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SERIES L: ENVIRONMENT AND ICTS, CLIMATE CHANGE, E-WASTE, ENERGY EFFICIENCY; CONSTRUCTION, INSTALLATION AND PROTECTION OF CABLES AND OTHER ELEMENTS OF OUTSIDE PLANT

E-waste management framework for countries

Recommendation ITU-T L.1030

ITU-T L-SERIES RECOMMENDATIONS

ENVIRONMENT AND ICTS, CLIMATE CHANGE, E-WASTE, ENERGY EFFICIENCY; CONSTRUCTION, INSTALLATION AND PROTECTION OF CABLES AND OTHER ELEMENTS OF OUTSIDE PLANT

OPTICAL FIBRE CABLES	
Cable structure and characteristics	L.100–L.124
Cable evaluation	L.125–L.149
Guidance and installation technique	L.150–L.199
OPTICAL INFRASTRUCTURES	
Infrastructure including node elements (except cables)	L.200–L.249
General aspects and network design	L.250–L.299
MAINTENANCE AND OPERATION	
Optical fibre cable maintenance	L.300–L.329
Infrastructure maintenance	L.330–L.349
Operation support and infrastructure management	L.350–L.379
Disaster management	L.380–L.399
PASSIVE OPTICAL DEVICES	L.400–L.429
MARINIZED TERRESTRIAL CABLES	L.430–L.449

For further details, please refer to the list of ITU-T Recommendations.

Recommendation ITU-T L.1030

E-waste management framework for countries

Summary

Recommendation ITU-T L.1030 provides an e-waste management framework for countries. It summarizes the different steps that countries need to adopt in order to put in place an e-waste management system. The different steps of the e-waste management system described in this Recommendation will be further elaborated in future Recommendations. In addition, the Recommendation provides highlights concerning the environmental impact of improper handling of e-waste as well as the economic opportunities that could emerge from the sustainable management of e-waste.

History

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FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications, information and communication technologies (ICTs). The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

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As of the date of approval of this Recommendation, ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database at http://www.itu.int/ITU-T/ipr/.

Table of Contents

Introduction

Recommendation ITU-T L.1030 identifies the main steps for the design and implementation of an e-waste management system. It takes into consideration the different standards and supplements produced by ITU-T as well as other key standardization bodies.

It notes the environmental impact of e-waste if improperly handled, as well as the economic opportunities it could provide if properly managed. This Recommendation was drafted with support from and in consideration of activity in other standards developing organizations (SDOs) and other types of organizations.

Recommendation ITU-T L.1030 is designed to ensure that countries have a simple blueprint for e-waste management systems, that complements the different focused standards produced on the various steps of this framework. It is also meant to address the ICT divisions within countries which could play an important role in designing and facilitating the proper e-waste management systems in cooperation with the entities in charge of the environment.

Recommendation ITU-T L.1030

E-waste management framework for countries

1 Scope

This Recommendation provides a set of guidelines that countries can refer to when designing or adjusting their e-waste management systems. It provides guidance on policy/legal frameworks, resource mobilisation, collection mechanisms, financial mechanisms and engagement with all relevant stakeholders.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

For all revision update to be checked

[ITU-T L.1000] Recommendation ITU-T L.1000 (2011), *Universal power adapter and charger solution for mobile terminals and other hand-held ICT devices*.

[ITU-T L.1001] Recommendation ITU-T L.1001 (2012), *External universal power adapter solutions for stationary information and communication technology devices*.

[ITU-T L.1002] Recommendation ITU-T L.1002 (2016), *External universal power adapter solutions for portable information and communication technology devices*.

[ITU-T L.1010] Recommendation ITU-T L.1010 (2014), *Green battery solutions for mobile phones and other hand-held information and communication technology devices*.

[ITU-T L.1020] Recommendation ITU-T L.1020 (2018), *Circular economy: Guide for operators and suppliers on approaches to migrate towards circular ICT good and networks*.

[ITU-T L.1021] Recommendation ITU-T L.1021 (2018), *Extended producer responsibility – Guidelines for sustainable e-waste management*.

[ITU-T L.1100] Recommendation ITU-T L.1100 (2012), *Procedure for recycling rare metals in information and communication technology goods*.

[ITU-T L.1400] Recommendation ITU-T L.1400 (2011), *Overview and general principles of methodologies for assessing the environmental impact of information and communication technologies*.

[ITU-T L.1410] Recommendation ITU-T L.1410 (2014), *Methodology for environmental life cycle assessments of information and communication technology goods, networks and services*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 audit [b-ISO/IEC 17000]: Systematic, independent, documented process for obtaining records, statements of fact or other relevant information and assessing them objectively to determine the extent to which specified requirements are fulfilled.

3.1.2 component [b-SBC, 2011b]: Element with electrical or electronic functionality connected together with other components, usually by soldering to a printed wiring board, to create an electronic circuit with a particular function (for example an amplifier, radio receiver, or oscillator).

3.1.3 distributor [b-EU, 2012/19/EU]: Any natural or legal person in the supply chain, who makes an EEE available on the market. A distributor may also be a producer.

3.1.4 electrical and electronic equipment (EEE) [b-EU, 2012/19/EU]: Equipment which is dependent on electric currents or electromagnetic fields in order to work properly and equipment for the generation, transfer and measurement of such currents and fields and designed for use with a voltage rating not exceeding 1 000 volts for alternating current and 1 500 volts for direct current.

3.1.5 e-waste [b-UNEP]: Electrical or electronic equipment that is waste, including all components, sub-assemblies and consumables that are part of the equipment at the time the equipment becomes waste.

3.1.6 generation (of WEEE) [b-UNU, 2014]: The weight of discarded products (waste) due to national consumption from a national territory in a given reporting year prior any activity (collection, reuse, treatment or export).

3.1.7 orphan waste [b-Hester]: Products deposited for recycling that are the responsibility of a company that is either no longer present in the market or has not paid for its recycling.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 circular economy (based on [b-EMcA]): An economy that is restorative and regenerative by design, which aims to keep products, components and materials at their highest utility and value at all times.

NOTE – A concept that distinguishes between technical and biological cycles, the circular economy is a continuous, positive development cycle. It preserves and enhances natural capital, optimises resource yields, and minimises system risks by managing finite stocks and renewable flows. A circular economy works effectively at every scale.

3.2.2 disposal (based on [b-StEP, 2014]): Material that cannot be recycled into raw material for use in manufacture of new electrical and electronic equipment (EEE) or other products would need to be disposed of using other methods, such as energy recovery or landfill.

3.2.3 exporter of WEEE (based on [b-Basel]): Any person under the jurisdiction of the state of export who arranges for waste electrical and electronic equipment (WEEE) to be exported.

3.2.4 extended producer responsibility (EPR) (based on [ITU-T L.1021]): An environmental policy approach in which a producer's responsibility for a product is extended to the post-consumer stage of a product’s life cycle with two related features of that policy: the shifting of responsibility (physically and/or economically; fully or partially) upstream toward the producer and away from municipalities, and to provide incentives to producers to incorporate environmental considerations in the design of their products.

NOTE – EPR is a policy principle to promote total life cycle environmental improvements of product systems by extending the responsibility of the manufacturers of the product to various parts of the entire life cycle of the product, and especially to the take-back, recycling and final disposal of the product.

