews three of the most comprehensive environmental standards for the recycling and disposal of ICT/e-waste, identifying key issues and common aspects. Chapter 4 contains a set of general recommendations for key points to be included in a model legal, policy and regulatory framework to facilitate the management of ICT/e-waste. Annex 1 presents an overview of treatment methods and Annex 2 a thorough examination of the content of the three standards reviewed. To complement the analysis, Annex 3 presents a review of the legislation of five countries from different regions of the world, including both developed and least developed countries (Bhutan, Canada, Colombia, France, South Africa).

Working definition

Electrical and electronic waste (e-waste)

Different institutions and organizations use different definitions of e-waste. This Handbook, for its part, uses the definition adopted by the Solving the E-Waste Problem (StEP) Initiative (2014):

E-waste is a term used to cover items of all types of electrical and electronic equipment (EEE) and its parts that have been discarded by the owner as waste.

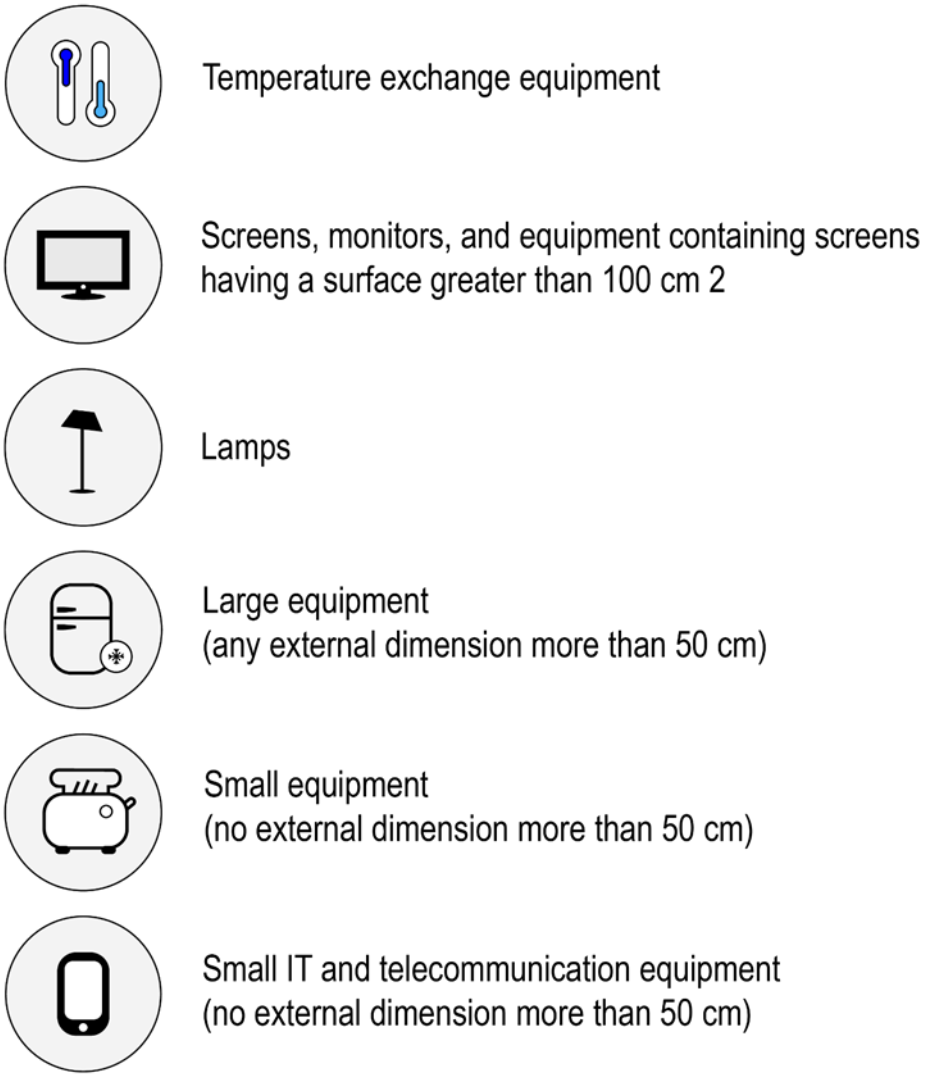
The definition includes all types of EEE “with circuitry or electrical components with power or battery supply”. The term “parts” refers to parts that have been removed from EEE by disassembly and are electrical or electronic in nature. The word “discarded”, meaning thrown away or disposed of as useless, is also central to the definition. It implies that the item is considered excess or waste by the owner. It refers to the critical point at which an item changes in nature from being a potentially useful product to waste.

[1] See http://www.itu.int/en/connect2020/Pages/default.aspx.

Categories of electrical and electronic equipment

Even though this Handbook takes a global view, it is worth noting the more holistic classification adopted by Directive 2012/19/EU, whereby there are six categories of EEE (see Figure 1).[2]

Figure 1 – Categories of EEE



Source: Directive 2012/19/EU (2012)

[2] In accordance with Directive 2012/19/EU, the six categories will be effective as of 15 August 2018. Between the Directive's adoption and 14 August 2018, the following 10 categories apply (Annex III): 1. Large household appliances; 2. Small household appliances; 3. IT and telecommunication equipment; 4. Consumer equipment and photovoltaic panels; 5. Lighting equipment; 6. Electrical and electronic tools (with the exception of large-scale stationary industrial tools); 7. Toys, leisure and sports equipment; 8. Medical devices (with the exception of all implanted and infected products); 9. Monitoring and control instruments; 10. Automatic dispensers.

CHAPTER 1 – ICT-derived waste: benefits, challenges and opportunities for effective management

1.1 ICTs: benefits and opportunities

Access to and use of ICTs has expanded significantly around the world, although the digital divide remains a challenge. By 2017, close to half the world's population was using the Internet and the number of mobile-cellular subscriptions had grown to 7.7 billion.

According to ITU (2016b), achievement of the SDGs requires the use of ICTs: "All three pillars of sustainable development – economic development, social inclusion and environmental protection – need ICTs as key catalysts. This is why […] ICTs […] will be absolutely crucial for achieving the SDGs" (see Figure 2). Some examples of how ICTs can help achieve the SDGs are given below:

- Reduced deployment costs: ICTs can significantly reduce the costs of implementing new services. There are good examples in the fields of health care and online banking. Thanks to ICTs, for instance, patients can obtain diagnoses and treatment from community health workers in the community rather than from doctors at high-cost facilities (The Earth Institute Columbia University & Ericsson, 2016), and the world's unbanked population can obtain access to financial services through online banking.
- Increased training opportunities and access to information: ICTs can accelerate the spread of technology by providing low-cost online platforms for training and capacity building.
- Climate change mitigation: ICTs can contribute to energy efficiency, global warming mitigation and cost optimization through the application of green ICT.[3] For instance, smart grids can improve energy efficiency and reduce greenhouse gas emissions from the power network. Costs can be minimized by using services and applications related to dematerialization (such as e-government, cloud computing, e-commerce, telework, telepresence, e-mail, videoconferencing and e-books). Eco-design, for its part, can prevent the generation of hazardous e-waste.

Figure 2 – The three dimensions of sustainable development

Source: ITU

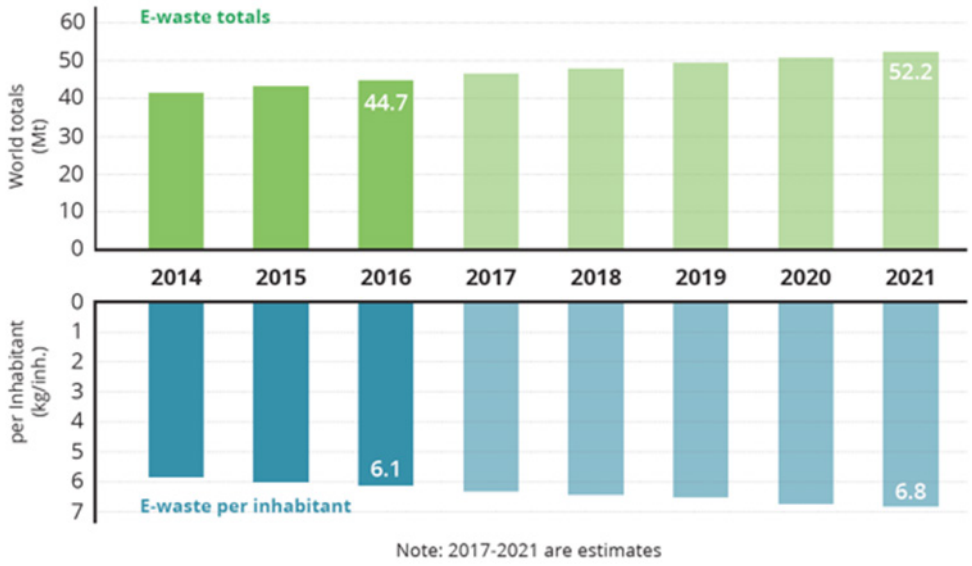
1.2 Challenges arising from ICT/e-waste

Worldwide, an estimated 44.7 million metric tonnes of e-waste were generated in 2016, a figure that is expected to increase to 52.2 million metric tonnes, or 6.8 kg/inh, by 2021. Of the total e-waste produced in 2016, only 8.9 million metric tonnes (or 20%) was reported as being formally managed by an e-waste collection and management system (Baldé, 2017). Graph 1 shows the total and per

[3] See also ITU, Green ICT and Smart Grids, 2016. Available at: http://www.itu.int/en/ITU-D/ Regional-Presence/ AsiaPacific/Pages/Events/2015/Sep%20Green%20ICT/GreenICT.aspx.

capita quantities of e-waste produced worldwide from 2014 to 2016, and the quantities projected for 2017 to 2021.

Graph 1 – E-waste generated globally 2014–2021



Source: Baldé 2017

ICT/e-waste is generated *inter alia* by continuous technological advances and EEE life cycles. Several studies show that the latter are generally becoming shorter as a consequence of technological innovation and the consumer's desire to acquire the latest ICT equipment on the market.[4] In addition, many developing countries have not legislated on ICT/e-waste, and some have weak enforcement systems.

Estimates of the amount of e-waste generated, collected and recycled at international, regional and national level are very important for the design and implementation of the proper and environmentally sound management of e-waste. A major initiative to help produce better e-waste statistics, based on nationally comparable data, is currently being conducted by ITU, UNU and ISWA (see Box 1.1).

Inadequate management of ICT/e-waste can have adverse consequences for human health and the environment.

[4] This is a general tendency across countries and EEE types. However, some studies also indicate that IT equipment that is up to 10 years old is being disposed of at municipal sites.

Box 1.1 – The Global E-waste Statistics Partnership

More and more people are joining and benefiting from the opportunities of the digital economy and information society. As technologies change at great speed, and as access to and use of EEE increase, product life cycles are becoming shorter and many designs do not support repair or reuse. As a result, the amount of e-waste is growing rapidly. Used, broken or obsolete equipment, such as phones, laptops, sensors, TVs and batteries, contain substances that pose considerable environmental and health risks, especially if treated inadequately. Most e-waste is not properly documented and not treated through appropriate recycling chains and methods.

Measuring e-waste is an important step towards addressing the e-waste challenge. Statistics help to evaluate developments over time, set and assess targets, and identify best practices. Better e-waste data will help to minimize e-waste generation, prevent illegal dumping, promote recycling, and create jobs in the reuse, refurbishment and recycling sectors. It will contribute to the achievement of the Sustainable Development Goals, in particular SDG12, to "ensure sustainable consumption and production patterns".

ITU, UNU and ISWA have joined forces to form the Global E-waste Statistics Partnership. Its main objectives are to improve and collect worldwide e-waste statistics, to heighten awareness of the importance of tracking e-waste, and to deliver national and regional capacity-building workshops.

Source: https://www.itu.int/en/ITU-D/Climate-Change/Pages/ewaste/globalewastestatisticspartnership.aspx

ISWA International Solid Waste Association

ITU

UNITED NATIONS UNIVERSITY
UNU-VIE SCYCLE
Sustainable Cycles Programme

1.2.1 Human health

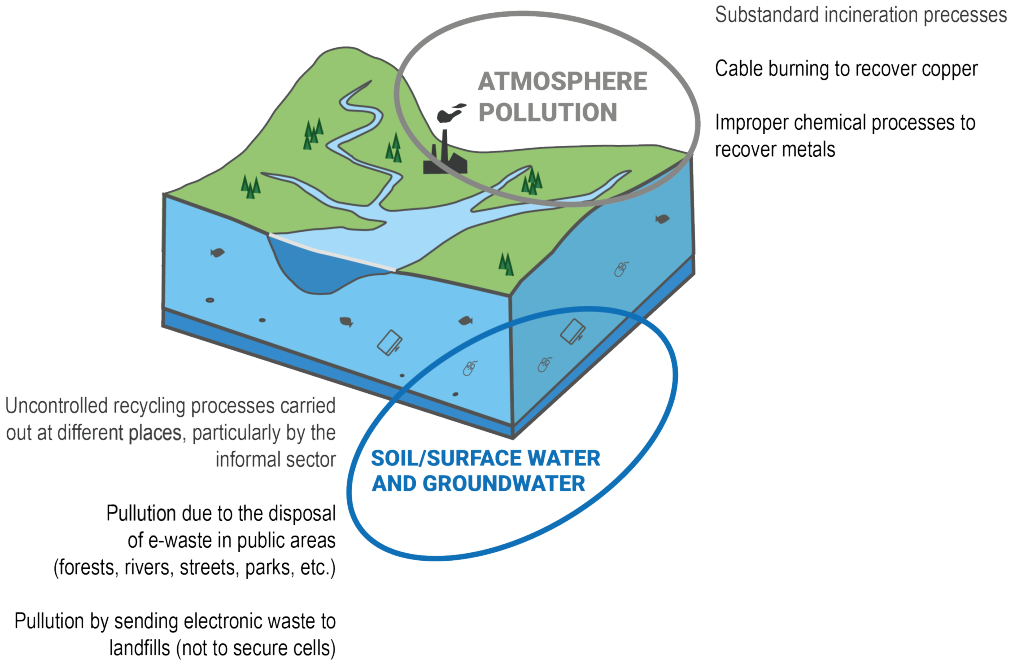
Long-term exposure to the hazardous components present in e-waste can have negative effects on the human body, in particular the nervous system, the kidneys, the bones, and the reproductive and endocrine systems (Kumar and Kumar, 2014). The 2013 Geneva Declaration on E-Waste and Children's Health was published to raise awareness of the health risks of exposure to e-waste (Alabaster et al., 2013). There are several ways in which e-waste can pose a health risk.

- Improper handling of e-waste (direct contact with harmful materials, inhalation of toxic fumes) can pose health risks, as can the accumulation of chemicals in soil, water and food. Incorrect e-waste management also generates toxic by-products. For example, the burning of cables and plastics containing flame-retardants, without regard to appropriate technical criteria, produces dioxins and furans, which are highly toxic and carcinogenic compounds (WHO, 2016).
- Hazardous substances contained in e-waste can be released in uncontrolled recycling processes as a mixture. Persistent organic pollutants and heavy metals have been found at and near recycling plants. The degree of exposure varies depending on the type of e-waste, the length of the recycling history, the volume of recycling, specialization in recycling processes, the location of recycling workshops, and the daily activities of workers (Kumar and Kumar, 2014).

1.2.2 The environment

The production, use and final disposal of ICT/e-waste also have an environmental impact, or "foot-print". Improper e-waste management can cause air pollution and lead to the contamination of soil, surface water and groundwater (as illustrated in Figure 3).

Figure 3 – Adverse effects on the environment of improper e-waste management



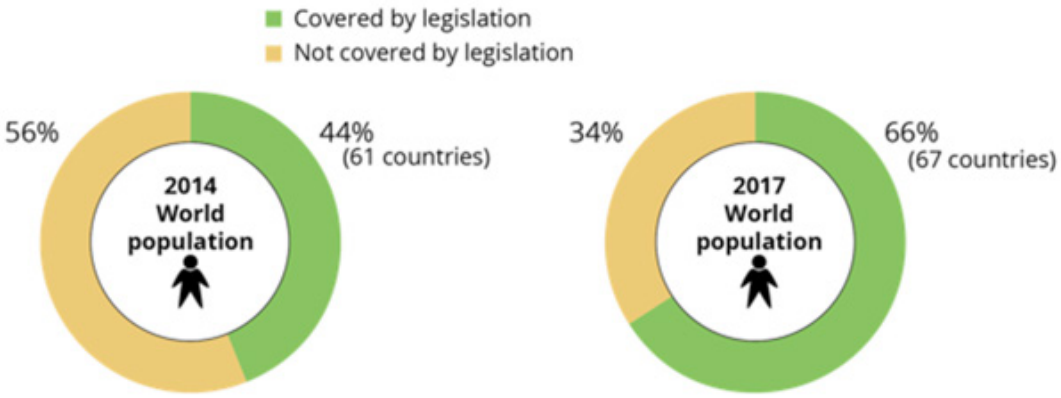
Source: ITU

1.3 E-waste legislation around the world

According to *The Global E-waste Monitor 2017*, in January 2017, approximately 4.8 billion people – or 66 per cent of the world's population – were covered by national legislation in 67 countries. This represents an improvement over 2014, when only 44 per cent (61 countries) were covered. However, national legislation does not always translate into concrete action. In addition, the range of products covered and targeted by e-waste laws may differ from the more extensive range used in this report.

Graph 2 shows the number of countries and and the world population covered by e-waste legislation in 2014 and 2017.

Graph 2 – World population (and number of countries) covered by e-waste legislation in 2014 and 2017



Source: Baldé 2017.

1.4 Recovering ICT and EEE components: challenges and benefits

ICT services and applications depend heavily on the use of different types of EEE, which contain hazardous substances and have ever shorter life spans, at the end of which they turn into electronic residues. The production of EEE also has an environmental footprint, which needs to be limited to improve sustainable development. Environmentally sound management of ICT/e-waste is thus necessary to limit the adverse impact on the environment of the production, use and disposal of EEE.

ICT/e-waste contains a variety of materials and metals that can be recovered by applying different techniques and technologies depending on how hazardous they are. This is reflected in the Basel Convention, which classifies electrical and electronic waste under different codes on the basis of its content (hazardous vs. non-hazardous).

Materials that are considered "clean" (not hazardous) can be recovered, using appropriate techniques, for commercialization and subsequent re-entry into production processes (examples are copper, aluminium, glass, rubber, ferrous metals, some types of plastic). However, hazardous substances (e.g. cadmium, lithium, mercury, bromine, beryllium, lead, selenium, chromium, nickel) require further treatment, since their release into the environment without proper controls can cause serious pollution problems, affecting human and animal health. Table 1 provides a brief summary of the major hazardous components and materials that can be found in ICT/e-waste.

Table 1 – Major hazardous components and materials in ICT/e-waste

1	Batteries	Heavy metals such as lead, mercury and cadmium are present in batteries.
2	CTRs	Lead in the cone glass and fluorescent coating cover the inside of panel glass. Heavy and rare metals are present in the fluorescent coating (europium and yttrium).
3	Components such as switches and fluorescent lamps in LCDs	Mercury is used in thermostats, sensors, relays and switches (e.g. on printed circuit boards and in measuring equipment and discharge lamps). It is also used in medical equipment, data transmission and telecommunication devices, and mobile phones.

4	Toner cartridges (liquid and pasty) and colour toner	Toner and toner cartridges have to be removed from any separately collected e-waste. The photoconductive drums in old equipment contain selenium and cadmium. When the drums are integrated into the toner cartridge, they are organic photo conductors, which do not contain dangerous components and can be recycled.
5	Printed circuit boards	Cadmium occurs in certain components, such as SMD chip resistors, infrared detectors and semiconductors.
6	Capacitors	PCB-containing capacitors have to be removed for safe destruction.
7	LCDs	LCDs contain indium tin oxide and fluorescent coatings. LCDs with a surface area greater than 100 cm^2 have to be removed from e-waste.
8	Plastics	Plastics can contain halogenated flame retardants, which can produce toxic fumes during incineration/combustion.
9	Gas discharge lamps	Gas discharge lamps contain mercury, which has to be removed.

Source: Based on Khaliq et al., 2014

ICT/e-waste also contains precious metals (e.g. gold, silver, platinum, gallium, palladium, tantalum, tellurium, germanium and selenium) and rare earth elements (such as yttrium, europium and coltan), which makes it attractive for recycling (Khaliq et al., 2014).

The recovery of precious metals and rare earth elements is beneficial for environmental preservation, energy efficiency and resource conservation. The extraction of virgin metals has been proven to consume more energy and generate greater amounts of CO^2 than what is known as urban mining (see Glossary), i.e. the recovery of metals from e-waste. In fact, obtaining 1 tonne of copper produces an average of 300 tonnes of toxic or polluting emissions and requires 30 to 500 litres of water, depending on the field (Handal, 2010). Producing a 10-gram gold ring produces 20 tonnes of emissions and waste and requires 7 to 8 thousand litres of water for the initial treatment of the rock (Mudd, 2008). In fact, more gold can be recovered from one tonne of computer e-waste than from 17 tonnes of gold ore (Khaliq et al., 2014).

The recovery of materials from e-waste has other economic, social and environmental benefits. Some studies have shown how reuse and preparation for reuse of a selection of waste streams can bring extensive benefits to the economy by creating additional employment opportunities.[5]

In the context of reuse, it should be noted that the data and information stored on computers, mobile phones and other electronic equipment call for proper data security measures, or data sanitization (see Glossary), to avoid loss or theft of data (StEP, 2014b).

[5] This position is not, however, unanimously shared.

CHAPTER 2 – The legal, regulatory and policy framework for the ICT/e-waste management system

A proper legal framework represents a critical step that governments should take to address the problems caused by ICT/e-waste. Clear regulations and detailed standards and procedures are needed for the smooth, effective and productive functioning of the management system (regulatory framework) (StEP, 2016). In parallel, governments should also adopt well-defined policies setting national goals, and regulate and implement planned activities related to ICT/EEE and ICT/e-waste. It does not suffice, however, to design a legal framework for e-waste. Governments must also guarantee and oversee its implementation and enforcement.

The overall success of an environmentally sound e-waste management system is contingent on the clear definition of all aspects, from e-waste collection and transport to reception, classification and treatment (StEP, 2014b). This Handbook lists the key points to be covered by the policy framework establishing an environmentally sound system (see Glossary) for managing ICT-derived waste, in line with the concepts of sustainable development and green ICT.

While this chapter focuses specifically on the legal, regulatory and policy framework, it also discusses other elements (e.g. preventive action, government awareness-raising activities).

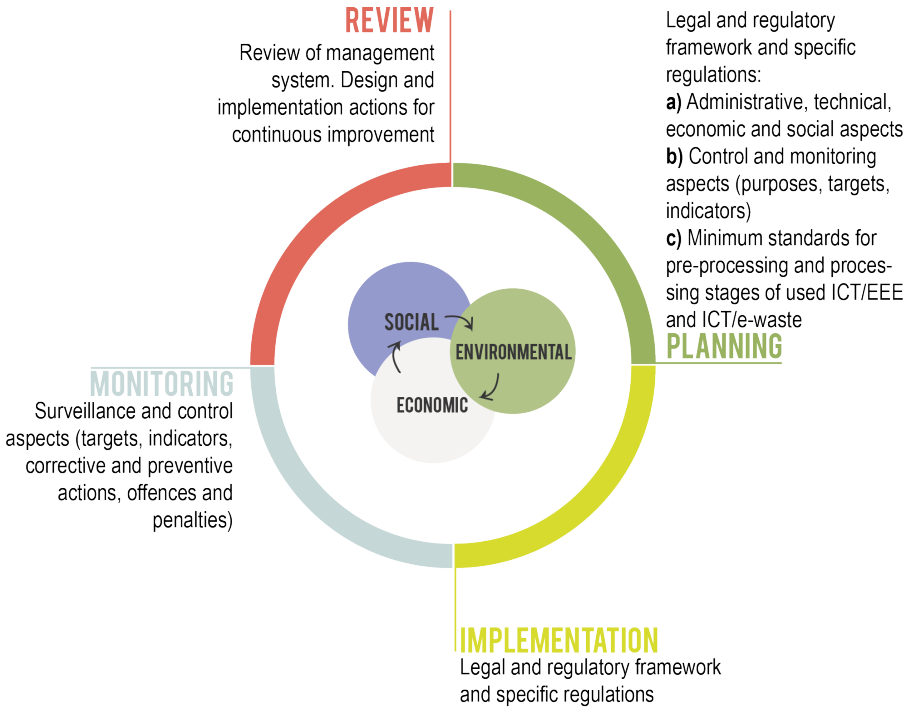
2.1 Phases of e-waste management

The design and implementation of a system for the environmentally sound management of ICT/e-waste can be structured in four phases,[6] as summarized in Figure 4.

- Planning: During the first phase, a legal and regulatory framework is defined to covers the administrative, technical, social and economic aspects that are key to the environmentally sound management of ICT/UEEE and ICT/e-waste.
- Implementation: In a second phase, the stakeholders apply the various components of the regulations defined in the previous phase.
- Monitoring: In order to ensure its correct implementation by all stakeholders (see Glossary), the government defines minimum standards enabling authorized managers (see Glossary) to properly manage UEEE (see Glossary) and e-waste through different stages leading to reuse or recycling, and to carry out monitoring and assessment (see Figure 5).
- Review: Depending on the results of the monitoring and assessment, the regulations are reviewed and adjusted, for example by increasing collection, reuse, recycling and recovery targets.

[6] A similar approach is adopted by the Deming Cycle, or the Plan, Do, Check, Act (PDCA) Cycle. The four phases are repeated over and over, as part of a never-ending cycle of continuous improvement (The W. Edwards Deming Institute, 2016).

Figure 4 – ICT/e-waste management system



Source: ITU

The four phases for the design and implementation of an environmentally sound e-waste management system are explained below in detail.

2.1.1 Planning

The planning phase starts with a thorough assessment of the current situation in terms of used ICT equipment and e-waste at the national level, to obtain an overview with a view to designing general and specific regulations (PACE and Basel Convention, 2017), and to assess legal compliance with regional and international legislation and treaties (StEP, 2014b).

General regulations: According to existing best practices, the government should adopt clear general regulations on ICT/UEEE and ICT/e-waste (StEP, 2014b and 2016). Those regulations should comprise, at a minimum:

- clear definitions of the administrative, technical, economic and social commitments of stakeholders;
- clear definitions of concepts to ensure they are properly understood by all stakeholders (i.e. what is e-waste, who is a producer, a collector, etc.) and, wherever possible, are aligned with internationally recognized definitions;
- the establishment of a licencing or certification system to ensure that all collectors and recyclers are known to the government and are authorized to carry out their specific activities (StEP, 2016);

- a clear definition of government monitoring and control, with goals, targets and indicators to monitor the results of enforcement;
- clearly assigned enforcement responsibilities for government agencies or bodies;
- clear indications of the role and obligations of each stakeholder involved in collection and recycling;
- clear collection and recycling targets;
- clear procedures for the registration of producers, marketable quantities and reporting requirements;
- clear procedures for licencing and auditing dismantling and recycling operations, to ensure that they meet the standards for environmentally sound management;
- a list of sanctions and penalties for non-compliance in proportion to the offence and enforceable by government agencies, to stop unwanted behaviour;
- regular communication between stakeholders, e.g. environmental, customs and port authorities, as well as between the e-waste information system and PROs (see Glossary), to facilitate monitoring and enforcement;
- the adoption of the precautionary principle (see Glossary), which entails assuming that potential environmental and health impacts will actually occur, and therefore requires the prompt adoption of measures to mitigate and counter adverse effects (StEP, 2014b);
- the introduction of EPR (see Glossary) to ensure that producers finance the collection and recycling of e-waste, thereby also encouraging product design aimed at reuse and recycling (PACE and Basel Convention, 2017; StEP, 2014b and 2016).

Specific regulations: In addition, regulations have to be enacted specifying minimum technical standards to ensure the environmentally sound management of ICT/UEEE and ICT/ e-waste by authorized managers (see Glossary).

2.1.2 Implementation

In the implementation phase, all stakeholders apply the general and specific regulations adopted during the previous stage.

2.1.3 Monitoring

The monitoring phase covers monitoring and compliance. The government engages in monitoring and assessment, determines any violations to the legislation, and enforces applicable sanctions. It establishes a global estimate for the indicators and goals defined during the planning phase and drafts preventive/corrective/improvement measures (for example, modifying collection, reuse, recycling and recovery targets) according to the results obtained during the implementation phase.

2.1.4 Review

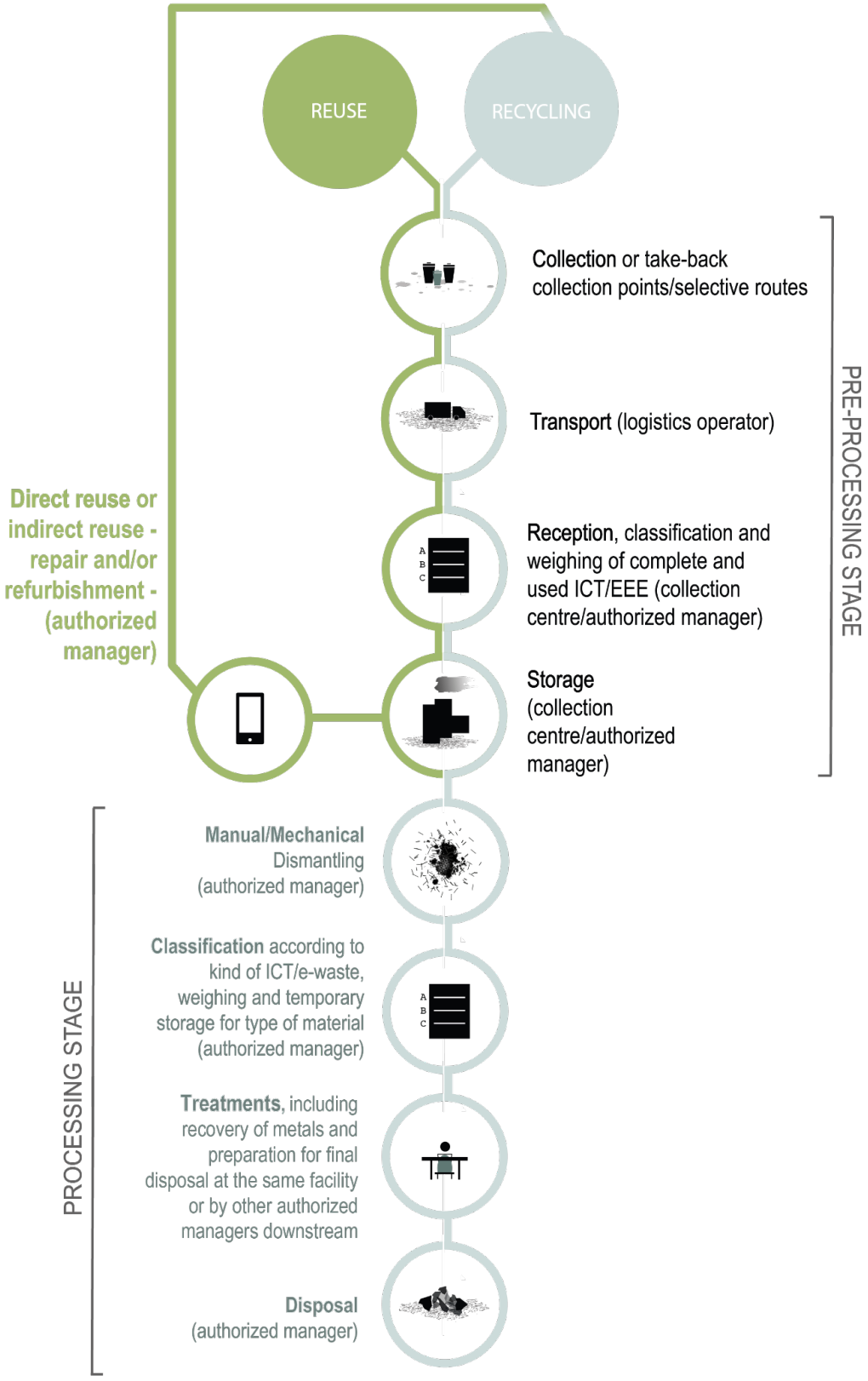
In the review phase, the government applies the preventive, corrective and improvement measures needed for the e-waste management system to function properly. Those measures are implemented and monitored in a circular process, allowing for continuous improvement.

2.2 Stages of ICT/EEE and ICT/e-waste management

Figure 5 summarizes the stages in the management of ICT/UEEE and e-waste. Ideally, recycling should occur after reuse, but if the ICT/UEEE, when sorted, is found not to be suitable for reuse, recycling can occur at the end of the equipment life cycle. Recycling can also be the result of repair and

refurbishment processes. It is worth noting that proper recycling can give some items multiple life cycles and allow them to be reused more than once.

Figure 5 – Stages in the management of ICT/UEEE and ICT/e-waste



Source: ITU

The green path in Figure 5 shows the reuse stages of ICT/UEEE, which are as follows:

- **collection or take-back of ICT** equipment after its first life cycle through selective routes (see Glossary) or at collection points where consumers drop off their used EEEs;
- **transport** by logistics operators (see Glossary) from collection points to collection centres (see Glossary) or to authorized managers (see Glossary);
- transport of **equipment** that is complete and in good or regular condition in line with the specific requirements set forth in domestic legislation;
- **reception, classification and weighing of ICT/UEEE** (The UEEE is received, classified by type of equipment (e.g. printers, CRT monitors, flat-screen monitors, cell phones, etc.) and weighed. Quantities (units) and weight (kg) are recorded in specific registers. UEEE may be classified at collection points before being transported to collection centres or authorized managers. Unclassified equipment is weighed at two separate moments: at reception in the authorized centres or by the managers, and after classification);
- **storage**: once classified and weighed, ICT/UEEE is stored in appropriate conditions to avoid deterioration, with a view to its possible reuse, and to prevent the release of hazardous substances into the environment.

After the storage stage, the ICT/UEEE can follow two different routes.

- **Direct or indirect reuse (repair and/or refurbishment)**: If the ICT/UEEE was delivered to authorized managers, the reuse process will begin in the same facility. However, if the ICT/UEEE is in collection centres, it will have to be transported to the facilities of authorized managers, undergoing an additional stage of reception, sorting, weighing and storage. The equipment received is reviewed in order to determine whether it can be directly reused, or if it needs to be repaired and/or refurbished. Some equipment may be unsuitable for reuse, in which case it must be sent to authorized recycling plants, together with e-waste resulting from repair and/or refurbishment. If devices are sent for recycling, transportation must meet the requirements stipulated in domestic legislation. In the case of ICT devices on which personal information is stored, data security requirements (what is known as data sanitization, see Glossary) should be met to prevent theft or abuse of the previous owner's personal information (StEP, 2014b).
- **Reuse or second useful life**: Once the processes necessary for the direct or indirect reuse of the ICT/UEEE have been completed, the used equipment is released for reuse (for a second or multiple life cycle).

Alternatively, when EEE is considered to be waste, it can be recycled. To increase EEE lifespans and limit waste, reuse should be incentized whenever possible. Recycling can take place after a second (or multiple) use.

In this case, the ICT/UEEE becomes ICT/e-waste and follows the recycling path indicated in grey in Figure 5. This path has two stages: pre-processing and processing.

The **pre-processing stage** comprises the preparatory phases before the ICT/e-waste is actually treated, starting from the collection of the ICT equipment until its storage. This path overlaps with the reuse path indicated in green in Figure 5.

The **processing stage** comprises all the steps required for the treatment and disposal of ICT/e-waste (indicated in grey in Figure 5).

- **Manual/mechanical dismantling**: If the reused ICT/EEE was delivered to an authorized manager, the recycling process (manual/mechanical dismantling) will begin at the same facility. If the reused ICT/EEE is at a collection centre, it must be transported once again to an authorized manager's facility and undergo a further process of reception, classification, weighing and

storage. Transportation must meet the legal requirements of each country, as entire pieces of equipment, in regular and poor condition, will be transported.

- **Classification** according to type of ICT/e-waste **and temporary storage** by type of material: The materials resulting from manual or mechanical dismantling are classified at the authorized manager's facility. Clean materials or streams (e.g. aluminium, copper, ferrous metals, clean plastic, etc.) and materials or components containing hazardous substances (e.g. lead and other batteries, ink, toners, CRT screens, LCD and plasma screens, fluorescent tubes) need to be separated. The materials obtained are weighed to record the mass balance (the weight of the complete equipment equals the weight of its parts plus an acceptable percentage of loss resulting from waste of material during the dismantling process). After weighing, the ICT/e-waste is temporarily stored. Records must be kept of the process.
- **Valuation of components and clean materials**: Clean materials or streams may be commercialized or valued for reintegration into productive processes. Not only does this generate a small economic benefit, it contributes to energy efficiency by promoting urban rather than traditional mining (see Glossary).
- **Treatment**, including recovery of metals, and **preparation for final disposal**: This step can be carried out at the same facility or by other authorized managers downstream, who must obtain the requisite permits and licences to treat components and materials containing hazardous materials and to recover rare and precious metals. Recovery processes must not generate by-products that are equally or more contaminating than the hazardous materials prior to treatment. If transportation to other facilities is needed, it must conform to national requirements, considering the dangerous content of the load. If export to other countries is required, it must meet the requirements of the Basel Convention.
- **Disposal**: Materials that cannot be treated or recovered can be disposed of at the same facility or by other authorized managers with relevant permits downstream. Depending on the type of material to be disposed of, sanitary landfill safety cells or controlled and technical incineration processes may be used.