3.2.5 formal sector (based on [b-PMID]): E-waste represented by that which is regulated by environmental protection laws specifically designed for e-waste.

3.2.6 gate fees (based on [b-Chalmin]): The "exchange value" associated to waste electrical and electronic equipment. It identifies the monetary flow from collection or treatment facilities operators to producer compliance schemes when the e-waste value is higher than management costs, e.g., recovery, recycling, re-use. The inverse money transfer takes place when e-waste management activities generate a net cost for the facility. Some of the factors that concur to determine the gate fee are the potential energy generated, the presence of recoverable materials and the ratio between secondary and primary raw materials price.

3.2.7 illegal traffic (based on [b-Basel]): Any trans-boundary movement of hazardous wastes or other wastes that has not been notified nor received consent, or whose consent has been obtained "through falsification, misrepresentation or fraud"; whose content "does not conform in a material way with the documents" or "that results in deliberate disposal" ([b-Basel], article 9).

3.2.8 lifetime (or residence time) (based on [b-PMID]): The time that electrical and electronic equipment spends at household businesses and the public sector, including the exchange of second hand equipment among and between households, and businesses.

3.2.9 importer of WEEE (based on [b-Basel]): Any person under the jurisdiction of the state of import who arranges for waste electrical and electronic equipment (WEEE) to be imported.

3.2.10 producer (based on [b-EU, 2012/19/EU]): Any natural or legal person, established in a state, who manufactures or markets or resells electrical and electronic equipment (EEE) under his own name or trademark; places on the market of that state, on a professional basis, EEE from a third country or from another state; or sells EEE by means of distance communication directly to private households or to users other than private households in a state, and is established in another state or in a third country.

3.2.11 put-on-the-market (based on [b-EU, 2012/19/EU]): First making available of a product on the market within the territory of a Member State on a professional basis.

3.2.12 recovery (based on [b-EU, 2012/19/EU]): Any operation the principal result of which is waste serving a useful purpose by replacing other materials that 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.

3.2.13 recycling (based on [b-EU, 2012/19/EU]): Any recovery operation by which waste materials are reprocessed into products or materials whether for the original or other purposes. It includes the reprocessing of organic material but does not include energy recovery and the reprocessing into materials that are to be used as fuels or for back-filling operations.

3.2.14 re-use (based on [b-StEP, 2012a]): Re-use of electrical and electronic equipment or its components is to continue the use of it, for the same purpose for which it was conceived, beyond the point at which its specifications fail to meet the requirements of the current owner and the owner has ceased use of the product.

3.2.15 treatment (based on [b-EU, 2012/19/EU]): Recovery or disposal operations, including preparation prior to recovery or disposal.

3.2.16 used electrical and electronic equipment (based on [b-StEP, 2014]): Any electrical and electronic equipment (EEE) that is discarded by the owner as waste with the intention of re-use for the same purpose for which it was conceived, beyond the point at which its specifications fail to meet

the requirements of the current owner and the owner has ceased use of the product. Products could be donated or traded before or in this phase.

3.2.17 waste electrical and electronic equipment (WEEE) (based on [b-EU, 2012/19/EU]): Electrical or electronic equipment which is "Any substance or object which the holder discards or intends or is required to discard" [b-EU, 2008/98/EC], "including all components, sub-assemblies and consumables which are part of the product at the time of discarding".

NOTE – WEEE is a complex mixture of materials and components that because of their hazardous content, and if not properly managed, can cause major environmental and health problems. Moreover, the production of modern electronics requires the use of scarce and expensive resources (e.g., around 10% of total gold worldwide is used for their production). To improve the environmental management of WEEE and to contribute to a circular economy and enhance resource efficiency the improvement of collection, treatment and recycling of electronics at the end of their life is essential.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AC	Alternating Current
CE	Circular Economy
CFC	Chlorofluorocarbons
CRT	Cathode Ray Tube
DC	Direct Current
DVD	Digital Versatile Disc
EEE	Electrical and Electronic Equipment
EHS	Environment, Health and Safety
EPR	Extended Producer Responsibility
EoL	End of Life
e-waste	electronic waste
ICT	Information and Communication Technology
ID	Identifiers
IT	Information Technology
KPI	Key Performance Indicator
LCA	Life Cycle Assessment
LCD	Liquid Crystal Display
PCB	Printed Circuit Board, Polychlorinated Biphenyl
PCS	Producer Compliance Scheme
POM	Put-On-the-Market
ppm	parts per million
RE	Resource Efficiency
RFID	Radio Frequency Identification
StEP	Solving the E-waste Problem
SWOT	Strengths, Weaknesses, Opportunities and Threats

TV Television

UPA Universal Power Adapter

WEEE Waste Electrical and Electronic Equipment

5 Conventions

This Recommendaion uses the following conventions:

Al Aluminium

Ag Silver

Au Gold

Cu Copper

Fe Iron

Pd Palladium

6 Scope for regulation and standardization

This Recommendation aims to draw the attention of policymakers to one of the main environmental problems and economic opportunities of our time: the generation of waste electrical and electronic equipment (WEEE).

The increasing amount of WEEE or electronic waste (e-waste) is still an emerging global environmental threat in terms of management and disposal due to the hazardous components therein. This threat has become more significant over the past two decades in most countries due to the enormous uptake of information and communications technology (ICTs), and specifically with the introduction of mobile telephony and now the recent migration from analogue to digital technologies. The use of ICT equipment and products comes with an known rate at which these gadgets become obsolete due to technology advancements and hence the need to be replaced by their owners which has led to an enormous increase in the generation of related waste.

E-waste is now considered as one of the fastest growing solid waste in the world. In developed countries, it amounts to 1% of total solid waste on average.

The management of e-waste has thus experienced rapid changes in response to a variety of developments which include among others: components used and the need to recover, reuse and recycle; changes in energy consumption associated with both the manufacturing and use of equipment; and the expanding global market for reused and counterfeited/substandard devices. There are a variety of economic, environmental and social factors that influence the end of life (EoL) management of WEEE

There are many reasons why countries should establish or reinforce their e-waste management national systems. According to the European Union (EU) WEEE directive, the appropriate management of WEEE is paramount due to the presence of hazardous substances, such as "mercury, cadmium, lead, hexavalent chromium, polychlorinated biphenyls (PCBs) and ozone-depleting substances" [b-EU, 2012/19/EU]. Consequently, if not treated properly, WEEE could have significant negative environmental, economic, and social effects.

It has been observed, for instance, that improper management of e-waste can have severe effects on human health, causing allergies, respiratory diseases and cancer [b-Puckett]. Furthermore, leaching, open-air burning and heating, as well as uncontrolled discharge of scrap, acids, cyanides and other by-products from processing operations pollute the soil, groundwater and food [b-Terazono]. On the contrary, effective recycling of e-waste has a direct positive impact on the environment, economy and society.

Prevention is paramount as 20-50 million tonnes of e-waste is generated globally each year [b-UNEP, 2013a]. E-waste is one of the fastest growing waste streams in the world. E-waste is also an economic opportunity. Equipment can contain rare metals, including gold, silver, palladium, lithium, ruthenium, antimony, indium and tin [b-UNEP, 2013a], as well as base metals (e.g., copper, lead and zinc). E-waste is a rich source of precious metals compared to primary ores [b-ATMI]. The case is often made that for every ton of ore at a gold mine only 5 g of gold can be extracted, whereas 1 ton of mobile phones can contain up to 400 g of gold [b-SMG]. One ton of used mobile phones (around 6000 handsets) contains approximately 3.5 kg of silver, 340 g of gold, 140 g of palladium and 130 kg of copper. The combined present value is just over $25000. Moreover, one ton of personal computer waste contains more gold than 17 tons of gold ore [b-ATMI].

The extraction of precious and base metals from e-waste is a major economic driver due to their associated value, as summarized in Table 1 [b-ATMI].

Table 1 – Weight vs. value distribution

Weight vs. value distribution %	**Fe (wt%)**	**Al (wt%)**	**Cu (wt%)**	**Plastics (wt%)**	**Ag (ppm)**	**Au (ppm)**	**Pd (ppm)**
TV-board	28%	10%	10%	28%	280	20	10
PCBs	7%	5%	20%	23%	1000	250	110
Mobile phone	5%	1%	13%	56%	1380	350	210
Portable audio	23%	1%	21%	47%	150	10	4
DVD-player	62%	2%	5%	24%	115	15	4
Calculator	4%	5%	3%	61%	260	50	5
Value-share	**Fe**	**Al**	**Cu**	**Sum PMs**	**Ag**	**Au**	**Pd**
TV-board	4%	11%	42%	43%	8%	27%	8%
PCBs	0%	1%	14%	85%	5%	65%	15%
Mobile phone	0%	0%	7%	93%	5%	67%	21%
Portable audio	3%	1%	77%	19%	4%	13%	2%
DVD-player	13%	4%	36%	47%	5%	37%	5%
Calculator	0%	5%	11%	84%	7%	73%	4%

As primary materials are increasingly more difficult and expensive to extract, recycling becomes an attractive option. Recycling would, in fact, contribute to preserving natural resources and move toward more sustainable production practices.

The use of secondary raw materials allows energy savings [b-Cui] and greenhouse gas emission avoidance [b-Khaliq]. For example, recycling 1 kg of aluminium saves 95% of the energy required for primary production as shown in Table 2 [b-Cui].

Table 2 – Recycled materials energy savings over virgin materials

#	Materials	Energy savings (%)
1	Aluminium	95
2	Copper	85
3	Iron and steel	74
4	Lead	65
5	Zinc	60
6	Paper	64
7	Plastics	>80

Furthermore, reuse, refurbishing and recycling offer direct business development opportunities for communities, thus contributing to job creation. On a per-ton basis, sorting and processing recyclables alone generate 10 times more jobs than dumping or incineration. For example, computer reuse and recycling creates 296 more jobs for every 10000 tons of material disposed each year [b-ILSR].

Finally, improving the effectiveness and pervasiveness of national e-waste management systems contributes to counteracting and preventing illegal shipments of e-waste. These flows disproportionately affect developing countries due to the presence of low-cost, low-skilled labour and loose environmental, health and safety (EHS) requirements and controls. According to [b-Gartner], global shipments of electronic devices (personal computers, tablets, ultra-mobiles and mobile phones) were expected to reach 2.5 billion units in 2014, a 6.9% increase since 2013. This equipment will eventually become waste. Therefore, countries must have an appropriate management system in place. Yet, according to a report by the United States Environmental Protection Agency (2008), only 19% of e-waste is recycled whereas 81% is disposed in landfills [b- EPA, 2008].

7 Definition of waste electrical and electronic equipment

E-waste has been defined similarly by different international organizations. The legislations of most countries refer to electrical and electronic equipment (EEE) as "any device that for functional reasons is dependent on electric currents or electro-magnetic fields in order to work properly. It becomes e-waste when the holder discards, intends or requires to discard" [b-Morselli].

The EU defines electrical and electronic equipment as "equipment which is dependent on electric currents or electromagnetic fields in order to work properly and equipment for the generation, transfer and measurement of such currents and fields and designed for use with a voltage rating not exceeding 1000 V for alternating current and 1500 V for direct current" [b-EU, 2012/19/EU].

Solving the E-waste Problem (StEP) refers to e-waste as a term used to cover items of all types of EEE and their parts that have been discarded by their owners as waste without the intention of re-use. The EU defines e-waste (WEEE) as: "any substance or object which the holder discards or intends or is required to discard" [b-EU, 2008/98/EC], "including all components, sub-assemblies and consumables which are part of the product at the time of discarding" [b-EU, 2012/19/EU].

Appendix I contains a list of some definitions that may be used as a reference for policymakers. The term e-waste is generally used interchangeably for both electrical and electronic equipment due to the increasing integration of electronic components into electrical appliances.

It is important to note that the definition includes all types of EEE, as there is no room for regional variance or preference in a global definition; the fact that the item in question meets the definition "with circuitry or electrical components with power or battery supply" qualifies it for inclusion [b-StEP, 2014].

E-waste does not include used EEE as the latter is still considered a commodity. "Reuse of electrical and electronic equipment or its components is to continue the use of it (for the same purpose for which it was conceived) beyond the point at which its specifications fail to meet the requirements of the current owner and the owner has ceased use of the product" [b-StEP, 2014].

Annex A of the aforementioned directive provides an indicative list of categories and types of waste electrical and electronic equipment. However, should policymakers in countries need to prioritize certain types or categories, taking into account their environmental impact and socio-economic relevance, Annex B and D of this Recommendation, can be used as a reference to determine the environmental impact. National statistics and inventories should be used to determine the socio-economic relevance of each category or type of WEEE.

A preliminary nucleus could be constituted, for example, by refrigerators, clothes dryers, washing machines, computers, cathode ray tubes (CRTs) and liquid crystal display (LCD) screens, printers, mobile phones and lamps.

In a subsequent stage, the following e-waste categories could be considered:

– temperature exchange equipment;
– large household appliances;
– fluorescent lamps;
– photovoltaic panels;
– small equipment, especially IT and telecommunication equipment.

8 E-waste management system design

As a preliminary step for the preparation of drafting e-waste management legislation, countries must:

1) identify sources of e-waste generation and compile an inventory of e-waste in the country keeping in view the categorization mentioned in clause 7;
2) consult producers, traders, service operators, academia, industry associations, voluntary producer compliance schemes, municipalities, collection and treatment facilities operators, informal operators (i.e., collectors, dismantlers, recyclers, and scrap dealers), consumer associations and civil society organizations;
3) ensure the availability of public funds to:
    a) Promote cooperation among competent ministries and enforcement agencies (e.g., customs, police);
    b) Organize nationwide, publicly funded awareness-raising campaigns to inform consumers of available e-waste collection points and of the risks that improper handling and management of e-waste may cause to human health and the environment;
    c) Define incentives for adequate collection;
    d) Assess e-waste technologies, practices and skills already available in the country compiling an inventory of:
        • available collection and recycling facilities (name, address and specialization);
        • available repair, dismantling and treatment technology.
4) conduct a survey to assess the level of expertise of personnel in collection and recycling facilities:
    a) Conduct a cost-benefit analysis of different e-waste management system designs, considering economic, environmental and social factors, including potential job creation or suppression in each economic sector involved;
    b) Estimate the size of the informal sector and evaluate the possibility to collaborate with and/or empower them. It is possible to derive the amount of WEEE handled by the informal sector from the estimate of WEEE generated. The latter can be estimated via a "multivariate input-output analysis", including "sales, stock size, stock age composition, lifespan profile, quantity of e-waste generated and e-waste age composition" [b-Wang 2];
    c) Extend the scope of public agencies and authorities to include e-waste;
    d) Establish a register for all stakeholders addressed by the legislation.