CHAPTER 3 – Environmental standards for the recycling and disposal of ICT/e-waste

This chapter summarizes the information on three key technical standards used in different countries or regions to guide authorized managers (see Glossary) in the environmentally sound management of UEEE and e-waste. The aim is not to compare the standards, but to identify the most important and any common aspects that might help countries draw up specific regulations defining minimum standards.

3.1 Standards reviewed

The three standards reviewed – R2, WEEELABEX and e-Stewards – are among the most comprehensive in existence and cover different geographical areas (country, region) or are international. They are described in Table 2.

Table 2 – Standards reviewed

Region/ country	Name	Supervising organization	Certification	Description
United States	R2 The Responsible Recycling Standard for Electronics Recyclers	Sustainable Electronics Recycling International (SERI)	Yes	This standard was created by the United States Environmental Protection Agency. It sets international standards pertaining to the environment and occupational health and safety for the electronics refurbishing and recycling industry. Compliance is on a voluntary basis. It is available in English and Spanish.
Europe	WEEELABEX	WEEE Forum Association	No certification but conformity verification	This standard was introduced in 2011 in the framework of a project co-financed by the European Commission's LIFE+ programme. It sets out a coherent, continent-wide and comprehensive set of technical requirements with respect to e-waste operations. Compliance is voluntary. The requirements laid down in WEEELABEX are embedded in Directive 2002/96/EC and its transposing legislation. WEELABEX comprises three documents: collection, logistics and treatment. It is available in seven languages.
International	e-Stewards, Standard for Responsible Recycling and Reuse of Electronic Equipment	Basel Action Network	Yes	Introduced in 2009 by the non-governmental organization Basel Action Network (BAN), this standard is the basis for an accredited third-party certification programme. It establishes requirements for an environmentally sound system for managing electronic equipment. It is applicable to all entities along the recycling chain and internationally. Compliance is voluntary.

Source: ITU

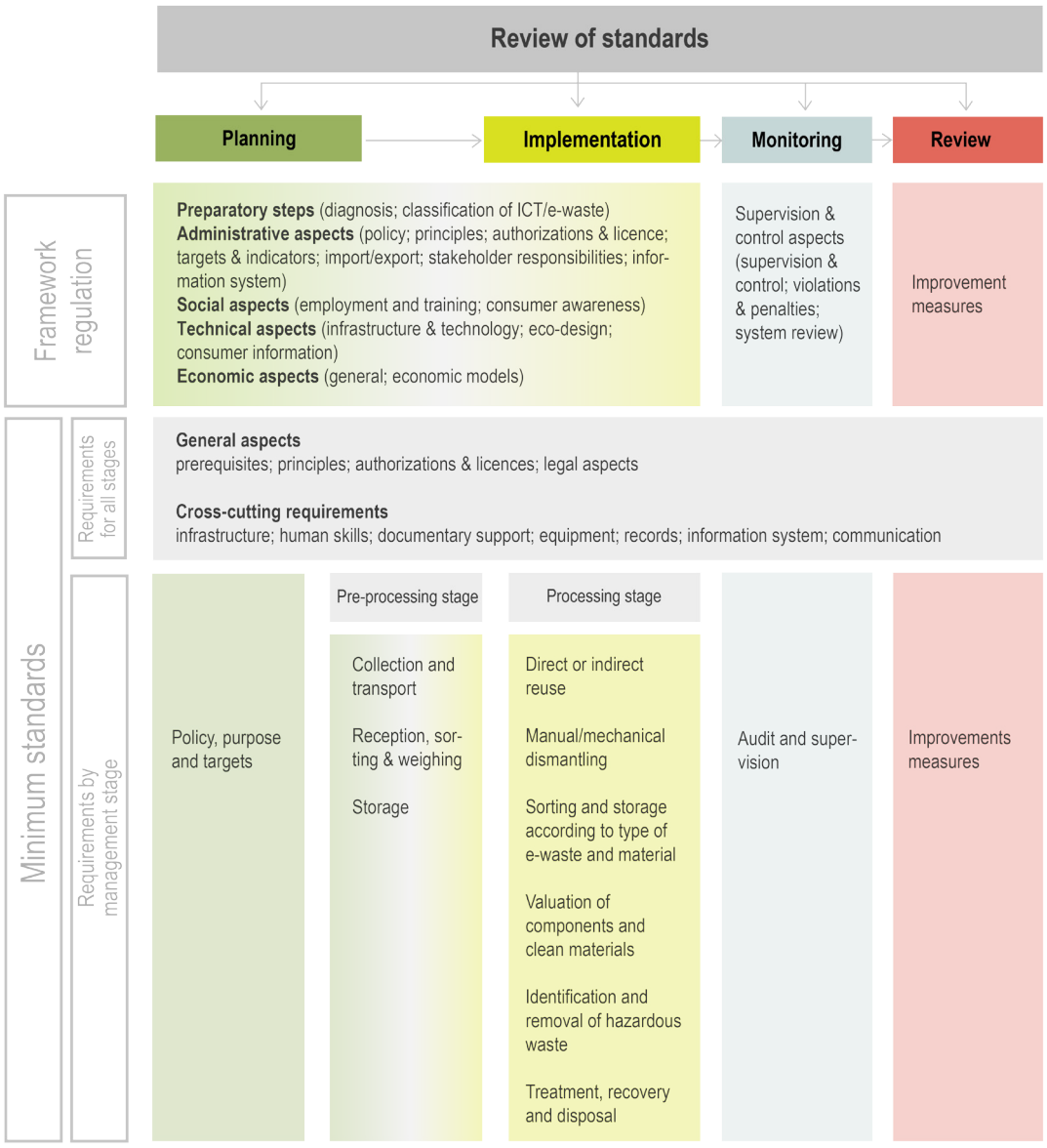
3.2 Structure of the review of standards

The structure of the review of standards is detailed in Figure 6. The main points covered by each standard are classified by the four phases described in Chapter 2.

The **planning** phase covers administrative, legal and financial aspects. The technical criteria for the management of ICT/UEEE and ICT/e-waste are described under the **implementation** phase, across the two macrostages of pre-processing and processing. Different categories are covered within these macrostages (i.e. infrastructure; human skills; documentary support; tolls and equipment; information and communication systems).

Audits and supervision are reviewed under **monitoring** and include both government monitoring and internal audits for improvement and certification. Finally, the **review** phase considers measures of improvement resulting from the outcomes of the monitoring phase.

Figure 6 – Structure of the review of standards



Source: ITU

3.3 Review of selected standards

The information provided below summarizes the most important aspects identified in the analysis of the selected standards and serves as the basis for the minimum standards recommended in Chapter 4. The results of the review of standards are presented in detail in Annex 2.

3.3.1 Planning

Scope	**R2** and **WEEELABEX** establish standards for producers, logistics operators and authorized managers (see Glossary). They are both subject to a third-party conformity assessment (StEP, 2014b).
Prerequisites	**R2** determines that electronics recyclers or managers must be certified as having one or more comprehensive systems (certified and mandatory). Certification is through an accredited third-party certification body. **WEEELABEX** requires that the operator or manager implement a health, safety, environment and quality system. It does not require certification. It stipulates that contracts can be entered into only with operators or managers that comply with these or equivalent requirements. **e-Stewards** contains provisions for an environmental management system that enshrines ISO14001:2015 requirements, health and safety management system conditions, and more specific e-Stewards' obligations that often go further than the law. It provides businesses with a best practices framework for effective management of the different types of risks they face (environmental, health and safety, legal, operational, customer-related).
Administrative aspects	**Principles: All three standards** share general principles such as: protection of occupational safety and health (see Glossary) and public health and safety; environmentally sound management; and demonstrated technical capacity of the facility or manager concerned. **WEELABEX** requires the establishment of an environmental, health and safety policy. **e-Stewards** calls for the adoption of a plan for the responsible management and disposal of UEEE and e-waste, a waste hierarchy (see Glossary), and compliance with the precautionary principle (see Glossary). **WEEELABEX** and **e-Stewards** also adopt the polluter-pays principle (see Glossary). In addition, **e-Stewards** applies the EPR principle (see Glossary) of due diligence throughout the downstream recycling chain; stringent data security requirements; and prevention and minimization of waste in production processes. (More information on these principles is provided in Chapter 4). **Policy, purposes and targets**: **R2** calls for the adoption of a policy on management of UEEE and end-of-life EEE, based on the waste hierarchy principle, and requires the facility or manager concerned to demonstrate the requisite technical capacity. **WEELABEX** requires the establishment of an environmental, health and safety policy. **e-Stewards** calls for the adoption of a plan for the responsible management and disposal of UEEE and e-waste, and the provision of adequate resources (human, technical and financial) for the effective and efficient operation of the environmental management system. **Licences and authorizations**. All three standards require licences and authorizations for facilities handling UEEE and e-waste.

Legal aspects	In **all three standards**, compliance with the legal obligations (including those relating to transboundary movement of UEEE and e-waste) is mandatory. **WEEELABEX** stipulates that, should a legal obligation conflict with one of its requirements, the most restrictive is to prevail, whereas **R2** and **e-Stewards** establish that the legal obligation prevails. **e-Stewards** provides that its standards are to be implemented insofar as they do not conflict with the law. **All three standards** explicitly and/or implicitly require the application of due diligence (see Glossary) (i.e. process of examining and verifying accuracy of procedures and implementation of requirements) to each facility and to the other actors in the downstream recycling chain (see Glossary). For **R2** it is acceptable to outsource certain activities and requirements to partners or downstream vendors. However, it is the responsibility of the electronics recycler to ensure that these downstream partners and vendors conform to the requirements of the R2 Standard. For **e-Stewards** a risk assessment must be carried out at least every three years of the environmental and stewardship aspects associated with all forms of electronic equipment managed. According to **all three standards**, facilities or managers must obtain insurance to cover potential risks and liabilities.

3.3.2 Implementation

All macrostages and stages	
Infrastructure	**All three standards** require an appropriate infrastructure meeting the security conditions needed for the operations. **e-Stewards** requires that facilities use the best available techniques (see Glossary) and processes or applications to safely recover and reuse maximum materials, and responsibly dispose of non-recyclable fractions.
Human skills	**All three standards** require employees to be familiar with the environmental, health and safety risks at the facility; they further stipulate that appropriate controls must be established for hazards and risks. Employees must have personal protective equipment and be instructed and trained to perform their tasks correctly. **WEEELABEX** requires that employee training materials and information be made available at the workplace and that the effectiveness and suitability of the training be checked. Programmes for controlling accidents and incidents should also be established. PACE requires training for the informal sector and identification of options to integrate the informal sector into local/regional/national programmes. **R2** requires training for new hires and refresher courses for all employees. It also stipulates the designation of (a) qualified employee(s) or consultant(s) to coordinate efforts to promote occupational health and safety and environmental protection. **e-Stewards** specifically states that job training must be provided and documented for employees whose jobs relate to the employer's environmental, occupational health and safety, and data security responsibilities, and its e-waste management system.

All macrostages and stages	
Documentary support (processes and procedures)	**All three standards** require legally binding procedures and emergency plans. **WEEELABEX** also requires procedures for monitoring hazards and risks deriving from UEEE and e-waste treatment, and for documenting the downstream recycling chain. **e-Stewards** establishes that the organization must ensure that its environmental management system includes emergency preparedness and specify how it will respond to possible emergencies, injuries, accidents and data security breaches. **R2** defines procedures or plans to ensure proper closure of the facility. **R2** and **e-Stewards** require that recyclers or managers document data destruction procedures (information stored on hard disks).
Tools, equipment and machinery	For **WEEELABEX**, all management of UEEE and e-waste, including loading, unloading and transport, must be carried out using appropriate tools and containers, which must be repaired/maintained to avoid damage.
Records	**R2** establishes that records must be kept of commercial transfers of equipment, components and material. Adequate data destruction procedures must be followed and relevant records kept. **WEEELABEX** establishes that records should be kept *inter alia* of the amount of e-waste collected and forwarded, operator activities, compliance with legal and regulatory obligations, mass balance, measures taken as a result of an accident or incident, and accidents or dangerous occurrences. Logistics and collection records are to be kept for at least three years and treatment records for at least five years. **e-Stewards** requires identifying records for each item of electronic equipment (including components) destined for reuse. Records are also required of conformance with the complete e-Stewards standard and procedures.
Pre-processing stage	
Collection or take-back and transport	**R2** does not stipulate specific standards for the collection of e-waste, but includes requirements for the safe transportation of electronics. **WEEELABEX** requires that e-waste not be mixed with other waste, and that lamps, CRTs and flat screens be prepared and transported in such a way that they are not damaged. **e-Stewards** does not have specific requirements for collection, but it requires the establishment of procedures to ensure safe and legal transportation/shipping of electronic equipment. It also calls for accurate classification and labelling/placarding, record keeping, and appropriate packaging and security for transport.
Reception, sorting and weighing	**WEEELABEX** states that e-waste is to be sorted into the e-waste collection categories. **e-Stewards** states that, on reception, hazardous e-waste is to be safely consolidated and packaged to prevent leakage, spills, dispersal and release of vapours, fumes, dust and liquids.
Storage	**All three standards** identify the following infrastructure requirements for storage areas: impermeable surfaces, spillage collection facilities, weather-proof covering and labelled containers.

All macrostages and stages	
Processing stage	
Direct or indirect reuse (repair/refurbishment)	**R2** requires the traceability of downstream equipment; before UEEE and components containing FMs (see Glossary) are shipped (domestically or internationally), each shipment must be identified and data sanitization (see Glossary) ensured. Quality controls must be established to ensure effective data sanitization, purging and destruction. **WEEELABEX** and **R2** set out that authorized managers (see Glossary) may establish business relationships only with authorized third parties having the capacity to repair or refurbish used equipment; fractions that are not used are to be returned to the collection facility. **WEEELABEX** requires parties putting refurbished equipment on the market to label it with their name; to protect the original manufacturer from any claim related to the equipment; and to issue corresponding legal warranties. **e-Stewards** stipulates that UEEE destined for recovery and/or final disposal is to be treated, processed and managed only in facilities allowed by the law, throughout the recycling chain. It also requires the use of best available techniques and processes/applications to safely recover and reuse maximum material. Any EEE shipped for reuse is subject to strict labelling requirements, and each shipment exported for reuse must be accompanied by a completed and signed declaration/document.
Manual / mechanical dismantling	**R2** establishes that FMs are to be sent to treatment facilities that meet regulations and have proper capabilities, and provides that equipment that will not be reused may be manually or mechanically dismantled. Under **WEEELABEX**, the crushing or compacting of e-waste before treatment is not permitted. WEEELABEX also stipulates the destruction of personal data stored on the memory of ICT equipment (using software or by physically destroying the storage device) and bans the dilution of WEEE components. If it is uncertain that the e-waste contains hazardous substances, it must be treated as if it did. Both **WEELABEX** and **R2** require the removal of all liquids, substances, preparations and components from e-waste prior to treatment. **e-Stewards** lists the items that must be safely removed from UEEE and e-waste, separated, and mechanically processed only if best available techniques are used.
Sorting according to kind of e-waste and storage according to type of material	**WEEELABEX** prescribes that CRT display appliances, flat panel displays and lamps are to be placed in containers or stacked in stable piles; e-waste must be handled in accordance with legal and regulatory requirements, and stored with due care in order to avoid the release of hazardous substances. **e-Stewards** requires accurate classification, labelling/placarding and record keeping, appropriate packaging and secure transport.
Treatment, recovery and disposal	**All three standards** contain recommendations on the treatment of CRT display appliances, flat panel displays, lamps and batteries, and on the recovery of metals. These are addressed in depth in Chapter 4. Annex 1 provides information on treatment methods for fluorescent lighting components and batteries and on minimum standards for treatment options.

3.3.3 Monitoring

Audits and supervision	
Evaluation and auditing	**R2** provides for audits of recycler compliance with legal requirements, the adoption of corrective measures, and the performance of annual audits on downstream facilities. **WEELABEX** provides that managers' policies are to be evaluated in order to monitor their effectiveness. Shipments should also be monitored. **e-Stewards** provides for independent third-party audits, in addition to regular internal audits of the management system to check initial implementation of, and continuing conformity with, system requirements. Ongoing due diligence (see Glossary) is required on all immediate downstream processors, with regular evaluations and on-site audits at least once a year.

3.3.4 Review

Improvement	**WEELABEX** establishes that the operator or manager must provide evidence that activities are being continuously improved through a review and management process. **e-Stewards** requires top management regularly to review the performance of the environmental management system (at least once a year) and to take appropriate action to correct and improve the system on the basis of internal and third-party audit results.

CHAPTER 4 – Recommendations for a model policy framework for the management of ICT/e-waste

On the basis of the information presented in the previous chapters, ITU proposes that countries developing a model policy framework for the management of ICT/UEEE and ICT/e-waste take account of the key elements set out below.

The model framework must take full account of the national context and existing legal, policy and regulatory framework. Despite differences in national contexts, ITU proposes a standardized framework for ICT/e-waste management aimed at applying the concepts of sustainable development, green ICT and the circular economy.

Chapter 4 contains a review of the legal, policy and regulatory requirements and of the minimum standards to be considered when formulating a national e-waste policy framework. It takes into account the results of the assessment of specific country needs and realities.[7]

4.1 Legal, policy and regulatory requirements for the management of ICT/e-waste

The following requirements should be taken into account when establishing a policy framework for responsible management of ICT/UEEE and ICT/e-waste. They are based on best practices emerging from international studies, the information presented in Chapter 3, and the analysis of domestic legislation provided in Annex 3. The key requirements are presented under the four phases described above (planning, implementation, monitoring and review).

4.1.1 Planning and implementation

Countries interested in planning and developing a policy framework on ICT/UEEE and ICT/e-waste should first take the following preparatory steps, then consider the administrative, social, technical and economic aspects.

4.1.1.1 Preparatory steps

Assessment

It is crucial to know the country's situation in terms of waste management (including ICT/e-waste) before designing and issuing a policy framework. It is therefore useful to conduct a thorough assessment of the country's situation with respect to the organization and management of waste, including e-waste and ICT/e-waste, and listing existing statistics and figures.