Annex C provides a framework for the analysis of strengths, weaknesses, opportunities and threats (SWOT) to assess baseline conditions.

For concrete success stories on e-waste management, [b-ITU-T L.Suppl.27] provides specific case studies for consultation.

9 General legal requirements

In order to comply with extended producer responsibility (EPR) provisions, manufacturers and importers must set up individual producer compliance schemes (PCSs) or join a collective one. Examples of system designs are displayed in Figure 1. See [b-Lazzarinetti].

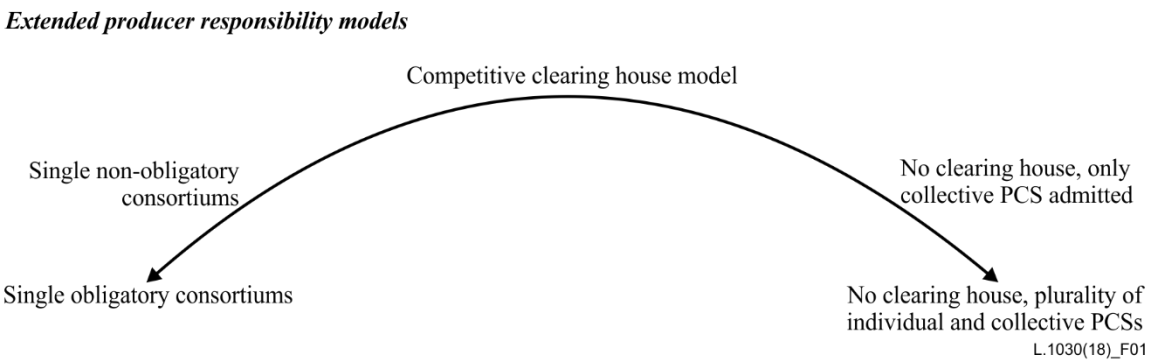

Figure 1 – Extended produce responsibility models

Prior to drafting provisions on producer responsibility, policymakers should decide which system design better suits the country's conditions: a "non-competitive" or more "competitive" one [b-Hester] relative to the number of PCSs operating in the national market that manage the same categories of e-waste equipment.

Single national compliance schemes can either specialize in the management of specific categories of e-waste, and cohabit with a limited number of schemes, or include in their mandate all waste electrical and electronic equipment. In both cases, their membership may or may not be compulsory. These are generally not-for-profit consortiums [b-Hieronymi]. Although these schemes take full advantage of the economies of scale, avoiding duplication [b-Magalini], they risk becoming monopolies, with all the drawbacks this case implies, including higher recycling costs [b-Hester]. It should be noted that the categories of EEE do not necessitate a "one size fits all" approach for effective management through their end of life, but rather specific considerations for similar categories depending on the stakeholders as well as on country/region basis. While benchmarking on international experiences and success stories is important, replicating these may not be feasible especially between developed and developing countries. Different approaches are therefore required for e-waste management of EEE in order to adopt approaches that best fit a situation.

The presence of multiple schemes for the same categories of e-waste can encourage competition and drive recycling costs and fees down [b-Magalini].

To facilitate coordination between compliance schemes in such pluralistic systems, countries could establish a clearing house, a non-profit body, which generally includes representatives of PCSs, but that could also involve government representatives. The clearing house guarantees homogenous and quality operations over all the national territory and it allocates responsibility on e-waste generated among PCSs [b-Jacob]. It might also facilitate agreements between stakeholders and prevent PCSs from selecting and managing only valuable WEEE (also called "cherry-picking") [b-Magalini]. In case the clearing house is run directly by governmental agencies, it might be in charge of setting and enforcing treatment standards [b-UNU, 2009]. In developing countries, the clearing house could also facilitate agreements between state-of-the art treatment facilities and informal operators. Given the extent of its responsibilities, it is advisable that PCSs are compelled to join the clearing house, if present. Otherwise, it might not be able to fully exercise its functions.

Finally, pluralistic systems that lack a clearing house might have higher compliance costs for manufacturers and guarantee only limited access to e-waste stored in collection sites [b-BIS].

PCSs shall submit a feasibility plan to the appropriate authority including at least:

1) proof of adequate financial resources and technical capacity to manage e-waste placed under their responsibility;
2) the operators under contract;
3) the total put-on-the-market (POM) and market share;
4) proof of registration.

PCSs could be encouraged to:

1) manage the scheme's financial resources in a transparent way;
2) pay for the costs incurred in proper e-waste management;
3) fulfil bureaucratic requirements on behalf of their members (e.g., reporting obligations and registration);
4) request operators involved in the network to undertake periodic audits.

If deemed acceptable by all parties involved, and only after consultations, policymakers may set up a public fund to support the nascent e-waste treatment industry.

A fund may also be established to cover the costs of an intermediary association, appointed or established to facilitate collaboration between informal and formal operators.

For more details about the EPR models, [ITU-T L.1021] provides a theoretical background and a number of case studies.

9.1 Use of manufacturer and equipment identifiers

A manufacturer's trademark should be clearly visible on the equipment in a way that would be difficult to remove. It should specify either the name of the producer, the registration number or registered logo. For countries that do not manufacturer, it is important to ensure that imports are from identified manufacturers, and registered with the PCS.

Serial number or other identifiers, including radio frequency identification (RFID) tags, quick response (QR) codes and handle IDs shall also be associated to equipment and components.

Reference could be made to [ITU-T L.1100] standardizing procedure for recycling rare metals in ICT goods. The Recommendation, which details considerations on rare metals contained in ICT goods in all phases of the recycling process, and suggests a communication method and format to provide such information, considers the use of barcodes, vermicides or RFID tags to facilitate the recycling process is [ITU-T L.1100].

Furthermore, policymakers could encourage tracking mechanisms aimed at:

1) tracking equipment from the collection point to the treatment facility;
2) sharing information regarding the equipment through all stages of post-consumption.

9.2 Financing models

Upon consultation with all relevant stakeholders, having analysed the country-specific characteristics (refer to clause 9), policymakers should define clear provisions regarding the financing of e-waste management systems. It is important to note that there is no optimal financing model for all countries. Each country should identify the most appropriate one and adjust it to its needs.

The legislation should specify the following:

1) the stakeholder charged (directly or indirectly) with the payment of the fee,

   for example, manufacturers, importers, customers, final users;
2) the method of calculation of the fee,

for example, market share, return rate of individual producer's products, statically valid sample of the producers' products relative to the total e-waste collected;

3) the time of leverage of the fee, for example,

upon POM, purchase or disposal [b-UNU, 2009].

In addition to the selected financing model, after consulting and obtaining the consensus of the parties involved, countries may consider introducing a provision on financial guarantees. This consists of a deposit made by manufacturers and importers when the EEE is put on the market. The deposit can be made, for instance, in the form of a blocked bank account or a recycling insurance. Financial guarantees can prevent the generation of orphan waste. Hence, they avoid placing additional costs on individual and collective PCSs [b-Ökopol]. Financing models are appropriate for equipment with a long lifespan [b-Lindhqvist]. However, if accountability mechanisms are not in place, and if there is a high risk that the deposit will not be managed transparently this option should be avoided.

Policymakers may decide to place partial or full EoL responsibility on donors of used EEE as well.

9.3 Collection phase

Collection is a key phase in adequate management of e-waste. E-waste legislation should compel consumers to return their EoL equipment through proper channels: authorized permanent collection facilities, collection bins in public areas, retail stores, distributors, manufacturers, or importers. In some cases, it may be necessary to put incentives in place for collection.

Provisions should be made to ensure that manufacturers, importers, retailers and service operators take back e-waste from end users, and transfer it to a designated collection facility or directly to a treatment facility. This obligation should not be extended to small assembler industries if they do not have the financial or the infrastructural capacity to set up a take-back scheme.

Collection facilities must have:

1) impermeable surfaces and drainage systems;
2) decanters, cleanser and degreasers;
3) weatherproof covering;
4) separated areas from other wastes;
5) different unit loads for different categories of e-waste;
6) scales;
7) storage space for equipment containing hazardous substances (listed in Annex B);
8) deposit area for WEEE designed for repair and refurbishment.

Permanent collection facilities should be registered and authorized by the competent authorities.

Policymakers are encouraged to ensure that the number of collection facilities per inhabitant is appropriate.

9.3.1 Distributors' responsibilities

Distributors should be compelled to take back e-waste at the point of sale free of charge, provided the following non-mutually exclusive conditions are met [b-EU, 2012/19/EU]:

1) the sales area is at least 400 m^2 (400 m^2 is a proposed value, different limit can be used taking into consideration the national distribution situation);
2) the product was originally purchased at the store;
3) the distributor sells similar equipment to the one returned;
4) the distributor sells equipment pertaining to the same brand.

Distributors should not be compelled to take back e-waste that would endanger their health.

Distributors are subject to the following minimum obligations:

1) arrange the transportation of e-waste to collection facilities or authorized treatment facilities;
2) inform their customers of the correct means to discharge their EEE at end-of-life.

Distributors should be allowed to comply with their take-back responsibilities individually or collectively. Sensitization of appropriate take back schemes should be done in cases where appreciation is low.

Preferential access to e-waste should be granted to individuals or companies, formal or informal, who intend to repair and sell for reuse WEEE that has not reached its EoL yet.

On-line distributors need to be taken into consideration based on the distributor's volume of sales.

9.3.2 Engaging and handling the informal sector

In many countries, the informal sector is a key stakeholder that policymakers cannot and should not ignore, but should rather empower. It is widely acknowledged that the informal sector should be integrated in the formal e-waste management system. E-waste often represents the only source of sustenance for the underprivileged. However, there is no single solution to this challenge. If deemed acceptable by all parties, public authorities could, for example, facilitate agreements between informal collectors and manual dismantlers, on one side, and authorized recycling facilities, on the other. With such an agreement, the first party would accept to hand over to the second the e-waste collected, after having pre-sorted and manually dismantled it.

There is a need for study towards framing stringent but rational policies in developing nations.

There is also a need to devise specific action plan for reuse of WEEE in the direction of creating "green jobs" for the informal sector. For more details about the recycling in the informal sector, [ITU-T L.1021] will address the accreditation systems for recyclers.

9.4 Processing phase

National e-waste legislation should mandate that WEEE is recycled only if reuse, repair, reconditioning, refurbishing and remanufacturing are not viable, according to the principle of the waste hierarchy.

E-waste processing involves three stages:

1) pre-processing: manual dismantling, i.e., separation and sorting of materials and components for further treatment [b-Blaser]; mechanical dismantling, using, for instance, belts, optical sensors, and metal-separation machines; removal of parts containing hazardous substances (depollution), liquids and gases, as well as easily removable valuable materials;
2) shredding and further mechanical dismantling operations;
3) end-processing: further treatment of segregated components (e.g., PCBs, batteries, plastics, CRTs) through mechanical, chemical, thermal or magnetic processes.

Any facility undertaking treatment of waste electrical and electronic equipment, including components, subparts and supplies should:

1) successfully undertake an independent audit;
2) obtain a licence from the competent authority;
3) have a local/national legislation fulfilment to operate.

Audits should be done regularly, if possible, and they should assess compliance with environmental, health and safety national regulations and international standards, as well as quality and labour standards.

In particular, treatment facilities should at least:

1) remove data, fluids and gases from WEEE;
2) comply with emission limits;
3) decontaminate and dispose by-products properly;
4) provide adequate training for employees;
5) establish a plan to prevent and address spillages;
6) lay out a plan in case the facility must be closed;
7) install a ventilation system; and
8) set up a comprehensive emission control system.

Recycling facility operators must carry out material flow analysis, keeping track of income and outcome flows [b-Blaser]. To this end, reporting obligations must be put in place (see clause 9.6).

9.5 Information responsibility

Policymakers are encouraged to introduce provisions that compel manufacturers, importers and distributors, including those who use distance selling channels, to inform their customers about:

1) their obligation to dispose of WEEE separately from municipal waste;
2) designated collection points and other collection services;
3) environmental and health impact caused by the improper disposal of e-waste [b-EU, 2012/19/EU].

Manufacturers and importers should be encouraged to share repair, reconditioning, remanufacturing and recycling businesses information regarding:

1) key components for dismantling, rare metals, materials, mixed materials;
2) location of hazardous substances, heavy metals and other metals;
3) assembling chain.

The legislation may specify standard submission format and procedure. Reference should be made to [ITU-T L.1100], Appendix II, which provides "example formats for collecting rare metal information".

Provisions leading to the infringement of intellectual property rights shall not be enforced.

9.6 Enforcement mechanisms and sanctions

All actors involved in the commercial handling and management of e-waste in a specific country, including manufactures and importers of EEE, producer compliance schemes (individual and collective), collection facilities, logistics operators, repair and refurbishing businesses, dismantling and recycling facilities, and exporters of WEEE must be registered in a dedicated national register.

In particular, manufacturers and importers, including those selling EEE via distance communication, should be registered to the relevant chamber of commerce prior to introducing the equipment on the national market for consumption. Measures should be put in place to ensure that all EEE imports at the points of entry in countries are registered.

The legislation (or an implementing decree) should indicate the procedure to register.

In particular, manufacturers and importers should be asked to provide at least the following information for registration and reporting:

1) name and address, including code;
2) the quantity, type, origin (domestic or professional), brand (and trade code, if applicable) of products POM;
3) the producer compliance scheme joined or established.

Manufacturers and importers should not be allowed to put their products on the national market prior to registration.

In order to avoid responsibility and duplication of efforts, policymakers are encouraged to identify the public authority responsible for monitoring of producer compliance schemes (individual and collective), collection facilities, logistics operators, dismantling and recycling facilities, and exporters of WEEE.

In particular, it is suggested that regional or local environmental agencies are entrusted with the responsibility to audit and grant licenses to collection facilities, repair and refurbishing businesses, dismantling and recycling facilities for WEEE. On the contrary, authorization to producer compliance schemes should be granted at the national level, by environment agencies.

The legislation can provide for sanctions and incentives to promote the proper handling and management of e-waste, as well as to discourage illegal traffic.