The analysis should consider the following:

- existing policies or regulations relating to e-waste and compliance with regional and international conventions and treaties;
- the situation in terms of import/export of EEE (new and used) and ICT/e-waste;
- the market shares of manufacturers, importers, assemblers, distributors;
- sales figures for ICT equipment; trends in sales and consumption of EEE; capacity building for the appropriate management of ICT/UEEE; ICT/e-waste generation rates;
- ICT/e-waste managers present in the country; analysis of ICT/UEEE management at each stage.

[7] More information is available in PACE and Basel Convention (2017) and StEP (2014b). More information focusing on local e-waste management stakeholders is available in UNEP (2007) and ITU-T (2016).

Classification of ICT/e-waste

ICT/e-waste needs to be classified as a special category and not as hazardous waste, to facilitate pre-processing and the recovery of resources and critical metals.

Other relevant aspects

The e-waste management system should be defined taking into account aspects such as the country's situation in terms of e-waste management (collection, disposal, processing, etc.), the infrastructure required for the management of e-waste, and possible funding mechanisms.

4.1.1.2 Administrative aspects

Policy	A national legal, regulatory and policy framework on the environmentally sound management of ICT/UEEE and ICT/e-waste should be adopted following the best management practices set out below.
Overarching principles	A policy framework for the management of ICT/UEEE and ICT/e-waste should encompass the following overarching principles.
	Protection of the environment and human health: Management of ICT/UEEE and ICT/e-waste should be environmentally sound so as to avoid any negative impact on the environment and human health (StEP, 2014b). Likewise, management processes must be safe and not generate pollutant by-products.
	Environmentally sound management: This entails the use of best available techniques in line with best environmental practices (see Glossary), eliminating or mitigating any negative impact on the environment and human health.
	Precautionary principle: This principle requires decision-makers to adopt precautionary measures when scientific evidence about an environmental or human health hazard is uncertain and the stakes are high (see European Parliament, 2015, and StEP, 2014b).
	3Rs: This principle aims to promote reductions in e-waste through smart procurement and good maintenance of ICT/EEE; reuse of functioning electronic equipment that can be donated or sold; and recycling of components that cannot be repaired (ITU, 2014).
	Waste hierarchy (applicable to all types of waste, including ICT/e-waste): This is a set of priorities for the efficient use of resources. The waste hierarchy has three levels: (1) **avoidance**, including preventive action to reduce the amount of waste generated by households, industry and all levels of government; (2) **resource recovery**, including reuse, recycling, reprocessing and energy recovery, consistent with the most efficient use of the recovered resources; and (3) **disposal**, including management of all disposal options in the most environmentally responsible manner (NSW Environment Protection Agency, 2015). In the case of e-waste management, the hierarchy goes from the most preferable to the least preferable process: prevention; minimization; direct reuse; indirect reuse (repair and refurbishment); recycling and recovery of materials and metals for use in new products and applications; and disposal. Disposal must be the last resort, solely when there is no alternative.
	Polluter-pays principle: According to this principle, the polluter should bear the cost of measures to reduce pollution according to the extent of either the damage caused to society, or the exceeding of an acceptable level (standard) of pollution (OECD, 2001). This principle is enshrined as Principle 16 of the Rio Declaration on Environment and Development (1992), in the Treaties of the European Communities and in the domestic legislation of many countries worldwide.

	EPR principle: EPR is a policy approach under which producers are given a significant responsibility – financial and/or physical – for the treatment or disposal of post-consumer products. Assigning such responsibility could, in principle, provide incentives to prevent waste at the source, promote environmentally friendly product design and support the achievement of public recycling and materials management goals (OECD, 2016). The responsibility of the manufacturer or producer extends throughout the different stages of the ICT life cycle (StEP, 2014b). The manufacturers internalize the cost of managing these devices at the end of their useful life, through EPR. EPR involves the sustainable design of the product through the application of the green ICT concept (reduction and elimination of toxic substances, use of recycled and recyclable materials, upgradeability and ease of dismantling of equipment for repair and recycling), participation in take-back and recycling programmes, and liability for the management of e-waste until its disposal. Producers can organize themselves into individual or collective systems, also known as producer responsibility organizations, or PROs (see Glossary). ICT/UEEE collection that operates individually and by brand makes it difficult to achieve targets, thus increasing related costs. Collective systems make it easier to achieve targets and reduce costs; allow for the inclusion of historical and orphan equipment, since there is no brand discrimination; and facilitate the identification of "free riders" (producers that are not registered and therefore do not contribute to the system's financing). Public-private partnerships can be established to implement a network of collection points (door-to-door collection involves significant costs) and facilitate negotiation with ICT/UEEE and ICT/e-waste managers. The government should promote the formation of several PROs. The PRO should be monitored and audited by the government, which may request it to provide financial statements.
	Sustainable production and consumption: Sustainable production is the creation of goods and services using processes and systems that are non-polluting, conserving of energy and natural resources, economically viable, safe and healthful for workers, communities and consumers, and socially and creatively rewarding for all working people. The environment, employees, communities and organizations all benefit from sustainable production, which in the long term can lead to more economically viable and productive enterprises (Lowell Center for Sustainable Production). Sustainable consumption, on the other hand, is the consumption of goods and services that have minimal impact on the environment, are socially equitable and economically viable, while meeting the basic needs of humans worldwide. Sustainable consumption targets everyone, across all sectors and all nations, from the individual to governments and multinational conglomerates (The Global Development Research Center, 2017).
Authorizations and licences	ICT/e-waste should be managed only by companies that have an environmental licence, permit or authorization. Pre-processing should not require licencing, but companies engaged in pre-processing should register with the government or with authorized PROs/ collection agencies and should be supervised. Processing of ICT/e-waste should be managed only by companies that have the necessary licences, permits or authorizations for the relevant activities.
Targets and indicators	The government should set realistic targets for collection, reuse, recycling and recovery. It should also establish indicators to monitor progress in the e-waste management system (for more information, see UNU, 2015). Targets should be reviewed and adjusted gradually, depending on the results obtained, for example, from the information system review (with data reported by producers and authorized managers), surveillance and control action, and the application of indicators.

Import/export of ICT/UEEE and ICT/e-waste	**Basel Convention – General information** E-waste contains hazardous substances, which can have an adverse impact on the environment and health. During the 1970s and 1980s, it was customary to move hazardous waste from industrialized countries to least developed and developing countries, where environmental awareness was weak, regulatory mechanisms did not exist and options for eliminating this type of waste were cheaper (Basel Convention, 2011). This state of affairs led to the adoption in 1989 of the Basel Convention, which entered into force in 1992. The Convention aims to eliminate illegal and/or indiscriminate transport of this type of waste and its inappropriate final management and disposal. The Convention currently has 170 States Parties. It is common for ICT/UEEE to be transferred, particularly from developed countries to least developed and developing nations, for instance for direct reuse, for repair or refurbishment, for return under warranty and for leasing. Unfortunately, e-waste is often labelled as equipment for reuse even if it is not functional. It is therefore of paramount importance to become familiar with essential aspects of the processes to import and export electronic waste with hazardous contents, distinguishing them from the import and export of functional and non-functional ICT/UEEE as described below. Some of the main provisions of the Basel Convention that are relevant for this Handbook are as follows: • e-waste is classified in Annex VIII under entries A1180, A1190, A1150 and A2010, and in Annex IX under entry B1110; • the Basel Convention only applies to wastes defined as “hazardous wastes” based on their origin and/or composition and their characteristics, and to two types of waste defined as “other wastes” – household waste and incinerator ash; • customs officials should be trained to supervise and control the import and export of used and functional or non-functional ICT/EEE in an exacting manner and to identify ICT/e-waste; • according to the Basel Convention, “[p]arties exercising their right to prohibit the import of hazardous or other wastes for disposal shall inform the other Parties of their decision”; “[p]arties shall prohibit or shall not permit the export of hazardous or other wastes to the parties which have prohibited the import of such wastes when notified”; “[a]ny transboundary movement of hazardous and other wastes is subject to prior written notification from the exporting country and prior written consent from the importing country and, if appropriate, transit countries”; • export is not allowed in the case of parties to the Basel Convention (particularly least developed countries) that have adopted legislation prohibiting all imports of “hazardous” or “other waste”, or when there is reason to believe the waste will not be subject to environmentally sound management; • hazardous waste should be handled and disposed of in the country of origin and in an environmentally sound manner. **Specific provisions** With regard to the import and export of ICT/UEEE and ICT/e-waste: • government entities should be mandated to ensure ICT/e-waste traceability and to establish the maximum quantities that can enter the country; • illegal exports and imports of ICT/e-waste should be combated by the entities delegated by the government; • the principles of transparency and respect are to be observed by the parties involved.

Import/export of used and functional EEE (the Basel Convention does not apply)

Before starting the import process, the ICT/EEE should be tested for functionality with due regard for the technical functionality guidelines for different categories of ICT equipment issued by international organizations, to ensure that they are not actually ICT/e-waste. Documents and records should accompany the shipment (StEP, 2014b).

The entry of ICT/EEE "near the end of the life cycle" requires special consideration, since, although it still works and can be used, it will become waste in the near future.

An instrument (control and supervision of used and refurbished, repaired or reconstructed EEE entering the country) should be applied by a government-delegated entity in order to ensure compliance with the EPR principle and the differentiated environmental management of equipment nearing the end of its useful life.

Used equipment is waste in a country if it is so defined or considered in accordance with the provisions of that country's domestic legislation.

Evidence (documents and records) should be presented to prove that the used and functional equipment is not waste.

Import/export of used and non-functional ICT/EEE (the Basel Convention does not apply)

If the import of non-functional ICT/EEE not considered e-waste is accepted (for instance, ICT/EEE whose operation has been tested and that can subsequently be directly reused; for failure analysis or reuse after repair or refurbishment; for hardware/software repair; for repair and refurbishment only; for return under warranty; for leasing), standardized controls should be established, particularly at customs, since there are no uniform international criteria for the procedures to be applied.

Evidence (documents and records) should be presented to prove that the used and non-functional equipment is not waste.

Used equipment is waste in a country if it is so defined or considered in accordance with the provisions of that country's domestic legislation.

If a party does not wish to allow the import or export of used and non-functional EEE, it is fully entitled to do so if it complies with applicable international, regional and national legal instruments.

4.1.1.3 Stakeholder roles and responsibilities

Clearly differentiated responsibilities should be established for all stakeholders in the supply chain, including producers (manufacturers, importers, assemblers, distributors and marketers), consumers, and ICT/EEE and ICT/e-waste managers. Examples of the responsibilities of different stakeholders are given below.

Stakeholder roles and responsibilities	**The government should:** • assign clear responsibility to government entities and other stakeholders; • establish, monitor and gradually adjust realistic targets for collection, reuse, recycling and recovery; • design, manage and monitor an information system; define strategies for training and inclusion of the informal sector; • carry out oversight and control; • create and operate technical committees with the participation of all stakeholders.
	Producers should, for example: • comply with regulations; feed and periodically update the information system; meet established targets and report results; work on eco-design and cleaner production; • provide technical and relevant information to ICT/UEEE and ICT/e-waste managers and ICT/EEE consumers; • comply with the model established for the financing of the e-waste management system; allow government supervision; participate in technical committees; • develop information and awareness campaigns to facilitate the collection of ICT/UEEE; install equipment collection points.
	Consumers should, for example: • comply with regulations; • promote the reduction of ICT/e-waste generation rates through responsible consumption; deliver UEEE for proper handling; comply with the model for financing the system; • enable government oversight and control; participate in technical committees.
	ICT/UEEE and ICT/e-waste managers should, for example: • comply with regulations; • promote the reduction of ICT/e-waste generation rates; • carry out environmentally sound management of UEEE and e-waste; • comply with regulations on inclusion of the informal sector; • support the achievement of established targets; • enable government oversight and control; • participate in technical committees.

Information system	The government should design an information system and designate a public entity responsible for its administration. Stakeholders should be responsible for feeding the system and updating the information in timely fashion in terms of, for example: - **general information** on ICT/EEE producers, ICT/EEE on the market by type, brand, weight and quantity, ICT/EEE lifespan; - **generation and management of ICT/UEEE**, including figures on reverse logistics (take-back and/or return of ICT/UEEE), types and quantities of ICT equipment suitable for direct or indirect reuse (repair and/or refurbishment), destination, types and quantities of e-waste sent for recycling, general information on authorized managers (see Glossary) and logistics operators (see Glossary), and data on their environmental licences; - **generation and management of ICT/e-waste**: types and quantities of e-waste collected; types and quantities of e-waste treated; type of treatment; types and quantities of materials recovered and destination; types and quantities of components or materials exported and destination; information on the e-waste exporting process; general information on authorized managers and logistics operators and data on their environmental licences; types and quantities of e-waste disposed of and type of disposal. The government should use the information for planning purposes, to adapt regulations and for surveillance and monitoring purposes. The information can also be used to identify and track targets.

4.1.1.4 Social aspects

Employment and training (informal sector)	Environmentally sound management of ICT/UEEE (both for reuse and recycling) encourages the creation of jobs (direct and indirect) for unskilled, semi-skilled and qualified labour (depending on the management stage). In some countries (particularly least developed countries), the existence of informal recyclers is a reality and their lack of knowledge about the composition and correct management of ICT/UEEE and ICT/e-waste is causing major health problems for the workers, their families and the population in general, and having an impact on the environment. It is thus essential to establish government-led programmes to raise awareness and to train and include the informal sector in proper ICT/UEEE and ICT/e-waste management. India, China and some African countries are highly dependent on the informal sector for the collection and management of e-waste; the large numbers of workers and cheap labour force are strengths enabling those countries to provide extensive coverage. Governments should take advantage of these strengths and create programmes to formalize the sector and to protect workers.
Consumers awareness	Responsible consumption of technology should also be promoted. The media, the government and other stakeholders able to provide financial support should foster environmental awareness among consumers to ensure, *inter alia*, the delivery of ICT equipment at collection points and the responsible consumption of technology. The education sector should promote environmental awareness among children and young people as permanent users of ICT.

4.1.1.5 Technical aspects

Infrastructure, technologies and technical guidelines (standards)	There must be sufficient capacity to manage reused ICT/EEE and ICT/e-waste (pre-processing and processing stages). Mechanisms should be established to provide financial support (cooperation between the public, private and international sectors). Technology must be incorporated to facilitate the recovery, use, treatment and disposal of ICT/e-waste in an environmentally sound manner in the country where the waste originates, respecting the proximity principle (see Glossary) and allowing for the creation and retention of wealth in each nation (recovery of precious and rare metals). Minimum standards should be applied to ensure best practices in the management of ICT waste throughout its life cycle (see Chapter 3).
Eco-design	Eco-design is an innovative approach allowing companies to integrate environmental criteria from the product design phase on, with a view to reducing the product's impact throughout its life cycle, from the extraction of raw materials to the end of life (Oree, 2017). The application of the EPR principle encourages eco-design, since ICT/e-waste management costs will be lower if the equipment contains fewer hazardous substances. Formal standards and regulations for producers should therefore include material selection and manufacturing processes. Eco-design is the manufacturers' responsibility and is in line with the concept of a circular economy (see Glossary) and the cradle-to-cradle approach (see Glossary). Manufacturers should constantly make environmental improvements to their designs and research ways to extend the life cycle of ICT equipment; they must include reuse and recycling information in product labelling and work to replace all toxic substances with benign and environmentally friendly substitutes. Examples of eco-design include: rechargeable batteries that use renewable energy sources (solar cells, muscle power); consistently selecting the same plastics at the design stage, enabling recyclers to eliminate sorting; finding environmentally friendly substitutes for lead, beryllium and brominated flame retardants; eliminating unnecessary technical incompatibilities between ICT/EEE; eliminating the use of hazardous substances prohibited by Directive 2002/95/EC; the design and manufacture of universal current adapters and chargers (ITU-T, 2016). Manufacturers should periodically share information with e-waste managers on the components and materials used in the manufacturing process, so as to facilitate ICT/e-waste management.
Information from manufacturers to ICT/EEE consumers	ICT/EEE manufacturers should inform consumers that e-waste must not be disposed of as ordinary waste; to that end, their products should display a specific symbol, such as the crossed-out wheeled bin prescribed by Directive 2012/19/EU. Manufacturers must also comply with labelling requirements and disclose data related to hazardous content, potential risks to health and the environment, and the location of collection points.

4.1.1.6 Economic aspects

General	Economic aspects should be considered to ensure the feasibility and financial sustainability of the ICT/UEEE and ICT/e-waste management system. ICT/UEEE and ICT/e-waste management is a business opportunity, ensuring that a balance is struck between environmental, social and economic concerns. For ICT/UEEE to be reused, it should re-enter the system in the shortest possible time (reducing storage time in homes and companies), as this translates into lower costs, higher incomes, longer useful life and higher sales prices. The initial investment in infrastructure, the take-back of ICT/UEEE (depending on the method applied), the treatment of CRT, batteries and capacitors, and the recovery of precious and rare metals incur the largest outlays. The sale of reused equipment, the valuation of ferrous and non-ferrus metals, and the recovery of rare and precious metals generate the most revenues. Developing countries must have the infrastructure required to recover valuable materials (precious and rare metals), in order to avoid their export.
Economic models	Different models have been used to finance ICT/UEEE and ICT/e-waste management systems: producer-financed (EPR); consumer-financed (polluter pays); and financing by the public or private sectors, or by international organizations. A combination of these three models can ensure the system's sustainability, especially in developing countries. It is important to note that there is no optimal financing model. Each country should identify the most appropriate one and adjust it to its needs.
	Producer-financed: Producers (manufacturers, importers, assemblers, marketers and distributors) are responsible for financing the management system on the basis of their market share, type of EEE placed on the market and the environmental impact of their products at the end of their life cycle.
	Consumer-financed: Consumers pay an advance recycling fee, which is charged at the time of purchase and corresponds to the cost of managing new equipment once it reaches the end of its useful life. The fee depends on the type of EEE and its environmental impact at the end of its life cycle. It may be invisible or visible to the consumer. Alternative models of consumer financing could be envisaged, e.g. payment when the consumer disposes the e-waste at municipal collection points.
	Financing by the public or private sector or by international organizations: Additional funding sources could be found among the public, private and international cooperation sectors.
	Creation of a fund: A fund should be created that draws on contributions from the government, producers and consumers, and fines for non-compliance with e-waste regulations, among others. The fund should be monitored by an entity designated for that purpose by the government.

4.1.2 Monitoring

Supervision and control	The government should delegate supervision and control of ICT/UEEE management system stakeholders to public entities ensuring compliance with the legal, policy and regulatory framework. Audits should be carried out periodically and with the requisite transparency, impartiality and efficiency.

Violations and penalties	Different kinds of penalties could be applied: administrative, criminal or disciplinary. The penalties should be effective, proportionate and dissuasive.
System review	The entity or entities delegated by the government should calculate indicators and local/regional and global targets (collection, reuse, recycling and recovery), based on the data reported by the producers and managers in the information system. The results of the government's surveillance and control should be used to take preventive action and make improvements to the e-waste management system.

4.1.3 Review

Improvements	The government should take the preventive action and make the improvements proposed during the monitoring phase, in order to develop the e-waste management system and enhance its performance.

4.2 Minimum standards

The following minimum standards and best practices should be enshrined in specific regulations on responsible management of ICT/UEEE and ICT/e-waste and should be applied by the ICT/UEEE and ICT/e-waste managers. They are based on the information presented in Chapter 3 and on the key issues brought to light by the analysis of five national legislative frameworks (see Annex 3).

4.2.1 General aspects

This section covers general aspects that countries should consider when defining the minimum standards to be applied in the environmentally sound management of used ICT equipment and ICT-derived waste. The general aspects apply to all four phases (planning, implementation, monitoring, review).

General aspects	
Prerequisites	Authorized managers should only be able to establish contractual relations with other managers in the recycling chain who comply with the minimum standards. In line with the EPR principle, producers (manufacturers, importers, assemblers, distributors and marketers, individually or organized in collective systems) should be responsible for verifying compliance with the minimum standards by authorized managers (see Glossary) and logistics operators (see Glossary) in the recycling chain, without prejudice to the supervision and control work of State entities. Producers should provide managers with information on the hazardous substances contained in the EEE and their location.

General aspects	
Principles	The following are the general overarching principles to be considered when defining minimum standards for the environmentally sound management of ICT/UEEE and ICT/e-waste: • protection of the environment and human health; • environmentally sound management; • the precautionary principle; • the 3R principle; • the waste hierarchy: prevention; minimization; direct reuse; indirect reuse (repair and refurbishment), recycling or recovery of materials for use in new products and applications; recovery of metals; disposal; • the polluter-pays principle; • the EPR principle; • sustainable production and consumption. In addition, operations should make use of the best available techniques and be in line with best environmental practices.
Authorizations and licences	All authorized managers and logistics operators should have licences and authorizations, in accordance with the procedures defined in each country, to ensure compliance with the legislation and the minimum standards. Authorized managers and logistics operators can be required to submit a statement of compliance with the applicable legal, policy and regulatory framework and with the minimum standards, based on which the competent authorities grant them licences and permits that will be withdrawn if, during oversight and control, their non-compliance is confirmed.
Legal aspects	Application of the suggested minimum standards does not exempt authorized managers from complying with existing applicable national standards for the management of ICT/e-waste, or from compliance with domestic legislation on the environment, hygiene, industrial safety and quality. Where legal obligations conflict with the minimum standards, the former prevail. Authorized managers and logistics operators should conduct periodic evaluations to ensure compliance with the legislation and the minimum standards. Authorized managers should apply the principle of due diligence in respect of themselves and when selecting downstream logistics operators and managers. Authorized managers and logistics operators should have insurance coverage commensurate with the size and nature of their operations, and the requisite legal and financial guarantees should they have to close facilities. No manager should initiate, permit or contribute to UEEE and ICT/e-waste shipments that would result in treatment that does not comply with the legal requirements and those set out in this document.

General aspects	
Infrastructure	All facilities should comply with each country's current standards in terms of earthquake resistance. The infrastructure should be appropriate, in terms of size and technology, depending on the stages in which each manager is involved. Facilities should be equipped with signalling (emergency, fire, obligation, prohibition, warning); maps and evacuation routes; safe and marked entries and exits; natural and artificial lighting and ventilation, to prevent and control the accumulation of particulate matter, dust and fumes; and security systems and alarms (security cameras, smoke detectors, motion sensors, among others), to prevent theft and reduce risks. Efforts should be made to develop an adequate infrastructure for the environmentally sound management of ICT/UEEE and ICT/e-waste with the support of producers, other stakeholders, multilateral and regional development banks and bilateral donors. The facilities and their areas should have appropriate security conditions and allow access to authorized personnel only.
Human skills	The minimum standards also encompass a number of aspects related to human skills. • Vulnerable groups and the informal sector should be included in the e-waste management system. The theoretical and practical training in all matters relating to the environmentally sound management of e-waste of personnel involved in ICT/UEEE and ICT/e-waste management (including the informal sector) should be certified by a government entity. In addition, the government should establish mandatory annual refresher courses with relevant exams. • Periodic training should be provided for all personnel (on, for instance, ICT/e-waste management, ICT/e-waste content, health and environmental risks, action to be taken in case of UEEE breakages, processes and procedures, use of personal protective equipment, correct handling of tools). • Personnel should have permits for handling machinery and working at heights; those permits should be renewed periodically. • Strict occupational health and industrial safety measures should be applied in plants specialized in the treatment of mercury lamps. • Employees should undergo medical tests, both periodically and upon separation, including blood and urine tests to control lead and mercury levels following accidental breaks in CRT, LCD and fluorescent lamps. • The facilities and work areas should be kept clean. • Personnel should use protective equipment appropriate for the activity to be performed. • Information and training materials for employees should always be available at the workplace or an easily accessible place.

General aspects	
Documentary support (processes and procedures)	The following should be documented and recorded: • technical processes, procedures and instructions (depending on the stages in which the manager is involved); batch results; • identification of, access to and compliance with applicable legal requirements; • hazards and risks (identification and assessment); • environmental aspects and impact; • controls (elimination, substitution, engineering controls, administrative controls); • programme on safety and health at work; • training, induction and re-induction plans (the effectiveness of which should be assessed); • emergency plans, including evacuation drills; • procedures for measuring lead and mercury in and outside working areas, to ascertain that they do not exceed the occupational exposure threshold; • care provided following incidents; • site maintenance and servicing of machinery; • management review and improvement processes; • application of preventive and corrective measures and dissemination of lessons learned; results of and documents on downstream monitoring; • plan for closure.
Equipment, tools and machinery	Facilities should be equipped with multipurpose extinguishers suitable for the type of ICT/UEEEE and ICT/e-waste stored in them, and fireproof shelves; shelves and extinguishers should be located at suitable and easily accessible spots. Facilities should have the necessary tools and machinery, depending on the management stages being carried out. There should be log sheets and maintenance and calibration certificates for equipment and machinery.
Records	Records should enable tracking of ICT/UEEE and ICT/e-waste from collection to disposal (origin-destination), including processing at different stages and by the various stakeholders in the recycling chain. In addition to the records described under “Documentary support”, managers should calculate the mass balance by batch or annually and keep records of process and procedure implementation, compliance with legal and regulatory obligations, and recycling and recovery rates. The records generated by ICT/UEEE and ICT/e-waste management should be kept for five years or more, depending on each country’s legislation, in either magnetic or physical format. Record keeping allows managers to measure performance and make informed decisions to meet targets and, if necessary, take corrective action.

General aspects	
Information system	The producers, managers and logistics operators involved in the recycling chain should feed and update a database (administrated by the government) with information on: types and quantities of e-waste collected and transported; types and quantities of e-waste treated; type of treatment; types and quantities of materials recovered and destination; types and quantities of components or materials exported and destination; the e-waste exporting process; managers and logistics operators, with specific data on their environmental licences; types and quantities of e-waste disposed of and type of disposal; and so on. Producers are required to periodically inform the relevant authorities about their management results (individually or collectively) and targets met (collection, reuse, recycling, recovery).
Means of communication	For safety and security reasons, managers should have access to means of communication (Internet, land lines and cell phones) and have at hand the list of entities dealing with occupational risks, health matters, emergency care, etc.

4.2.2 Requirements for the management stages

This section covers the requirements to consider when defining the minimum standards to be applied for the management of used ICT equipment and ICT-derived waste.

4.2.2.1 Planning

Policy, purposes and targets	Managers should have an environmental, health and safety policy that includes the commitment to control the risks arising from ICT/UEEE and ICT/e-waste management. The policy should comprise purposes, targets and indicators designed to measure the management system's performance (e.g. figures on: reverse logistics; types and quantities of ICT equipment suitable for direct or indirect reuse (repair and/or refurbishment) and destination; types and quantities of e-waste sent for recycling; types and quantities of e-waste collected; types and quantities of e-waste treated; type of treatment; types and quantities of materials recovered and destination; types and quantities of components or materials exported and destination; types and quantities of e-waste disposed of and type of disposal; mass balance results). The policy should be published and brought to the attention of the manager's in-house and external customers. A policy should be drawn up and implemented on what used equipment can be accepted depending on the facility's technical capacity.

4.2.2.2 Implementation

Pre-processing stage	
Collection and transport	This is a critical stage, and it is important to find ways to promote collection systems. At the collection site, it is important that e-waste not be mixed with other waste, or ICT/e-waste with other e-waste. **Containers, labelling and identification**: ICT/UEEE should be placed in suitable and resistant containers of adequate size, so that they can be moved mechanically without breaking. Each container should be duly covered, labelled and identified with information on its contents, as follows: type of ICT/EEE, date of packaging, weight (kilograms), quantity (units), batch number, official in charge, etc. **Transport companies and vehicles**: Transport companies should have the required authorizations, depending on the regulations in force in each country, the type of waste and the means of transport used. Vehicles that transport ICT/UEEE by land should meet certain general requirements (if complete equipment is not considered hazardous waste) or comply with the regulations for the transport of hazardous goods (if complete equipment or some components are classified as hazardous waste). Each container should be secured to the vehicle by the necessary devices, which should be located at each of the container's four corners; the load should be covered with impermeable materials; the vehicle should have certificates attesting to technical-mechanical reviews and compliance with emission standards, and be equipped with multipurpose extinguishers, road equipment and a toolbox. **Records**: Records of the collection and subsequent delivery of ICT/UEEE should be generated through a "transport document", with data relating to type of ICT/e-waste, provenance, batch number, weight (kilograms), quantities (units), destination and vehicle data (number plate and type), signature of the official in charge, etc. **Standards for mobile phone collection**: These comprise collection points conveniently located for users; separate collection; collection with battery chargers and accessories, and with batteries in the phones (any loose batteries should be identified and properly handled). Used mobile phones should be collected selectively so as to preserve the working characteristics and resale value of collected devices.
Reception, sorting and weighing	**General**: ICT/UEEE should be unloaded with mechanical aid. It should be verified that the amounts and/or weight that arrive at the manager's facilities correspond to what is expected, according to the information as recorded in the "transport document". If it is necessary to repackage the ICT/UEEE, uncontrolled tipping-over of equipment with CRTs, LCDs, plasma or fluorescent lamps, etc., should be avoided. If necessary, ICT/UEEE should be resorted (UEEE from the ICT sector should be sorted into ICT/UEEE collection categories or any other groups based on legislation) and re-weighed, labelled and identified (ICT/UEEE that is to be refurbished or repaired should be identified and sorted) with the following data: type of ICT/UEEE, weight (kilograms), quantity (units), batch number, container number, assigned shelf place, date, official in charge, etc. E-waste should be handled (packaged, loaded and unloaded, stored, moved inside the manager's facilities, etc.) with care to avoid damage and leakage of hazardous substances.
	Equipment, tools and machinery: Authorized managers should have the necessary equipment, machinery (scales and forklifts) and tools. Machinery and equipment should undergo minimum maintenance and calibration every six months. Machinery, equipment and tools should be periodically checked and kept in good condition, to facilitate work and avoid accidents.
	Records: The following records should be generated and maintained: transport document; tools, machinery and equipment reviews; maintenance and calibration certificates for equipment and machinery.

Pre-processing stage	
Storage	**Infrastructure**: Storage areas require impermeable surfaces, spillage collection facilities and, where necessary, decanters and cleanser-degreasers; they need weather-proof covering and labelled containers. The maximum amounts of ICT/UEEE stored should comply with legal and regulatory requirements or, failing that, should not exceed the amount of used equipment that can be processed in six months.
	Documentary support (processes and procedures): Safety sheets and emergency cards should be available for the main substances that ICT/UEEE and ICT/e-waste may contain, for application in the event of equipment or component breakdown. Used mobile phones should be properly packaged to protect their integrity; batteries should be packaged so as to avoid contact with their terminals; mobile phones destined for refurbishment should be handled with a view to protecting them from damage and avoiding the release of hazardous substances.
	Equipment, tools and machinery: The equipment needed for the activities carried out at this step should be available. Heavy-duty shelving is required to ensure optimal use and organization of space in the facilities.
	Information systems: An information system, or at least a database, should be designed and periodically updated.
	Records: Records should be kept of periodic maintenance of heavy-duty shelving (minimum every 12 months).

Processing stage	
Direct or indirect reuse (repair/refurbishment)	
General	Contracts for reuse should be agreed only with authorized third parties that have the capacity to repair or refurbish used equipment; fractions that are not used and discarded parts should be properly managed as spare parts or as e-waste, depending on their condition. Parties putting refurbished equipment on the market should place their name on the equipment, protect the original manufacturer from any claim related to the equipment and deliver the corresponding legal warranties. Documentation and labelling should certify that the equipment is in working order and fit for purpose. Used equipment should be remarketed in a way that ensures that it continues to meet all applicable standards and requirements. Refurbishers and managers should ensure compliance with all applicable laws in the case of export/import of refurbished equipment. Evaluation and/or testing and labelling are required to decide whether ICT/EEE can be directly reused, or requires repair, refurbishment or upgrading before reuse, or must be sent for environmentally sound material recovery and recycling. The parts used to refurbish ICT-derived electrical equipment, cases and covers should be of a type and design that ensure the devices comply with the rated operational characteristics specified by the original equipment manufacturer. Refurbishers should not add or update software on refurbished ICT equipment in a way that changes the rated operational characteristics specified by the original equipment manufacturer. Refurbishers and managers should ensure that all data are sanitized (data destruction by electronic means). Quality controls should be carried out to ascertain the effectiveness of data sanitization, purging and destruction techniques. Any party refurbishing or remarketing ICT/UEEE should inform the subsequent purchaser that the product is used and/or refurbished and provide contact information. Refurbishers and managers should ensure that refurbished equipment is labelled and that documents are made available attesting, as far as possible, to the type of equipment, the model and serial numbers, the year of manufacture, the date of refurbishment/repair, and any evaluations and tests performed, and generally confirming that the refurbished/repaired equipment is suitable for reuse. Refurbishers and managers should ensure traceability of downstream equipment. Before shipping used electronics and components (domestically or internationally), the manager should ensure appropriate packaging and security for transport and clearly identify each shipment.

Manual/mechanical dismantling	
General	• Equipment that is not intended for direct reuse should be dismantled and separated into components manually and/or mechanically. • Manual dismantling generates employment and ensures high-quality separated components. • Mechanical separation may take the form of grinding, shredding or size reduction, followed by various separation techniques. • Managers should remove all liquids, substances, preparations and components from e-waste prior to treatment. • Batteries and lamps may be removed manually, to minimize contamination of other materials and maximize recovery of substances. • Crushing or compacting of e-waste before treatment is not permitted. • Personal data stored on the memory of ICT equipment should be destroyed.
Documentary support (processes and procedures)	Procedures and instructions related to the manual/mechanical dismantling of ICT/UEEE should be documented.

Manual/mechanical dismantling	
Information systems	An information system or database should be used to record ICT/UEEE movements from the shelves (warehouse) to the dismantling area.

Sorting and storage	
Sorting (according to type of e-waste)	After manual/mechanical dismantling, clean materials (ferrous and non-ferrous metals such as aluminium and copper) can be evaluated and the remainder sent to properly equipped material recovery facilities. If there is any doubt about the presence of hazardous substances in e-waste components (separated and classified), it should be assumed that they are present (e.g. when it is not known if the capacitors contain PCBs or if the content of brominated flame retardants in plastic fractions is lower than the thresholds established in each country). No materials (either waste or not) should be added to fractions or substances classified as dangerous to bring the total volume of waste below the threshold that classifies it as hazardous (dilution prohibition). Substances, preparations and components removed from ICT equipment should be identified and labelled. CCFLs that break during manual disassembly are to be stored and transported in closed containers to prevent mercury emissions. The containers must be stored in places that are not exposed to heat. Eco-design is important in the sorting process (implement improvements in environmental design; include reuse and recycling information in product marking; label internal software; replace toxic substances with benign substitutes).
Storage (according to type of material)	**Infrastructure**: Items containing lithium should be stored separately and in a restricted area, avoiding exposure to heat, sunlight, humidity and water, as they may ignite or explode if exposed to high temperatures. Batteries should be stored in places protected from humidity and rain, and with waterproof covers. Mercury lamps and CRT, LCD or plasma screens that are accidently broken should be stored in closed and identified containers. The areas in which the lamps are stored should be ventilated and easily accessible to authorized personnel, but see as little traffic as possible. ICT/e-waste should be stored with due care in order to avoid the release of hazardous substances. The mercury and lead concentrations in the air should be regularly monitored in all working areas, including storage areas.
	Containers, labelling and identification: CRT display appliances, flat panel displays and lamps should be placed in containers or stacked in stable conditions. The containers should be labelled and identified with the following data *inter alia*: type of material or component, weight (kilograms), container number, shelf place, official in charge, date. The data should be entered into the information system along with the assigned destination of the material or components in each container. Output fractions of lamps must be stored in lockable containers designed to prevent mercury emissions. The facilities must be equipped with an industrial vacuum cleaner with activated carbon filters.

Treatment and disposal	
General	Shipments of materials or components containing hazardous substances as a result of dismantling or indirect reuse to authorized downstream managers or logistics operators should be insured against any accidents that may occur during the shipment, and drivers should have certificates attesting that they have taken a mandatory basic training course. Vehicles should be equipped with the following: reflective identification signs and devices, along with visibly placed plates bearing the United Nations number for the dangerous waste transported; basic emergency response items (fire extinguisher, protective clothing, flashlight, first aid kit, collection and cleaning equipment, absorbent material, and any other items indicated on the emergency card); at least two multipurpose extinguishers (one in the cabin and the other near the load); a warning device that sounds when the vehicle is in reverse; emergency cards and safety sheets in the official language of each country; a contingency plan for accident response during operations involving the transport of dangerous merchandise; a list of telephone numbers for notification in the event of an emergency. Recovery refers both to the sale of clean materials and other fractions from the dismantling process for reincorporation into production processes and to the application of other processing methods for the recovery of metals. Clean materials can be recovered when there is a market and their use has no negative impact. Fractions for the recovery of heavy, rare and precious metals should be sent to specialized treatment facilities. Hazardous waste for which appropriate treatment technology (including recovery of rare and precious metals) does not exist in the country of origin should be exported, with due regard for the provisions of the Basel Convention (if the countries concerned are party to the Convention) or of any other treaties and accords agreed by countries. Export records should always be kept.
Infrastructure	Water used for the wet treatment of CRTs or CRT display appliances (see Glossary) should be kept in a closed loop and should not be released into the sewage system. Dry treatment processes should have an effective dust extraction system, connected to a filtering system, so as to ensure compliance at all times with established emission thresholds. Treatment managers should periodically monitor air filtration system outputs in an accredited laboratory, so as to determine the quantities of dust and heavy metal (especially lead and cadmium) emitted. The facilities in which ICT/UEEE and ICT/e-waste are treated must be equipped with systems to control air, water and soil contamination, thereby monitoring compliance with the discharge limits established in each country's legislation. Treatment processes should be carried out in controlled environments to protect workers and the environment.
Equipment, tools and machinery	Specific equipment, tools and machinery are required according to the physical-chemical processes used to treat and recover metals.
Records	Records should include the following information: treatment and disposal methods applied to hazardous e-waste; quantities processed; kinds of materials/metals obtained and quantities; disposal methods (used at the manager's facilities or by other managers downstream). Records should also be kept of the mass balance, treatment and disposal certificates, and transboundary movements of hazardous ICT/e-waste.
Treatment options	Treatment options for some fractions are presented in **Annex 1**.