The legislation should specify the procedure for collaboration between:

1) ministries, environmental agencies and enforcement authorities (e.g., customs, police); and
2) chambers of commerce and national enforcement authorities.

9.6.1 Obligations for exporters and importers of used EEE

Exporters and importers should hold a license issued by the country of origin and import authorization from the country of destination.

Import taxes should not be too high, as a high import tax may provide an incentive for illegal action.

Exporters should be compelled to prove that shipments are not destined for disposal or improper treatment.

Systems should be in place with various regulation or standards bodies to approve/accept the products manufactured or imported in the country. Thus, exporters should be requested to accompany the equipment with:

1) a proof of functionality test;
2) a copy of the contract;
3) information regarding the year of production, date of disposal and remaining lifespan;
4) the brand of the equipment.

9.7 Targets and reporting obligations

Policymakers are encouraged to set minimum collection and recovery targets, preferably per category of e-waste (or product), and to identify a clear deadline for their attainment. In particular, collection targets can be calculated on a weight basis, relative to the total WEEE generated (or POM) in a given year, taking into account [b-EU, 2012/19/EU]:

1) the life cycle of different types of WEEE generated in the country; and
2) non-saturated markets.

The EU WEEE Directive introduced the following collection rates: 85% of WEEE generated; 65% of the average weight of EEE placed on the market in the three preceding years [b-EU, 2012/19/EU].

It should be noted, however, that there is no target that may suit every country [b-Wang 2].

The recovery target could be calculated by dividing the weight of input WEEE that enters a recovery, recycling or reuse facility by the weight of WEEE collected. It is advisable to identify a different target for each category of WEEE (%) [b-EU, 2012/19/EU].

Such provisions would not be applicable if reliable statistics or inventories are available.

In order to assess progress toward these targets, minimum reporting obligations must be introduced:

1) manufacturers and importers must report the types and quantities of EEE put on the market;
2) PCSs must report the type and quantity of WEEE collected, specifying whether they have been destined for reuse, recycling or export;
3) collection and treatment facilities must have a material flow monitoring system in place to keep record of input and output waste electrical and electronic equipment, their components, materials and substances [b-EU, 2012/19/EU]. In particular, they should report:
    a) the weight of input WEEE that enters a recovery, recycling or reuse facility;
    b) the weight of output WEEE that exits a recovery, recycling or reuse facility;
    c) the weight of WEEE collected [b-EU, 2012/19/EU].

Quantities shall be measured preferably in weight.

Policymakers are encouraged to set up an online information submission system, managed by a public authority, in parallel to a paper-based one.

In addition, the legislation should clearly specify:

1) a reporting declaration model, to be submitted annually; and
2) a procedure for online reporting.

A selected national agency, e.g., the environment agency, should be entrusted with responsibility to keep a register of the weight of WEEE recovered, as well as its components, materials and substances. The environmental agency should also monitor progress toward minimum collection, reuse and recovery targets.

10 International standards

In order to successfully address e-waste challenges, policymakers are encouraged to adopt international standards.

This Recommendation suggests that policymakers adopt the following ITU-T Recommendations:

10.1 For the detailed aspects of e-waste management:

1) [ITU-T L.1021] Extended producer responsibility: The Recommendation offers a description of the EPR system in dealing with e-waste. The Recommendation details different existing forms of EPR globally, not only in theoretical terms but also with a practical view to their feasibility, challenges and prerequisites.
2) [ITU-T L.1100] Procedure for recycling rare metals in information and communication technology goods: The Recommendation provides information on the recycling procedures of rare metals in ICT goods. It also defines a communication format for providing recycling information of rare metals contained in ICT goods.

10.2 For the minimization/reduction of e-waste/circular economy:

1) [ITU-T L.1000] Universal power adapter and charger solution for mobile terminals and other hand-held ICT devices: This Recommendation sets out technical specifications for a universal charger compatible with a wide variety of consumer electronic devices, reducing waste and improving user convenience. When fully implemented around the world, the new standard will eliminate an estimated 82000 tons of redundant chargers and at least 13.6 million tons of carbon dioxide (CO2) emissions annually [b-ITU-T E-waste].
2) [ITU-T L.1001] External universal power adapter solutions for stationary information and communication technology devices: This Recommendation establishes technical specifications for a universal power adapter (UPA) designed to serve the vast majority of

stationary ICT devices. This Recommendation will substantially reduce the number of power adapters that need to be manufactured by widening their application to more devices. The UPA would benefit from a longer lifetime and reduced energy consumption relative to other adapters. Furthermore, it promotes reuse and reduces the volume of e-waste generated [b-ITU-T E-waste].

3) [ITU-T L.1400] Overview and general principles of methodologies for assessing the environmental impact of information and communication technologies: This Recommendation presents the general principles on assessing the environmental impact of information and communication technologies (ICTs) and outlines the different methodologies that are being developed. The Recommendation also provides some examples of opportunities to reduce the environmental load due to ICT.

4) [ITU-T L.1410] Recommendation ITU- T L. 1410, Methodology for environmental life cycle assessments of information and communication technology goods, networks and services: This Recommendation deals with environmental life cycle assessments (LCAs) of ICT goods, networks and services. It is organized in two parts: Part I: ICT life cycle assessment: framework and guidance; Part II: "Comparative analysis between ICT and reference product system (baseline scenario); framework and guidance". Part I deals with the life cycle assessment (LCA) methodology applied to ICT goods, networks and services. Part II deals with comparative analysis based on LCA results of an ICT goods, networks and services product system, and a reference product system.

5) [ITU-T L.1010] Green battery solutions for mobile phones and other hand-held information and communication technology devices: This Recommendation defines a minimum set of parameters necessary to identify green battery solutions that should be considered by developers/manufacturers to reduce the future environmental impact of battery use. The provision of so-called green batteries is to extend the lifetime of handsets, reduce global resources consumption and preserve the environment.

6) [ITU-T L.1002] External universal power adapter solutions for portable information and communication technology devices: This Recommendation defines the requirements, and provides guidelines on the environmental aspects, of UPA solutions designed for use with portable information and communication technology devices.

7) [ITU-T L.1020] Circular economy: Guide for operators and suppliers on approaches to migrate towards circular ICT goods and networks: Guide for operators and suppliers on approaches to migrate towards circular ICT good and networks: This Recommendation suggests approaches of circular economy for ICT goods and networks. It focuses particularly on the next steps in improving circularity in the operators′ supply chain. The Recommendation provides a guide on how operators could work with their supply chain to improve circular economy (CE) aspects for ICT goods and networks but it does not provide metrics.

10.3 Success stories on e-waste management can be found in:

1) [b-ITU-T L.Suppl.27] Supplement on success stories on e-waste management: This Supplement sheds light on e-waste management success stories in different countries. The Supplement covers different policies, legislation, initiatives, and different stakeholders' involvement (government, private sector, non-governmental organizations (NGOs), and informal sector).

10.4 Others information on minimization/reduction of e-waste/circular economy

1) [b-ITU-T L.Suppl.28] Circular economy in information and communication technology; definition of approaches, concepts and metrics: This Supplement investigates current approaches, concepts and metrics of CE and resource efficiency (RE) and their applicability for the ICT infrastructure goods.

2) [b-ITU-T L.Suppl.20] Green public ICT procurement: This Supplement provides technical guidance to public authorities to improve their procurement practices to purchase green ICT goods and services. To this end, this Supplement collects and presents relevant standards, ecolabels and certifications from different organizations to help public authorities achieve green ICT public procurement practices. The guidance can be also used by private organizations interested in improving their green ICT procurement practise.

11 List of indicators/key performance indicators

a) List of indicators

1) EEE placed on the market (kg/inhabitant);
2) WEEE generated (kg/inhabitant);
3) WEEE exported for reuse (kg/inhabitant) [b-PMID];
4) WEEE exported for recycling (kg/inhabitant).

b) List of key performance indicators (KPIs)

1) WEEE collected through formal channels (kg/inhabitant).

Data related to different categories (or products) of WEEE should be recorded separately.

Annex A

Overview of electrical and electronic equipment properties and their influences on end-of-life management

(This annex forms an integral part of this Recommendation.)

Product property		Unit or indicator	Influences on end-of-life management	Mainly determined by
Intrinsic property	Weight and volume	– kg/unit; – m^3/unit.	– arrangement of collection; – pre-processing technologies.	Product functionality and product design.
	Material composition	– kg/kg; – kg/unit; – material value; – environmental impact score.	– material separation and refinery technologies; – recycling revenue and cost.	
	Material composition (toxics)	– kg/kg; – kg/unit; – environmental impact score.	–requirements for separation and detoxification; –cost of the recycling facilities.	
Extrinsic property	Product price	€/unit	Incentive for reuse.	– product design; – production cost; – marketing strategy.
	Quantity of product sales and stock	Units (or pieces).	Scale of take-back system treatment facilities.	– product function; – market conditions; – socio-economic status.
	Product lifespan	Years	Expected time until product is discarded and the quantities of e-waste generated.	– product design; – technology cycle; – user behaviour; – socio-economic status.

Source: [b-Wang 2]

Annex B

Materials, substances, components and hazardous properties in electrical and electronic equipment

(This annex forms an integral part of this Recommendation.)

Key components for dismantling	Source
CRT glass, PCB (in CRT black-and-white TV set); CRT cone glass, PCB (in CRT color-TV set); insulation materials, compressor (in refrigerators); electromotor (in washing machines); CRT cone glass, PCB (in computer monitor); PCB (in mainframe computer). Other components are: capacitor (electrolyte capacitors, PCB containing capacitors); LCD panel; mother board, battery (e.g., lead acid accumulators, nickel cadmium accumulators, button cells or unsorted batteries); gas discharge lamps; cartridges; speaker, screws, plastics, case, switch, electrical wiring, connectors, floppy disk drive, compact disk drive, hard disk drive and power supply (in waste computers); liquid crystal display; fluorescent lamp; cooling system; plastics; insulation; rubber. Metal rich components: PCB, drives, power supply unit, motors, coils, compressors, getter plates, integrated circuits.	[b-SwitchAsia]
Rare metals:	
Indium, chromium, tungsten, cobalt, manganese, molybdenum, vanadium, yttrium, gallium, arsenic, titanium, neodymium, barium, zirconium, tantalum, among others.	[ITU-T L.1100]; [b-SwitchAsia]
Materials:	
– glass: panel glass, funnel glass, mixed (panel and funnel) glass, glass from LCD panels, flat glass; – plastics: polypropylene, polyethylene, ABS, polycarbonate, Polystyrene, Polyurethane, mixed plastics, other plastics; – iron; – steel; – aluminium; – copper; – wood dust: chipboard, contaminated wood. Other materials: luminescent powder; oil from compressors; chlorofluorocarbons (CFC) R12; CFC R11. Mixed materials: concrete, plastic or metal mix, residual material mixed.	[b-ITU-T L.1100]; [b-SwitchAsia]
Hazardous substances:	
– antimony (antimony trioxide); – asbestos; – americium; – BBP (Butylbenzyl phthalate); – chlorofluorocarbons, HCFC, HFC; – DBP (Dibutylphthalate); – DEHP (2-ethylexyl phthalate); – HBCDD (hexabromocyclododecane); – MCCP (medium- chained chlorinated paraffins);	Annex III to [ITU-T L.1100]; [b-EU, 2008/98/CE]; [b-Wang 1]; [b-Wang 2]; [b-Adediran]; [b-SwitchAsia]

Key components for dismantling	Source
– nonylphenol; – PBB (polybrominated biphenyls); – PBDE (polybrominated diphenyl ethers); – PCB (polychlorinated biphenyls); – PVC (polyvinyl chloride); – SCCP (Short- chained chlorinated paraffins); – TBBA (tetrabromobisphenol-A). Heavy metals and other metals: – arsenic (diarsenic trioxide, arsenic trioxide); – barium; – beryllium (beryllium oxide, beryllium metal); – cadmium; – chromium VI; – lead; – lithium; – mercury; – nickel (dinickel trioxide); – selenium; – zinc sulphide.	
Hazardous properties:	
– explosive; – oxidizing; – flammable; – "sensitizing", harmful, toxic, carcinogenic, infectious, "toxic for reproduction", "mutagenic" (if inhaled, ingested or touched); – corrosive; – releases toxic or very toxic gases in contact with water, air or an acid; – toxic for the environment; – radioactive.	[b-RSC]

Annex C

SWOT analysis of baseline conditions for e-waste system design

(This annex forms an integral part of this Recommendation.)

Table C.1 contains a SWOT analysis of baseline condition for e-waste system design.

Table C.1 – SWOT analysis

Strengths	Weaknesses
– legislation on wastes and hazardous wastes already in place; – stakeholders have been identified and the consultation process launched to inform the definition of a legal framework for e-waste management; – presence of voluntary take-back initiatives, (or programme/projects) and willingness of producers, distributors, service operators to take responsibility for e-waste; – availability of treatment facilities with adequate capacity for managing e-waste; – pre-existent collection infrastructure, logistic network and contractual relationships between manufacturers/importers and waste management operators; – levels of collection, repair, refurbishment, recycling already achieved in both the formal and informal sector; – availability of a market for second-hand electrical and electronic equipment; – availability of public funds for the implementation of the e-waste legislation.	– long hibernation period for EoL electrical and electronic equipment; – poor coordination among ministries, enforcement authorities, between national and local administrations, and between local administrations and voluntary take-back schemes; – lack of awareness; – lack of collection and processing infrastructure and capacity; – inadequate training for recyclers; – dumping of e-waste that could be reused, repaired, reconditioned, remanufactured or recycled or that would require decontamination.
Threats	**Opportunities**
– environmental and health impact of improper processing practices and unregulated disposal of e-waste in landfills; – illegal shipments of e-waste; – illegal shipment of used electrical and electronic equipment nearing their end-of-life.	– job creation in the collection, repair, reconditioning, remanufacturing, recycling, logistics, disposal sector; – revenue generation; – waste prevention; – urban mining, i.e., the recovery of rare metals from "landfills sites, incineration ashes or waste waters" [b-Dodson]; – possibility to either formalize informal operators or facilitate collaboration between the formal and informal sector.

Annex D

Hazardous materials contained in e-waste

(This annex forms an integral part of this Recommendation.)

Table D.1 contains the list of international recognized list of hazardous materials at the publication date. The table can be updated in the future.