4.2.2.3 Monitoring

Audits and supervision	The environmental, health and safety policy should be adjusted when changes occur and its effectiveness evaluated. Audits may be conducted by first, second or third parties. • **First-party audits**: Managers should have in-house auditors who act objectively and on the basis of impartial criteria. • **Second-party audits** should be carried out by interested parties (e.g. producers organized into collective systems or acting individually) of the managers and logistics operators that are part of the recycling chain. • **Third-party audits** should be carried out by external, independent organizations offering certification of compliance. On the other hand, the competent authorities of each country should supervise the recycling chain and impose sanctions in the event of non-compliance At this stage, targets should be reviewed, indicators applied and reviews by management carried out to verify that the system is operating properly. Recommendations should be formulated for corrective, preventive and improvement measures.

4.2.2.3 Review

Improvement	Producers and managers should implement preventive, corrective and improvement measures to ensure ongoing improvement of the e-waste management system.

Conclusions

The use of ICTs generates major social and economic benefits for all countries, contributes to energy efficiency and helps mitigate global warming; the impact on society as a whole is generally positive. The widespread use of ICTs nevertheless also produces large amounts of electronic waste and accounts for 2% to 2.5% of global greenhouse gas emissions. Moreover, the increasing volume of end-of-life and near-end-of-life ICT equipment worldwide is becoming a matter of growing concern. Electrical and electronic devices are often discarded without due consideration being given to the hazardous substances or precious and rare metals or elements they may contain. If not properly treated, these substances are potentially harmful to the environment and human health. These problems can be addressed through the application of the concepts of sustainable development, green ICT and the circular economy (see Glossary).

Every country should establish a policy framework allowing for the environmentally sound management of waste (see Glossary) (e-waste and ICT/e-waste in particular), as one of the first steps towards preventing improper handling and mitigating or eliminating the negative effects on the environment and human health.

The policy framework needs to cover the design and implementation of an e-waste management system (see Glossary), establishing clear minimum standards and responsibilities for all stakeholders. It is not enough to enact proper legislation: it is paramount to ensure the legislation is actually implemented. In this regard, the government plays a fundamental role by raising awareness and monitoring and controlling implementation.

What the framework covers will depend on many things, such as: the country's general situation (i.e. least developed, developing or developed country) and size; ICT/EEE consumption habits and the current situation in terms of e-waste; the amount of e-waste generated; and the waste management technologies available. It is nonetheless key to cover a number of points, the main aspects of which are summarized below.

The financial sustainability of the e-waste management system needs to be ensured. It is therefore important to clearly set down in the legislation the financial contributions expected by the various stakeholders. In the case of least developed and developing countries, financing should be drawn from a combination of different sources (e.g. contributions from producers, consumers, governments, international organizations, as well as fines).

Small countries and countries with low ICT/e-waste generation rates can either: (a) legally export e-waste to countries that have the technology to manage it properly; or (b) authorize legal imports, investing in the infrastructure needed for the environmentally sound management of ICT/e-waste as a business alternative, ensuring the volume required to achieve economic, environmental and social benefits. Exports/imports of e-waste should be carried out in strict compliance with the principles of respect and transparency enshrined in the Basel Convention.

All countries stand to benefit greatly by recovering – either individually or in partnership with other countries in the region, and using appropriate technologies – the precious and rare metals contained in e-waste. The policy framework should enshrine a number of general principles in that regard. The **precautionary principle**, for instance, enables decision-makers to take precautionary measures when scientific evidence about an environmental or human health hazard is uncertain but the stakes are high. Adherence to the **3R principle** helps to: (a) reduce the amount of e-waste generated through smart procurement and good maintenance of ICT/EEE; (b) promote the reuse of still functioning electronic equipment donated or sold to someone who can use it; and (c) encourage recycling of components that cannot be repaired. Waste management operations should also make use, wherever possible, of the **best available techniques** (see Glossary) and be in line with **best environmental practices** (see Glossary). According to the **polluter-pays principle**, the polluter should bear the cost of measures to reduce pollution according to the extent of the damage to society or the degree to which an acceptable level (standard) of pollution has been exceeded. Finally, the **EPR principle** (see

Glossary) promotes the proper management of UEEE and e-waste, but also constant advances in eco-design, which will help reduce the environmental and financial costs of reuse and recycling.

Specific regulations for the responsible management of ICT/UEEE and ICT/e-waste should encompass a number of minimum standards to be applied by ICT/UEEE and ICT/e-waste managers. A clear licencing or certification system needs to be established, to ensure that all collectors and recyclers are known to the government and authorized to carry out their specific activities. In parallel, countries should set realistic targets and indicators, to be reviewed regularly, for the collection, reuse, recycling and recovery of ICT-derived waste. To this end, they should create and maintain an information system collecting data on EEE from ICT placed on the market and on the UEEE management system (including reuse and recycling). Such a system is a valuable supervisory tool enabling the government to identify how the legislation needs to be adapted and to exercise oversight and control of the stakeholders involved in the waste management system. Companies across the recycling chain should be required to keep appropriate records of their operations, so that ICT/UEEE and ICT/e-waste can be tracked from collection to disposal, through the different stages of the recycling chain. Specific requirements should also be set out regarding the infrastructure and facilities involved in waste management, the skills required by the personnel involved in the operations, and the process and procedures to be followed for all stages of ICT reuse and recycling.

Last but not least, it is crucial to integrate the informal sector into the environmentally sound management of ICT/e-waste, so as to take advantage of the large numbers of low-cost workers involved in this sector in many countries, to enhance their awareness of the issues, and to provide them with appropriate training and equipment.

Abbreviations

3Rs	Reduce, reuse, recycle
Basel Convention	Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal, 1989
CCFL	Cold-cathode fluorescent lamp
CRT	Cathode ray tube
EEE	Electrical and electronic equipment
EPR	Extended producer responsibility
FM	Focus material
ICT	Information and communication technology
ICT/EEE	ICT-related electrical and electronic equipment
ICT/UEEE	ICT-related used electrical and electronic equipment
ICT/e-waste	ICT-derived electrical and electronic waste
IT	Information technology
ITU	International Telecommunication Union
ITU-T	ITU Standardization Sector
ISWA	International Solid Waste Association
LCD	Liquid crystal display
OECD	Organisation for Economic Co-operation and Development
PACE	Partnership for Action on Computing Equipment
PCB	Polychlorinated biphenyl
PRO	Producer responsibility organization
SDGs	Sustainable Development Goals
StEP	Solving the E-Waste Problem Initiative
UEEE	Used electrical and electronic equipment
UNEP	United Nations Environment Programme
UNU	United Nations University
WEEE	Waste electrical and electronic equipment

Glossary

Authorized managers: entities that are part of the recycling chain and that have the environmental permits or licences needed to undertake some or all stages of ICT/UEEE and ICT/e-waste management

Best available techniques: the latest stage of development (state of the art) of processes, of facilities or of methods of operation which indicate the practical suitability of a particular measure for limiting discharges, emissions and waste (OSPAR Commission, 2015)

Best environmental practices: the application of the most appropriate combination of environmental control measures and strategies (OSPAR Commission, 2015)

By-product: a substance or object resulting from a production process, the primary aim of which is not the production of that item. By-products can come from a wide range of business sectors and can have very different environmental impacts. An incorrect classification could be the cause of environmental damage or unnecessary costs for business (European Commission, 2016).

Circular economy: an industrial system that is restorative or regenerative by intention and design. It replaces the end-of-life concept with restoration, shifts towards the use of renewable energy, eliminates the use of toxic chemicals, which impair reuse and return to the biosphere, and aims for the elimination of waste through the superior design of materials, products, systems and business models (World Economic Forum, 2016).

Collection centres: places to which logistics operators transport the ICT/UEEE deposited by consumers at collection points

Cradle to cradle: The cradle-to-cradle approach to design is a method used to minimize the environmental impact of products by employing sustainable production, operation and disposal practices; it aims to incorporate social responsibility into product development. Under the cradle-to-cradle philosophy, products are evaluated for sustainability and efficiency in manufacturing processes, material properties and toxicity, and potential to reuse materials through recycling or composting. Cradle-to-cradle designs are examples of “eco-effective” business practices that optimize human health, recyclable and compostable materials, product life, use of renewable energy, water efficiency and quality, while keeping the manufacturers socially responsible. The eco-effective, cradle-to-cradle philosophy responds to the “eco-efficiency” approach, which only seeks to minimize the negative environmental impact of a business or industry (Encyclopedia of environmental terms ecomii, 2017).

CRT display appliance: complete TV set or whole computer monitor containing a CRT or CRT with related deflection coil

Data sanitization: the process of irreversibly removing or destroying data stored on a memory device (hard drives, flash memory/SSDs, mobile devices, CDs, DVDs, etc.) or in hard copy form. It is important to use the proper technique to ensure that all data is purged (Stanford University, 2017). The most efficient and economical means of sanitizing computers and/or a storage media device is to overwrite the entire device with zeroes. In some circumstances, it is best to physically destroy the storage device (University of Michigan, n.d.).

Direct reuse: continued use of EEE and components by a second user, without the need for repairs, refurbishment or hardware updating, provided that such use is for the purpose for which the item was originally manufactured

Disposal: any operation that is not recovery, even where the operation has as a secondary consequence the reclamation of substances or energy (WEEELABEX, 2013)

Due diligence: the understanding of all obligations to which the company is subject and transparency with business partners (WEEELABEX, 2013)

Eco-design: an innovative approach allowing companies to integrate environmental criteria from the product (or good or service) design phase on, with a view to reducing its impact throughout its life cycle, from the extraction of raw materials to the end of life (Oree, 2017)

Environmentally sound management: management of electronic waste using best available techniques in line with best environmental practices, eliminating or mitigating the negative impact on the environment and human health

EPR (extended producer responsibility) principle: a policy approach whereby producers are given significant responsibility – financial and/or physical – for the treatment or disposal of post-consumer products

FMs (focus materials): materials in end-of-life electronic equipment that warrant greater care during recycling, refurbishing, materials recovery, energy recovery, incineration, and/or disposal owing to their toxicity or other potential adverse occupational health and safety, public health, or environmental effects that can arise if the materials are managed without appropriate safeguards (Responsible Recycling (R2) Certification Program, 2013)

Green ICT: the study and practice of designing, manufacturing, using and disposing of computers, servers and associated subsystems, such as monitors, printers, storage devices and networking and communication systems, efficiently and effectively, with minimal or no impact on the environment. Green ICT encompasses environmental sustainability, the economics of energy efficiency and the total cost of ownership, which includes the cost of disposal and recycling. Green ICT benefits the environment by improving energy efficiency, lowering greenhouse gas emissions, using less harmful materials, and encouraging reuse and recycling. Green design, green manufacturing, green use and green disposal are complementary paths of green ICT. Only by focusing on these four fronts can the IT industry achieve total environmental sustainability and make IT greener throughout its entire life cycle (CEPIS, 2016).

Hazardous waste: a residue or waste whose corrosive, reactive, explosive, toxic, inflammable, infectious or radioactive properties may represent a risk, or cause harm, to human health and the environment. Packages and packaging that have been in contact with such items are likewise considered hazardous residue or waste (Ministry of Environment and Sustainable Development of Colombia - MADS, 2005).

Historical WEEE: wastes from EEE which were put on the market before the entry into force of legal provisions governing WEEE (Ministry of Environment and Sustainable Development of Colombia - MADS, 2013)

Hydrometallurgy: the extraction of metal from ore by preparing an aqueous solution of a salt of the metal and recovering the metal from the solution. The operations usually involved are leaching, or dissolution of the metal or metal compound in water, commonly with additional agents; separation of the waste and purification of the leach solution; and the precipitation of the metal or one of its pure compounds from the leach solution by chemical or electrolytic means. The most common leaching agent is dilute sulfuric acid (Britannica, 1998).

Indirect reuse: use of EEE and components by a second user following repairs, refurbishment or hardware updating, provided that such use is for the purpose for which the item was originally manufactured

Life cycle: estimated time span during which an object can be expected to perform correctly the function for which it was manufactured (Study Groups ITU-T SG 5, Life cycle management of ICT equipment)

Logistics operators: entities taking part in the recycling chain, in charge of actions such as reverse logistics or recollection, transport, storage

Management system: the organization and coordination of the activities of a business or topic in order to achieve defined objectives. Management consists of the interlocking functions of creating corporate policy and organizing, planning, controlling and directing an organization's resources in order to achieve the objectives of that policy (Business Dictionary, 2016). A management system describes the set of procedures an organization needs to follow in order to meet its objectives (ISO, 2016). A waste management system includes the collection, transportation, recycling, disposal and processing of waste. The use of waste management systems varies according to both the kinds of waste material to be treated and the aims of the treatment itself.

Occupational safety and health: generally defined as the science of anticipating, recognizing, evaluating and controlling hazards arising in or from the workplace that could impair the health and well-being of workers, taking into account the possible impact on the surrounding communities and the general environment (Alli, 2008)

Orphan WEEE: wastes from EEE without any identifiable manufacturer or the manufacturers of which have left the market (Ministry of Environment and Sustainable Development of Colombia - MADS, 2013)

Polluter-pays principle: the principle that the polluter should bear the cost of measures to reduce pollution according to the extent of either the damage caused to society or the exceeding of an acceptable level (standard) of pollution (OECD, 2001)

Precautionary principle: The precautionary principle enables decision-makers to adopt precautionary measures when scientific evidence about an environmental or human health hazard is uncertain and the stakes are high (European Parliament, 2015).

Proximity principle: the principle whereby the disposal of hazardous wastes must take place as close as possible to their point of generation, recognizing that economically and environmentally sound management of some wastes will be achieved at specialized facilities located at greater distances from the point of generation (Basel Convention, n.d.)

Pyrometallurgy: the process through which ores and metals are heated to produce a finished product of workable compounds, purer metals and alloys. The process may be any of the following: drying, roasting, smelting, refining or alloying, among others. The use of high temperatures causes chemical and exothermic reactions in materials. Drying is a type of pyrometallurgy in which moisture is removed from the material; heat is applied to make the metal hotter than the boiling point of water, and then the moisture can be extracted from the material. Roasting occurs when metal sulfide is heated to the point that oxygen reacts to form solid metal oxide and sulfur dioxide gas. Smelting involves thermal reactions at a molten phase and typically takes place at a temperature higher than the metal's melting point; it removes carbon dioxide from the material, leaving a more refined metal. Refining removes impurities by heating the metals (WiseGEEK, 2016).

PRO (producer responsibility organization): a collective scheme set up by producers or through legislation that becomes responsible for the recovery and recycling obligations of individual producers

Recovery: any operation the principal result of which is waste serving a useful purpose by replacing other materials which would otherwise have been used to fulfil a particular function, or waste being prepared to fulfil that function, in the plant or in the wider economy (WEEELABEX, 2013)

Recycling: any recovery operation by which waste materials are reprocessed into products, materials or substances, whether for the original or other purposes. It includes the reprocessing of organic material but does not include energy recovery and reprocessing into materials that are to be used as fuels or for backfilling operations (WEEELABEX, 2013).

Recycling chain: made up of producers (manufacturers, importers, assemblers, distributors and marketers), consumers, logistics operators and managers

Refurbishment: a process for obtaining renovated or refurbished EEE by means of activities such as cleaning, data wiping and software updating. It may include repairs in cases of damaged equipment (Ministry of Environment and Sustainable Development of Colombia- MADS, 2013).

Repair: the process of correcting a specific hardware fault or series of faults in EEE

Selective routes: routes designed to collect a specific type of waste (in this case, routes specialized in the collection of ICT/UEEE)

Stakeholder: a person, group or organization with an interest or concern in an organization. Stakeholders can affect or be affected by the organization's actions, objectives and policies (Business Dictionary, 2017). They can be internal or external. Examples are governments, ICT/EEE producers (manufacturers, importers, assemblers, distributors and marketers), ICT/EEE consumers, and ICT/EEE and ICT/e-waste managers and logistics operators.

Sustainable development: According to the Brundtland Report, sustainable development is "development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It contains within it two key concepts: a) the concept of needs, in particular the essential needs of the world's poor, to which overriding priority should be given; and b) the idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs" (United Nations, 1987).

Take-back or reverse logistics: a procedure to take back and/or collect disused EEE and transport it to reuse centres or facilities authorized to manage e-waste (Ministry of Environment and Sustainable Development of Colombia- MADS, 2013)

Treatment: recovery or disposal operations, including any preparation prior to recovery or disposal (WEEELABEX, 2013)

UEEE: electrical and electronic equipment that has been put into service and used but subsequently taken out of service and not yet discarded as waste (WEEELABEX, 2013)

Urban mining: the passage from a linear to a circular approach that has characterized waste management strategies over the last few decades. Urban mining is the systematic management of anthropogenic resource stocks (products and buildings) and waste, with a view to long-term environmental protection, resource conservation and economic benefits (Cossu et al., n.d.). It is also defined as the process of reclaiming compounds and elements from products, buildings and waste (Urban Mining, n.d.).

Waste: any substance or object that the holder discards, or intends or is required to discard (WEEELABEX, 2013)

WEEE: waste electrical or electronic equipment, including all components, subassemblies and consumables that are part of the product at the time it is discarded (WEEELABEX, 2013)

Waste hierarchy: a set of priorities (1. avoid and reduce waste, 2. resource recovery and 3. disposal) for the efficient use of resources (NSW Environment Protection Authority, 2015).

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Annexes

Annex 1 – Treatment methods

Table A1 – Treatment methods for fluorescent lamp components

Output fraction	Purpose	Acceptor
Glass	Glass	Glass industry
		Lamp industry
	Glazing	Ceramics industry
	Abrasive sand for cleaning	Cleaning industry
	Fusion agent within black copper foundry	Metal industry
	Clinker	Building/cement industry
	Sand replacement	
	Under layer for asphalt road	
	Glass wool	
	Silicon substitute	Incinerators
Mercury	Cathode	Chlorine/ caustic soda industry
	Mercury	Lamp industry
	Fluorescent/ phosphor powder	Controlled landfill
Powders	Waste	Controlled landfill
	New use	Rare earth industry
Caps and metallic components	Metal foundries	Metal industry
Plastics	(Mix of) plastic	Plastic industry
	Plastic waste	Controlled landfill

Source: WEEELABEX, 2013 (normative document on treatment, V10)

Table A2 – Treatment methods for batteries

Battery type	Recycling process
Alkaline, manganese and zinc carbon batteries	Hydrometallurgical and pyrometallurgical processes can be used to recover zinc, steel and ferromanganese or padding for use in the construction industry.

Battery type	Recycling process
Nickel cadmium batteries	Pyrometallurgical processes are used to recover cadmium that is 99% pure, in order to produce new nickel cadmium batteries and ferronickel.
Nickel metal hydride batteries	This kind of battery is processed to recover nickel, iron and other metals.
Rechargeable lithium ion batteries	This kind of battery is processed to recover cobalt, iron and other metals.
Lead acid batteries	Lead is recovered for reuse in new batteries.
Button batteries	Silver oxides present in watches are collected and recycled by jewelers to recover silver. The batteries can also be processed to recover mercury, zinc and steel.

Source: Maria Gómez Gómez, 2010

Table A3 – Minimum standards – Treatment options

Kind of hazardous ICT/WEEE	Treatment options
General	Once the metallic and non-metallic fractions have been separated out, they can be processed as set out below. Metallic fractions: through metallurgical processes (hydrometallurgical, pyrometallurgical, electrometallurgical, biometallurgical, and combinations thereof) Non-metallic fractions: recycling methods are based on chemical processes (gasification, pyrolysis, supercritical de-polymerization and hydrogenolytic degradation) for the production of chemicals and fuels (non-metallic fractions can be used in pyrometallurgical processes as fuels and reducing agent). Hydrometallurgical and pyrometallurgical processes are the most common and can be followed by electrometallurgical / electrochemical processes (e.g. electrorefining or electrolytic extraction) for the separation and recovery of the selected metal. The use of biometallurgical processes (for example, the bioleaching of metals from electronic waste) has been limited to laboratory studies but it is an alternative worth exploring given its great potential (Khaliq et al., 2014). Hydrometallurgical processes are more reliable and easier to control than pyrometallurgical processes, which have high SO_2 and CO_2 emissions. Waste must be properly treated and treatment processes monitored, to ensure that ICT/WEEE management by-products do not contaminate as much or more than mismanagement.
Aluminium, steel and copper	Scrap steel can be used in electric arc furnaces to produce new steel. Scrap aluminum can be used in secondary aluminum furnaces to produce new aluminum. Scrap copper, scrap precious metals, and some other non-ferrous (special) metals are commonly recovered from computer circuit boards and other components/fractions by pyrometallurgical processing and/or by metal-specific hydrometallurgical refining.

Kind of hazardous ICT/WEEE	Treatment options
CRT screens	Clean and sorted CRT glass can be used to produce new leaded glass (e.g. for x-rays) or processed in lead smelters to produce lead. Cone glass and CRT glass mixtures should, as far as possible, be recovered or recycled in products or processes where the lead content has a technical function, to avoid dispersing lead to other products and in the environment. Otherwise, the glass should be used in such a way that the lead content of the final product does not exceed the limits specified in national legislation.
Mercury lamps	Mercury lamps should be properly packaged and sent to specialized mercury recovery facilities. All CCFLs from manual dismantling, whether broken or not, must be managed in treatment plants **(Table A1).**
Mobile phones	Mobile phones can be processed to recover copper, extremely valuable precious metals such as gold, silver and palladium, and other materials such as steel, aluminium and magnesium, tin, cobalt, lead and plastics. They can be smelted at the end of life to recover metals such as copper, precious metals, and most other metals (except iron, magnesium, and aluminum); plastics can be used as a source of heat and as reducing agents. Smelting of used mobile phones requires specialized equipment with pollution control systems. Electronic waste, including mobile phones, contains plastics and halogens (chlorine and bromine) which, when burned, can lead to the formation of dioxins and furans, which are highly toxic and carcinogenic.
Batteries	Batteries can be safely recycled to recover iron, aluminium, copper, nickel, cobalt and cadmium, depending on the battery type and the specific recovery process **(Table A2).**
Flat screens	For the treatment of flat-screen devices, which contain mercury, fluorescent coating and indium tin oxide, the screen type, fractions, components, and requirements for environmentally sound management should be taken into account. Flat screens may contain the following components: backlight lamps, fluorescent coating and/or lithium batteries. LCD panels and their fractions should be sent to treatment plants able to concentrate indium tin oxide. Fluorescent coatings and their fractions should be disposed of in landfills (security cells) or treated with appropriate thermal processes designed and authorized for hazardous substances. Processing of flat panel displays should be carried out in a controlled atmosphere. Suitable ventilation equipment and filters should be used to ensure that the occupational exposure limits and the emission limit values for particles and heavy metals are not exceeded at any time. The accumulation of heavy metals in dust should also be measured periodically.
Printed circuit boards	Lead, tin, antimony, chromium oxide, beryllium, cadmium, gold and silver can be recovered. The presence of brominated flame retardants and bromine in plastic components requires additional treatment. Advanced techniques combining hydrometallurgy and pyrometallurgy can be applied to recover rare and precious metals. The techniques must be controlled and will vary depending on the metal to be obtained (Cui and Zhang, 2008)

Kardous ICT/WSource: ITU, based on information from the standards and guidelines analysed

Annex 2 – Detailed comparison of standards

General aspects / Management stages	Standard		
	WEEELABEX	The Responsible Recycling Standard for Electronics Recyclers (R2)	e-Stewards
General			
Scope	The WEEELABEX requirements lay down measures related to protection of the environment, human health and safety of e-waste operations. They define both technical and management requirements for operators, and concern all steps in the chain, including collection and preparation for reuse.	The R2 Standard establishes responsible recycling ("R2") practices for the recycling of electronics globally. The R2:2013 Standard is applicable to all organizations in the recycling chain, regardless of their size or location.	The e-Stewards standard is established for use in an accredited third-party audited certification programme. It contains requirements for an environmental management system (including ISO 14001 and health and safety management system requirements) and more specific e-Stewards requirements, often beyond legal standards. e-Stewards is applicable to all organizations in the recycling chain in any country.
Prerequisites	Operators must ensure that a management system is in place for all activities in the fields of health, safety, the environment and quality. WEEELABEX systems may only contract with operators that comply with the requirements in the relevant normative document (WEEELABEX, 2013) or can demonstrate that they meet equivalent specifications.	Electronics recyclers must be certified according to one or more environmental, health and safety management system standard. Certification: through an accredited third-party certification body.	Operators must ensure that they have in place an environmental management system that encompasses environmental, occupational health and safety, data security, social accountability, and other performance requirements identified in the Standard. Certification: through an accredited third party certification body.

(continued)

General aspects / Management stages	Standard		
	WEEELABEX	The Responsible Recycling Standard for Electronics Recyclers (R2)	e-Stewards
General			
Principles	• A community environment policy aimed at preserving, protecting and improving the quality of the environment, protecting human health and utilizing natural resources prudently and rationally • Precautionary principle • Polluter-pays principle • Waste hierarchy • Presumption that operators adhere to the principle of due diligence in respect of all activities	• Protection of the health and safety of workers and the public • Environmentally sound management of UEEE • Electronics recyclers must develop and adhere to a policy for managing used and end-of-life electronic equipment that is based on a waste hierarchy of responsible management strategies.	• Protection of the health and safety of workers and the public • Data security • Precautionary principle • Polluter-pays principle • Waste hierarchy • Due diligence for downstream recycling (i.e. the organization establishes, implements, documents and maintains an effective system of controls to track EEEs to final disposal, and performs ongoing due diligence to ensure EEEs are managed in a manner that protects human health and the environment throughout each material's recycling chain) • Use of best available techniques and processes/applications

(continued)

General aspects / Management stages	Standard		
	WEEELABEX	The Responsible Recycling Standard for Electronics Recyclers (R2)	e-Stewards
General			
Licences and authorizations	Valid permits required by all relevant authorities must be maintained.	Electronics recyclers must verify that their transporters have: • all the necessary regulatory authorizations; • adequate insurance coverage consistent with the material and method of transportation; and • acceptable vehicle and driver safety records for the three previous years.	e-Stewards organizations must ensure that hazardous e-waste and problematic components and materials destined for recovery and/or final disposal are treated, processed and managed only in facilities which are licenced and permitted, by applicable jurisdictions, to receive and process or utilize them.
Planning			
Policy, objectives and goals	Operators must have an environmental, health and safety policy.	R2:2013 electronics recyclers must develop and adhere to a written policy stating how they manage used and end-of-life electronic equipment, components and material.	The e-Stewards programme provides businesses with a best practices framework to effectively manage the different types of risks they face (including environmental, health and safety, legal, operational and customer-related risks). The system constitutes a living tool for continually improving business performance.

(continued)

General aspects / Management stages	Standard		
	WEEELABEX	The Responsible Recycling Standard for Electronics Recyclers (R2)	e-Stewards
General			
Legal and administrative aspects	• Operators must comply with European Union legislation and its corresponding transposition law. • Compliance with WEEELABEX regulatory requirements does not exempt operators from compliance with other legal obligations. In those cases where WEEELABEX normative requirements differ from national or subnational legal or regulatory provisions, the stricter requirements are applicable. • E-waste intended for cross-border shipments is subject to the requirements of Directive 2002/96/EC. • Operators must maintain records documenting compliance with the legal and regulatory obligations applying to all activities undertaken on site.	Electronics recyclers must: • comply with the laws and regulations of all importing, transit and exporting countries (if the R2 requirement conflicts with an applicable legal requirement, the recycler must adhere to the legal requirement); • ensure that any downstream partners and vendors to whom they have outsourced certain activities and requirements under the Standard conform to the requirements thereof; • comply with all applicable environmental, health and safety, and data security legal requirements, and only import and export equipment and components containing FMs in full compliance with all applicable laws of importing, transit and exporting countries; • comply with all applicable environmental and health and safety regulations and permissible exposure limits for sampling and/or monitoring;	e-Stewards organizations must comply with the requirements of: • the OECD, the Basel Convention and its Ban Amendment; • other applicable international laws regarding trade in hazardous wastes, including regional treaties (e.g. the Waigani Convention, the Bamako Convention, the Izmir Protocol to the Convention for the Protection of the Mediterranean Sea against Pollution, the Central American Regional Agreement on the transboundary movement of hazardous wastes, the European Union Waste Shipment Regulation); and • the national legislation of countries concerned. Where e-Stewards requirements conflict with legal requirements, the law prevails. However, where the voluntary Standard is not in conflict, the e-Stewards requirements are implemented. e-Stewards organizations must:

(continued)

General aspects / Management stages	Standard		
	WEEELABEX	The Responsible Recycling Standard for Electronics Recyclers (R2)	e-Stewards
General			
Legal and administrative aspects	• No operator may initiate, contribute to, or otherwise allow shipments of e-waste that would result in treatment not in compliance with the objectives of WEEELABEX norms. • The logistics operator must have insurance coverage or other financial resources that are commensurate with the nature and scope of the operations.	• perform due diligence in respect of the downstream vendors to which they ship these materials; • have insurance to cover potential risks and liabilities associated with the nature and size of the facility's operations, and have the legal and financial resources needed for the proper closure of their facilities.	• at least once every three years, conduct and document a risk assessment of the environmental and stewardship aspects associated with all forms of electronic equipment and its management;• establish, implement, document and maintain an effective system of controls to track hazardous e-waste to final disposal, performing ongoing due diligence, throughout each material's recycling chain. • obtain and maintain liability insurance to cover potential risks and liabilities; • ensure that transporters have all legal authorizations and adequate insurance or financial guarantees to cover costs in the event of an accident or injuries; • prior to certification and every year, send the confidential e-Stewards database information on the organization, its processes and employees, and the weight or units of equipment processed and under organizational control.
Implementation			

(continued)

General aspects / Management stages		Standard		
		WEEELABEX	The Responsible Recycling Standard for Electronics Recyclers (R2)	e-Stewards
General				
All stages	Infrastructure	• Collection facilities must be secured to prevent damage to and theft of e-waste and components thereof. • Operators must have infrastructure that is suitable, in terms of size, technology and operational characteristics, for the activities performed on site (risk assessment, identification of hazards, risk elimination or reduction, and process documentation). • Collection facilities, including storage areas, must be designed, organized and maintained to provide safe access to and egress from the site, and to avoid access by unauthorized persons.	Recyclers must: • maintain a security programme that controls access to all or parts of the facility according to the type of equipment handled, the sensitivity of the media containing data, and customer needs; • demonstrate the expertise, knowledge and technical capability to process each type of equipment, component and material they accept in a manner that is legal and protective of worker safety, public health and the environment; • adhere to good housekeeping standards, including keeping all work and storage areas clean and orderly; • consider and establish controls to secure electronic equipment upon acceptance.	e-Stewards organizations must: • document and implement a plan for the responsible management and disposal of UEEE and e-waste; • provide resources (human, technical and financial) for the effective and efficient operation of the environmental management system and achievement of its goals; • ensure that facilities are licenced and permitted to receive and process or utilize the specific materials; • ensure that such facilities use best available techniques and processes/ applications to safely recover and reuse maximum materials, and responsibly dispose of non-recyclable fractions; • create a procedure to monitor, measure and document the operational characteristics of their significant environmental and stewardship aspects and impacts on the environment, data security, and occupational health and safety; • use and maintain properly calibrated or otherwise verified equipment for required monitoring and measurement.

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General aspects / Management stages		Standard		
		WEEELABEX	The Responsible Recycling Standard for Electronics Recyclers (R2)	e-Stewards
General				
All stages	Human skills	• All employees must be familiar with the environmental, and health and safety risks of the facility. • All employees must be familiar with the environmental, health and safety policy of the facility. • Employees and contractors must be instructed and trained to perform the tasks assigned to them. • Employee training materials and information must be available at the working place or be easily accessible at all times. • Training must be regularly checked for effectiveness and suitability. • Employees must make proper use of any personal protective equipment required pursuant to a risk assessment. • The operator must implement a programme to identify, evaluate and control incidents and accidents occurring at its facility.	Electronics recyclers must: • continuously identify hazards and assess the occupational health and safety and environmental risks that exist or could reasonably be expected to emerge at the facility; • manage environmental, health and safety hazards, minimize the risks identified, and prioritize the use of appropriate strategies to implement and maintain controls; • provide regular, documented environmental, health and safety training; • provide training for new hires and refresher courses for all employees (in the employees' language and tailored to their level of education); • ensure that personal protective equipment is available; • designate a qualified employee(s) or consultant(s) to coordinate efforts to promote worker health and safety and environmental protection.	e-Stewards organizations: • ensure that all personnel responsible for achieving the requirements of the complete e-Stewards Standard are qualified in terms of job training, work experience, and/or education; • provide and document awareness and job training for employees whose jobs relate to the organization's environmental, occupational health and safety, and data security aspects and impacts, and its environmental management system; • provide all employees with the equipment identified as required by a risk assessment.

(continued)

General aspects / Management stages		Standard		
		WEEELABEX	The Responsible Recycling Standard for Electronics Recyclers (R2)	e-Stewards
General				
All stages	Documentary support (processes and procedures)	Operators must: • establish and maintain a procedure to identify the legal requirements applicable to the environmental, health and safety aspects;	Electronics recyclers must: • develop a legal compliance plan to ensure they are fully compliant with all environmental, health, safety, and data security requirements applicable to their operations, and with all applicable import and export laws covering shipments of FMs and of untested or non-functioning equipment or components containing FMs;	e-Stewards organizations must: • establish and maintain operational controls, processes and procedures to identify legal requirements applicable to the environmental, health and safety aspects; • establish and maintain training, communications, documentation, processes and procedures to minimize the environmental, health and safety impact and ensure effective system implementation;

(continued)

General aspects / Management stages		Standard		
		WEEELABEX	The Responsible Recycling Standard for Electronics Recyclers (R2)	e-Stewards
General				
		• document processes (identification of hazards, assessment of risks and, where appropriate, risk elimination or reduction for all tasks performed on site); • trace and document the downstream logistics chain of e-waste; • have an emergency and contingency plan.	• keep the legal compliance plan up to date, identify and implement steps to comply with each requirement, and document implementation; • adopt emergency plan(s) for responding to emergency situations and exceptional circumstances to protect workers; • state in the FM management plan how they and their downstream vendors intend to conform with the requirements; • document data destruction procedures and include this documentation as part of their environmental, health and safety management system; • develop and maintain an updated, written plan and sufficient financial resources for proper closure of the facility.	• document processes (identification of hazards, assessment of risks and, where appropriate, risk elimination or reduction for all tasks performed on site); • maintain and control legible and verifiable records demonstrating conformity with the requirements of the environmental management system (records must be kept for a minimum of 5 years); • maintain thorough written documentation of initial and ongoing monitoring protocols and activities; • ensure that their environmental management systems provide for emergency preparedness and specify how they will respond to possible emergencies, injuries, and accidents, and data security breaches; • create and maintain a site closure plan indicating how the closed sites will be tested and remediated, if necessary.
All stages	Tools, equipment and machinery	E-waste must at all times be handled, including during loading, unloading and transport, using appropriate tools, containers and fixtures to avoid damages.		Properly calibrated or otherwise verified equipment must be used and maintained for required monitoring and measurement.