Table D.1 – Recognized list of international hazardous materials

Substance	Occurrence in e-waste
Halogenated compounds:	
– PCB (polychlorinated biphenyls)	condensers, transformers, TV enclosures.
– TBBA (tetrabromobisphenol-A); – PBB (polybrominated biphenyls); – PBDE (polybrominated diphenyl ethers).	flame retardants for plastics (thermoplastic components, cable insulation, TV enclosures); TBBA is presently the most widely used flame retardant in printed wiring, TV enclosures; boards and casings, housing of CRT screens.
– CFC	cooling and freezing units, Insulation foam.
– PVC (polyvinyl chloride)	cable insulation.
Heavy metals and other metals:	
– arsenic	small quantities in the form of gallium arsenide in light emitting diodes.
– barium	getters in CRT.
– beryllium	power supply boxes which contain silicon controlled rectifiers and x-ray lenses.
– cadmium	rechargeable Ni-Cd batteries, fluorescent layers (CRT screens), printer inks and toners, photocopying machines (i.e., printer drums).
– chromium VI	data tapes, floppy disks.
– lead	CRT screens, batteries, printed wiring boards, solders.
– lithium	lithium batteries.
– mercury	fluorescent lamps, some alkaline batteries and mercury wetted switches.
– nickel	rechargeable Ni-Cd batteries or Ni-MH batteries, electron guns in CRT.
– selenium	older photocopying machines (photo drums).
– zinc sulphide	interior of CRT screens, mixed with rare earth metals.
Others:	
– toner dust	toner cartridges for laser printers or copiers.
– radioactive substances – americium – asbestos	medical equipment, fire detectors, active sensing elements in smoke detectors. older appliances such as electric heaters, coffee pots, toasters and irons.

Source: [b-Wang 2]

Appendix I

Definitions of waste electrical and electronic equipment

(This appendix does not form an integral part of this Recommendation.)

Reference	Definition
Argentina [b-Buenos Aires]	"Waste electrical and electronic equipment [refers to] electric and electronic equipment discharged or to be discharged, including its components, subparts and supplies, both domestic and professional, from the time of disposal".
Australia [b-ABS]	"Waste electrical and electronic equipment that is dependent on electric currents or electromagnetic fields in order to function (including all components, subassemblies and consumables which are part of the original equipment at the time of discarding)".
[b-Bhuie] and [b-Cairns] in [b-Kahhat]	"Electronic and electrical equipment, including all components, sub-assemblies, and consumables, deemed obsolete or unwanted by a user" ([b-Bhuie], [b-Cairns]), excluding used electrical and electronic equipment [b-Kahhat].
Cameroon [b-Opencamer]	"Equipment which is dependent on electric currents or electromagnetic fields in order to work properly and equipment for the generation, transfer and measurement of such currents and fields and designed for use with a voltage rating not exceeding 1000 volts for alternating current and 1500 volts for direct current".
Canada [b-Canada]	"Surplus electronic and electrical equipment that is not suitable for reuse. Electronic and electrical equipment includes any equipment with a plug, battery or that uses electricity to perform its intended function excluding vehicles and vehicle parts. Electronic assets are considered surplus when they have reached the end of their intended useful life and can no longer be reallocated within a department".
Colombia [b-PCG]	E-waste as "electric and electronic equipment cast away or discarded. It includes all components, supplies and subparts that are part of the product when discharged, unless they are considered hazardous on their own. In this case they would receive treatment foreseen for such wastes".
Costa Rica [b-Costa Rica]	E-waste is "all equipment at end of life, dismantled and discharged whose original function was to transfer signals, data, images, sound and information through telecommunication network, including those provided through television and radio broadcasting network".

Reference	Definition
EU WEEE Directive [b-EU, 2012/19/EU]	electrical or electronic equipment which is "any substance or object which the holder discards or intends or is required to discard" (Directive 2008/98/EC [b-EU, 2008/98/CE), "including all components, sub-assemblies and consumables which are part of the product at the time of discarding".
India [b-MOEF]	"Electrical and electronic equipment means equipment which is dependent on electric currents or electro-magnetic fields to be fully functional".
Information Technology Association of South Africa [b-ITA-PEG]	"Discarded EEE that no longer can be reused and needs to be recycled".
[b-King]	"Electrical and electronic waste is defined as all appliances run by electricity that does not exceed 1000 volts for AC and 1500 volts for DC". It is likely that higher value equipment will be collected and managed directly by manufacturers without even entering official take back systems [b-King].
Malaysia [b-MDOE]	"The SW 110 [code] wastes are defined as wastes from the electrical and electronic assemblies containing components such as accumulators, mercury-switches, glass from cathode-ray tubes and other activated glass or polychlorinated biphenyl-capacitors, or contaminated with cadmium, mercury, lead, nickel, chromium, copper, lithium, silver, manganese or polychlorinated biphenyl".
Mexico [b-SEGOB]	"Electronic waste refers to used, end-of-life products and products that have been withdrawn from the market or discharged, that have been manufactured by the electronic or information technology industry, that are dependent on electric currents or electro-magnetic fields in order to work properly and that have reached the end of their useful life, including accessories, peripherals, raw materials and components that constitute them".
[b-Morselli]	"Any device that for functional reasons is dependent on electric currents or electro-magnetic fields in order to work properly. It becomes e-waste when the holder discards, intends or requires to discard".
OECD EPR Guidance Manual [b-OECD]	"Any appliance using an electric power supply that has reached its end-of-life".
Partnership for Action on Computing Equipment (PACE) [b-SBC, 2011b]	"End-of-life computing equipment: Individual computing equipment that is no longer suitable for use, and which is intended for dismantling or final disposal. It also includes off-specification or new computing equipment which has been sent for material recovery and recycling, or final disposal".
Peru [b-MINAM]	Electrical and electronic equipment are equipment that depend on electric currents or electromagnetic fields in order to work properly, and devices used to generate, transmit and measure such currents and fields.

Reference	Definition
Republic of South Korea [b-Eco-Frontier]	Electrical and electronic equipment is "equipment or device (including components and parts thereto) operated by electric currents or electromagnetic fields."
[b-SINHA]	"An electrically powered appliance that no longer satisfies the current owner for its original purpose".
Solving the E waste Problem (StEP) Initiative [b-StEP, 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 without the intention of reuse".
Turkey (Regulation n.28300) [b-Turkey]	Waste electrical and electronic equipment refers to all components, items and consumables contained in the products at end-of-life. EEE is defined as equipment, devices, appliances which are designed to operate on alternating currents of up to 1000 Volt and direct currents of up to 1500 Volt, and which are dependent on electrical power or electromagnetic fields to work properly. The term includes also the equipment used for production, transfer and measurement of such currents.
United Nations Environment Programme [b-UNEP, 2013b]	"Discarded computers, office electronic equipment, entertainment device electronics, mobile phones, television sets and refrigerators. This definition includes used electronics which are destined for reuse, resale, salvage, recycling, or disposal".
United States Congressional Research Service [b-EPA, 2013]	"E-waste refers to obsolete, broken, or irreparable electronic devices".
[b-Widmer]	"Electronic waste or e-waste for short is a generic term embracing various forms of electric and electronic equipment that have ceased to be of any value to their owners".
Africa [b-Africa]	"Anything that works with electricity or batteries and you no longer need it or it is no longer working".

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