(continued)

General aspects / Management stages		Standard		
		WEEELABEX	The Responsible Recycling Standard for Electronics Recyclers (R2)	e-Stewards
General				
All stages	Records	• Operators of collection facilities must record the quantity of e-waste collected and forwarded by means of weight notes or piece counts, or by documenting the number, size and filling level of receptacles. • Records of activities and related legal provisions must be controlled. • Electronic or hard copies of documents and records must be available for at least 3 years (logistics, collection).	Recyclers must keep commercial contracts, bills of lading, or other commercially accepted documentation for all transfers of equipment, components and materials for at least 3 years.	e-Steward organizations must: • have an environmental management system that documents records with evidence of conformance with the complete e-Stewards Standard, and procedures and records that may be necessary to ensure effective planning, implementation and control of their significant environmental aspects and impacts; • if requested by customers, including upstream e-Stewards organizations, provide, or allow review of, verifiable records of e-waste going for recycling or final disposal, including information for downstream processor(s) through final disposal; • provide and maintain identifying records for each item of electronic equipment (including components) destined for reuse;

(continued)

General aspects / Management stages		Standard		
		WEEELABEX	The Responsible Recycling Standard for Electronics Recyclers (R2)	e-Stewards
General				
		• Records must be kept demonstrating compliance with legal and regulatory obligations. • Treatment operators must keep a mass balance, which consists of the documentation of all material flows in an annual overview under consideration of stored amounts. • All documents must be stored securely and maintained for 5 years unless stipulated otherwise by legislation or the authorities (treatment). • Treatment operators must document all cleaning measures and decontamination activities carried out at the facility as a result of an accident or incident. • Treatment operators must keep records of accidents or dangerous occurrences.	Electronics recyclers do not need to track non-FMs beyond the first-tier downstream vendor. R2:2013 electronics recyclers must keep proper records of their data destruction activities and those of any downstream vendors.	• provide and maintain bills of lading/waybills and/or other relevant shipping records with both the buyer/receiver and seller/donor listed; • establish and document a clearly defined chain of custody for customer data; • provide verification records of successful sanitization for each device; • establish and maintain a process for internal reporting of events, including a summary log and up-to-date and accurate records of all environmental releases, health and safety accidents, incidents, injuries, exposures, and near misses; • retain all records required by the Standard for a minimum of 5 years, with the exception of workplace and worker exposure records, which must be retained for the length of each worker's employment plus 30 years.

Pre-processing stage			
Collection and transport	• During collection, e-waste may not be mixed with other wastes in the same container or receptacle. • CRT display appliances and flat panel displays must be prepared and loaded for transport in such a way that they are not damaged during loading and transport. • Appropriate methods must be used to prevent the breakage of flat panel displays during transport. • Uncontrolled tipping of containers of CRT display appliances, flat panel displays, temperature control equipment, and lamps is not permitted.		e-Stewards organizations must: • establish procedures to ensure safe and legal transportation/shipping of electronic equipment; • ensure accurate classification and labeling/placarding, record keeping, and appropriate packaging and security for transport; • use transporters that have all legal authorizations.
Reception, sorting and weighing	E-waste must be sorted into the e-waste collection categories or any other groups of e-waste based on legislation.		Hazardous e-waste must be safely consolidated and packaged to prevent leakage, spills, dispersal, and the release of vapors, fumes, dust and liquids.

(continued)

Pre-processing stage			
Storage	WEEE must be handled and stored with due care to avoid the release of hazardous substances as a result of damage and/or leakage. Storage areas at collection facilities require: • impermeable surfaces for all e-waste storage areas; • spillage collection facilities for all uncovered storage areas; • weather-proof covering. Sites for pre-treatment storage (including temporary storage) of e-waste require: • impermeable surfaces for storage areas; • spillage collection facilities; • decanters (where appropriate); • cleanser-degreasers; • weather-proof covering for appropriate areas. WEEE may be stored up to the maximum amounts allowed by law and regulations. In the absence of such provisions, the maximum amount must not exceed the amount of e-waste that can be treated within 6 months.	Electronics recyclers must store items removed, equipment and components destined for reuse in clearly labelled containers and/or storage areas and in a manner that: (1) protects them from reasonably foreseeable adverse atmospheric conditions and floods and, as warranted, includes a catchment system; (2) is fully compliant with the law; and (3) is secure from unauthorized access.	Hazardous e-waste must be stored, on site and off site, in a manner which prevents fires and contamination of air, soil, groundwater, and storm water runoff, including in: • weatherproof sheltering with impermeable flooring; • designated and labeled storage areas (or containers), in a manner which minimizes spills, breakages and injuries; in accordance with regulatory storage limits, including maximum time limits and quantities allowed in storage.

Processing stage			
Direct or indirect reuse (repair / refurbishment)	• Operators are entitled to contract with a third party authorized to perform reuse preparatory activities only if they can ensure that WEEE and fractions not destined for reuse are returned to the collection facility. • Any standard related to the marketing of equipment prepared for reuse should require that the party bringing the equipment prepared for reuse back on the market must place its name on the equipment; safeguard the original manufacturer from any claim related to the equipment; and deliver legal guarantees. • Storage areas designated for the storage of e-waste intended for preparation for reuse must have weather-proof covering.	Electronics recyclers must: • take all practical steps to direct tested equipment and components to reuse and resale, and equipment capable of repair to qualified refurbishers; • with respect to equipment and components they ship downstream: (1) label and sort each shipment in a manner sufficient to track throughput; (2) ensure that all data are sanitized; (3) handle and package shipments to prevent damage; • before shipping UEEE and components containing FMs, identify each shipment as either: (1) Tested for Full Functions, R2/Ready for Reuse; (2) Tested for Key Functions, R2/Ready for Resale; and/or (3) Evaluated and Non-Functioning, R2/Ready for Repair.	e-Stewards organizations must: • ensure that hazardous e-waste and components destined for recovery and/or final disposal are treated, processed, and managed only in types of facilities, throughout the recycling chain, as are allowed by law; • ensure that such facilities use best available techniques and processes/applications designed to safely recover and reuse maximum material; • put in place specific control procedures on exports and imports of electronic equipment for reuse; • ship EEE for reuse subject to strict labeling requirements, with each shipment exported for reuse being accompanied by a completed and signed declaration/ document.

(continued)

Processing stage			
Manual / mechanical dismantling	• Crushing or compacting of e-waste before treatment is not permitted. • Lamps are to be removed through environmentally sound recycling that does not hinder recovery of components or appliances. • Treatment operators must remove all liquids, substances, preparations and components from WEEE, without damaging or destroying components. • Personal data stored on the memory of ICT equipment being treated must be destroyed. • Non-waste materials may not be added to hazardous waste to make overall waste volume fall below the limit of hazardous waste (ban on dilution). • If it is uncertain whether hazardous substances are present, the e-waste or components must be treated as if they contained such substances.	Electronics recyclers must • take all practical steps to sort out, through manual dismantling and/or mechanical processing, the materials in equipment and components that are not directed to reuse or refurbishment and direct them to properly equipped materials recovery facilities; • remove FMs using safe and effective mechanical processing or manual dismantling, before shredding or recovering materials from equipment or components; • send removed FMs to processing, recovery or treatment facilities that meet all applicable regulatory requirements.	• e-Stewards standards list the items that have to be safely removed from UEEE and e-waste, and separated. Such items may not be mechanically processed except by an operation using best available technologies specifically designed to process the material concerned in a closed system with engineering controls that prevent releases into the environment and work area, with workers fully protected from exposure. • Unless otherwise requested in writing by the customer, the e-Stewards organization must effectively sanitize all consumer data before the device leaves the organization's control, so that data storage devices are permanently unusable, unreadable and/or indecipherable.

(continued)

Processing stage			
Sorting according to kind of WEEE and storage according to type of material	• Substances, preparations, and components to be removed from ICT equipment or fractions must be clearly identified, labelled and forwarded with related documentation. • CRT display appliances, flat panel displays and lamps must be stored in containers or stacked in a stable manner, to prevent damage or leakage.		e-Stewards organizations must: • ensure accurate classification, labelling/placarding and record keeping, appropriate packaging and secure transport; • establish and maintain a system of controls that secures electronic equipment, both inside and outside the facility, and clearly defines the chain of custody of the materials.
Treatment (including recovery) and disposal	• Information is provided regarding batteries, printed circuit boards, capacitors, switches containing mercury, and plastics containing brominated flame retardants. • Operators must meet specific requirements for the treatment of CRT display appliances, flat panel displays and lamps.	Electronics recyclers must manage print cartridges through print cartridge remanufacturers, recyclers, or original equipment manufacturers, in facilities that meet all applicable regulatory requirements and use technology designed to manage such cartridges, including ink and toner, safely and effectively.	CRT glass and panel display glass must be processed in facilities that use all the leaded glass to manufacture new products that will not leach metals during their useful life. CRTs (with or without vacuum) and uncleaned CRT glass must never be placed in solid waste disposal operations and must be directed to:

(continued)

Processing stage			
			• a CRT glass processor for preparation for use in the manufacture of new products; • a lead smelter, integrated copper smelter, or other technology capable of recovering lead and cadmium; or • as a last resort, a lined, leachate-controlled hazardous waste landfill, unless forbidden by law. CRT processing residues and CRT residues must: • never be processed in incinerators of any kind; • be processed in one or more of the following facilities that have been notified and have consented in writing in advance to accept such materials: • a facility that reclaims rare earth and critical metals (e.g. in phosphors); • a primary or secondary smelter that recovers lead and cadmium; • lined, leachate-controlled, and monitored solid waste landfill, only if residues have first been stabilized with pre-treatment in accordance with applicable laws.

(continued)

Processing stage			
Monitoring			
Audits and supervision	• The minimum monitoring requirements for shipments as laid down in Directive 2002/96/EC on WEEE and Regulation 1013/2006 on shipments of waste must be strictly adhered to. • The policy must be updated or revised, and evaluated, as operator activities change.	Electronics recyclers must: • periodically audit their compliance with legal requirements, and take corrective action to address any issues of non-compliance; • confirm, at least annually, and document, through audits or other similar means, that each downstream facility continues to conform to the requirements; • provide each customer that is R2-certified or in the process of becoming so, upon request and as legally appropriate, with the names and locations of all downstream vendors in the recycling chain handling the customer's FMs; • document, implement and monitor quality controls internally to ensure effective data sanitization, purging and destruction techniques.	e-Stewards organizations must: • arrange for independent third-party audits; • before initial certification, and by 31 January of every subsequent year, the e-Stewards database should be condidentially updated conduct regular internal audits of their management system, at least annually, to check for initial implementation and continuing conformity with system requirements; • conduct ongoing due diligence on all immediate downstream processors, by regularly (at least once a year) evaluating and performing on-site audits.

Review			
Improvement	Operators must continuously improve their activities by a review and management process.		Top management must regularly (at least annually) review the performance of the environmental management system and take appropriate action to correct and improve the system based on results. In so doing, it must consider internal system audit results, inputs from customers or outside parties, and the degree to which system objectives (including legal requirements) are met.

Annex 3 – Examples of existing legal, policy and regulatory frameworks on ICT-derived e-waste

This annex summarizes the legal, regulatory and policy framework on ICT-derived e-waste of five countries selected on the basis of the following criteria: they belong to different global regions, including developed and least developed or developing countries; they apply different e-waste legislation and present different levels of progress. The selected countries are: Canada (North America), France (Europe), Bhutan (Asia), Colombia (South America) and South Africa (Africa).

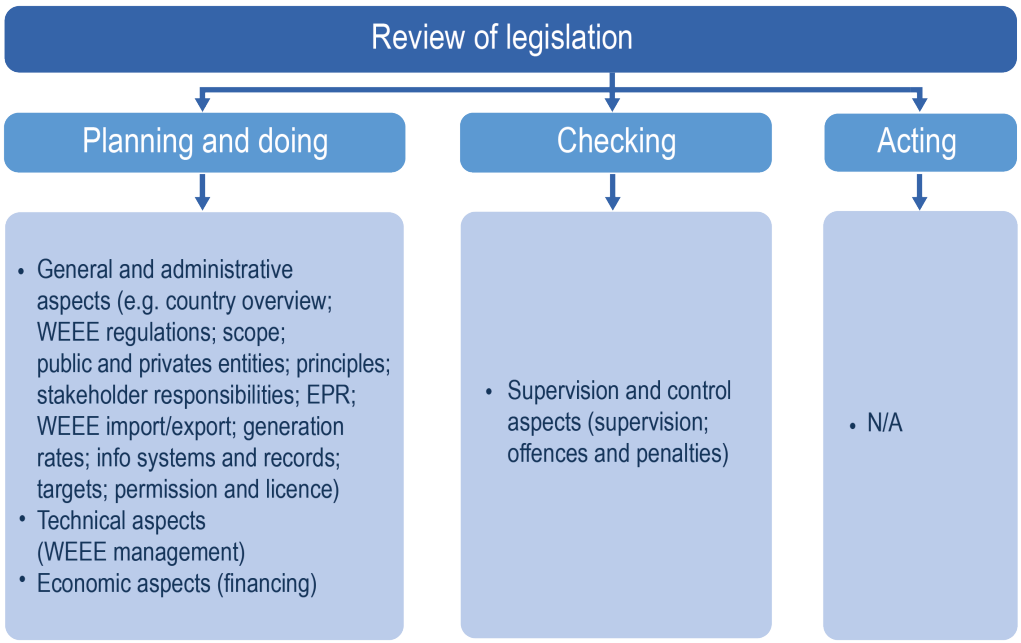
The main purpose of this exercice is not to compare the countries' profiles, but rather to provide examples of different legislative frameworks across different regions and to identify the main aspects to consider when drawing up a legal framework on electrical and electronic waste, in particular on ICT/e-waste. The final objective is to infer, from practical examples, general principles for the preparation of legislation tailored to specific contexts.

Structure of the review

The review was carried out taking into account the concepts of sustainable development and green ICT. The structure of the review is detailed in Figure A1 below. The relevant issues and common aspects are described for the four phases (planning, implementation, monitoring and review) and grouped in the following clusters:

- administrative;
- technical (environmental);
- economic; and
- monitoring and control.

Figure A1 – Structure of the review



In this context, the identification and formulation of regulatory aspects (planning) and the relevant enforcement phase (implementation) are analysed and systematized together, as some of them overlap and/or are correlated.

The following paragraphs summarize the most important aspects resulting from the analysis of the legal, policy and regulatory framework in the five countries. These aspects have been included in the recommendations presented in **Chapter 4**.

Planning and implementation phase

Administrative aspects

Governments developing a legal, policy and regulatory framework on ICT/e-waste need to identify public and private entities involved in (ICT/) e-waste management and assign clear stakeholder roles and responsibilities. (ICT/) e-waste management is under the jurisdiction of multidisciplinary public and private entities from the environmental, ICT, health and energy sectors, such as the health and industry ministries, and ICT producers, manufacturers and recyclers.

The **general principles** applied are similar in the five countries examined and include occupational safety and health, the precautionary principle, the polluter-pays principle, EPR, the 3R principle,[8] the waste hierarchy, and sustainable production and consumption[9]. In this regard, see also Chapter 4.

With regard to the **import and export of e-waste**, all countries reviewed have ratified, and are therefore bound by, the provisions of the Basel Convention.

Information systems and records – roles and responsibilities: Stakeholders have different roles and responsibilities with regard to the data and records to be included in the national information system. In particular:

- **the government** establishes a national and local e-waste management system and generates periodical reports on different points, such as existing producers and marketers, equipment placed on the market, consumption statistics, e-waste generated and auctioned (i.e. clean materials from e-waste that are auctioned in order to reincorporate them into productive processes and obtain some form of financial yield);
- **producers** submit a periodic report on the development and implementation of the WEEE management system, which serves as input for the national e-waste management system;
- **managers** register and report to the government all data concerning WEEE management at the different stages, and maintain records that allow WEEE to be traced.

Permissions and licences: E-waste is be managed (i.e. collected, treated and disposed of) only by companies that have the necessary environmental licence, permit or authorization. Companies or managers are subject to auditing. Certain activities require a special waste management licence. Small-scale e-waste collection and transportation activities may not require a licence.

Targets: All five countries studied have clearly defined targets for recovery, recycling, refurbishment and collection.

Technical aspects

All five countries share certain key technical aspects

WEEE category and management: The five countries examined classify e-waste differently, either including it in the definition of hazardous waste (e.g. South Africa) or considering it as a separate category (e.g. Bhutan). In Colombia, e-waste is subject to a specific waste management system.

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8 The 3R principle aims to promote reductions in e-waste through smart procurement and good maintenance of ICT/EEE; reuse of functioning electronic equipment that can be donated or sold; and recycling of components that cannot be repaired (ITU, 2014).

9 The principle of sustainable production and consumption refers to the creation of goods and services using processes and systems that are non-polluting; conserving of energy and natural resources; economically viable; safe and healthful for workers, communities and consumers; and socially and creatively rewarding for all working people (Lowell Center for Sustainable Production).

Collection: This differs from country to country and involves different entities at local or national level, including collection/recycling companies, producers, individuals and government agencies. In Bhutan, e-waste is channelled to designated collection centres/drop-off sites or e-waste management entities. In France, individuals deliver e-waste to more than 22 900 collection points in cities, and producers or individuals use more than 4 500 out-of-town recovery centres. In Canada, several national and provincial organizations deal with the collection and recycling of electronic waste by province.

Information for management: In one country (Bhutan), importers and producers provide information about the hazardous nature of e-waste and potential damage to human health and the environment.

The Restriction of Hazardous Substances Directive 2002/95/EC: In Bhutan, importers and producers have to comply with the Directive. In two countries (Bhutan, France), six substances have been identified as prohibited substances in EEE (i.e. lead, mercury, cadmium, hexavalent chrome, polybromobiphenyls and polybromodiphenylethers).

Clean-up/remediation: In France, PROs take direct charge of certain hazardous components through stricter traceability regulations.

Reuse: In France, in order to enhance reuse, social and solidarity economy structures are granted access to household e-waste landfills, and PROs (see Glossary) cover the costs of transporting the equipment to reuse facilities.

Pre-processing and processing stages: In Canada, recyclers use a smaller dismantling unit at local level (regional or sub-regional) before the e-waste is sent to specific processing centres.

Disposal: Colombia prohibits the disposal of e-waste in landfills, whereas in Canada, e-waste can be put it in the garbage, returned to the supplier, dropped off at a depot, or donated.

Economic aspects

The financing and functioning of the waste management system in the five countries is considered below.

In Bhutan, a fund can be created to collect and allocate adequate finding to ensure the proper implementation of e-waste management regulation. The fund can receive contributions from government, producers and importers, fines for non-compliance with electronic waste regulations, etc.

Resources from the public, private and international cooperation sectors are considered as possible funding sources in all five countries.

In Colombia and France, **producers pay a fee** for each product they place on the market. The fees vary according to different parameters (type and quantity of e-waste put on the market and collected, cost of collection and treatment, etc.). Producers bear the costs of selective collection and environmental management of e-waste. Suppliers/vendors accept the return of e-waste at no cost for the consumer.

Canada and France apply an eco-fee at purchase, a form of **financing by consumers**.

Monitoring

Surveillance and control aspects

Violations and penalties: All five countries define violations of the proper management of e-waste and commensurate penalties (including administrative sanctions, fines, imprisonment, and liability for the costs of avoidance, containment, abatement, medical compensation, mitigation, remediation, and restoration).

Review

The regulations reviewed contained no information related specifically to realignment. Nonetheless, it is clear that, on the basis of the outcomes of monitoring and control activities, the government is in a position to redefine targets and indictors or take corrective measures to improve the UEEE and e-waste management system.

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