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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

Guidelines for developing a sustainable e-waste management system

ITU-T L-series Recommendations – Supplement 4

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 element (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.

Supplement 4 to ITU-T L-series Recommendations

Guidelines for developing a sustainable e-waste management system

Summary

Supplement 4 to the L series of Recommendations 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 framework, collection mechanisms, financial mechanisms and engagement with all relevant stakeholders.

It has been developed in response to WTSA Resolution 79 (Dubai, 2012), which instructs ITU-T Study Group 5 to develop guidelines for developing an adequate e-waste management system for telecommunications and ICT equipment as well as to respond to Plenipotentiary Resolutions 182 and 200 (Busan, 2014).

Edition 2 introduces minor editorial updates to the Supplement.

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* To access the Recommendation, type the URL http://handle.itu.int/ in the address field of your web browser, followed by the Recommendation's unique ID. For example, http://handle.itu.int/11.1002/1000/11830-en.

FOREWORD

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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.

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Table of Contents

Supplement 4 to ITU-T L-series Recommendations

Guidelines for developing a sustainable e-waste management system

1 Scope

This Supplement 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, collection mechanisms, financial mechanisms and engagement with all relevant stakeholders.

2 Definitions

2.1 Terms defined elsewhere

This Supplement uses the following terms defined elsewhere:

2.1.1 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.

2.1.2 component [b-SBC, 2011]: 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).

2.1.3 discarded [b-StEP, 2014]: It is the critical point at which the potential nature of the item changes from a useful product to that of waste". It does not include equipment which "can be directly re-used by someone else for the same purpose for which the product was originally designed [b-StEP, 2014].

2.1.4 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 1000 volts for alternating current and 1500 volts for direct current.

2.1.5 disposal [b-StEP, 2014]: Material that cannot be recycled into raw material for use in manufacture of new EEE or other products would need to be disposed of using other methods, such as energy recovery or landfill.

2.1.6 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.

2.1.7 formal sector [b-PMID]: Represents the e-waste that is regulated by environmental protection laws specifically designed for e-waste.

2.1.8 gate fees [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.

2.1.9 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).

2.1.10 illegal traffic [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).

2.1.11 lifetime (or residence time) of electrical and electronic equipment [b-PMID]: The time the equipment spends at household, businesses and the public sector is called the lifetime or residence time. This includes the exchange of second hand equipment among and between households, and businesses.

2.1.12 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.

2.1.13 put-on-the-market [b-EU, 2012/19/EU]: First making available of a product on the market within the territory of a […] State on a professional basis.

2.1.14 producer [b-EU, 2012/19/EU]: any natural or legal person, established in a state, who manufactures or markets or resells 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.

2.1.15 recovery [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.

2.1.16 recycling [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.

2.1.17 re-use [b-StEP, 2012a]: Re-use of electrical and electronic equipment or its components is to continue to 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.

2.1.18 treatment [b-EU, 2012/19/EU]: Recovery or disposal operations, including preparation prior to recovery or disposal.

2.1.19 used electrical and electronic equipment [b-StEP 2014]: Any electrical and electronic equipment 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".

2.1.20 waste electrical and electronic equipment: "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" [b-EU, 2012/19/EU].

2.2 Terms defined in this Supplement

This Supplement defines the following terms:

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

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

3 Abbreviations and acronyms

This Supplement uses the following abbreviations and acronyms:

AC	Alternating Current
Al	Aluminium
Ag	Silver
Au	Gold
CFC	Chlorofluorocarbons
CRT	Cathode Ray Tube
Cu	Copper
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
EU	European Union
Fe	Iron
ID	Identifiers
IT	Information Technology
MOEF	Ministry of Environment and Forests
PCB	Printed Circuit Board, Polychlorinated Biphenyl
PCS	Producer Compliance Scheme
Pd	Palladium
POM	Put-On-the-Market
ppm	parts per million
QR-Code	Quick Response-Code
RFID	Radio Frequency Identification
StEP	Solve the E-waste Problem
TV	Television
UNEP	United Nations Environment Programme
UNU	United Nations University
UPA	Universal Power Adapter
US-EPA	United States-Environmental Protection Agency
WEEE	Waste Electrical and Electronic Equipment

4 Scope for regulation and standardization

This Supplement draws the attention of policy makers to one of the main environmental problems and economic opportunity of our time: the generation of waste electrical and electronic equipment (WEEE).

Manifold are the reasons why countries should establish or reinforce their e-waste management national systems. According to the European Union 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 environmental, economic, and social negative effects.

It has been observed, for instance, that improper management of e-waste can have severe effects on the human health, causing allergies, respiratory diseases and cancer [b-Puckett]. Furthermore, leaching, open air burning and heating, as well as the uncontrolled discharge of scrap, acids, cyanides and other by-products from processing operations pollute the soil, groundwater and food [b-Terazono]. On the contrary, the 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. In developed countries, it amounts to 1% of total solid waste on average.

The increasing "market penetration" in developing countries, "replacement market" in developed countries, and "high obsolescence rate" make e-waste one of the fastest growing waste streams. [b-UNEP, 2007].

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 per every ton of ore at a gold mine only 5g of gold can be extracted, whereas 1 t of mobile phones can contain up to 400 g of gold [b-SMG]. One ton of used mobile phones (around 6,000 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 $25,000. Moreover, one ton of waste personal computers 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 below [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%

Table 1 – Weight vs. value distribution

Weight vs. value distribution %	Fe (wt%)	Al (wt%)	Cu (wt%)	Plastics (wt%)	Ag (ppm)	Au (ppm)	Pd (ppm)
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 towards more sustainable production practices.

Furthermore, 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 below [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, 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 10,000 t of material disposed each year [b-ILSR].

Finally, improving the effectiveness and pervasiveness of national e-waste management systems contributes to counteract and prevent illegal shipments of e-waste. These flows affect disproportionately developing countries, due to the presence of low-cost, low-skilled labour force 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) are 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].

5 Definition of waste electrical and electronic equipment

There is no internationally agreed definition of waste electrical and electronic equipment (WEEE). Most countries' legislations 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]. Appendix I contains a list of definitions that may be taken as a reference for policy-makers. 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.

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].

The European Union 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].

It defines waste electrical and electronic equipment as EEE that is waste, i.e., "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 III of the aforementioned directive provides an indicative list of categories and types of waste electrical and electronic equipment. However, should policy makers in countries need to prioritize certain types or categories, taking into account their environmental impact and socio-economic relevance, Appendix II and III of this supplement, 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, CRT and 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.

6 E-waste management system design

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

1) Identify sources of e-waste generation and compile an inventory of e-waste in the country.
2) Consult producers, traders, service operators, 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 collection points for their waste equipment and of the risks that improper handling and management of e-waste may cause to human health and the environment.
    c) 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 destruction in each economic sector involved.

   b) Estimate the size of the informal sector and evaluate the possibility to collaborate with it. 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.

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

7 General legal requirements

In order to comply with extended producer responsibility 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[b-Lazzarinetti].

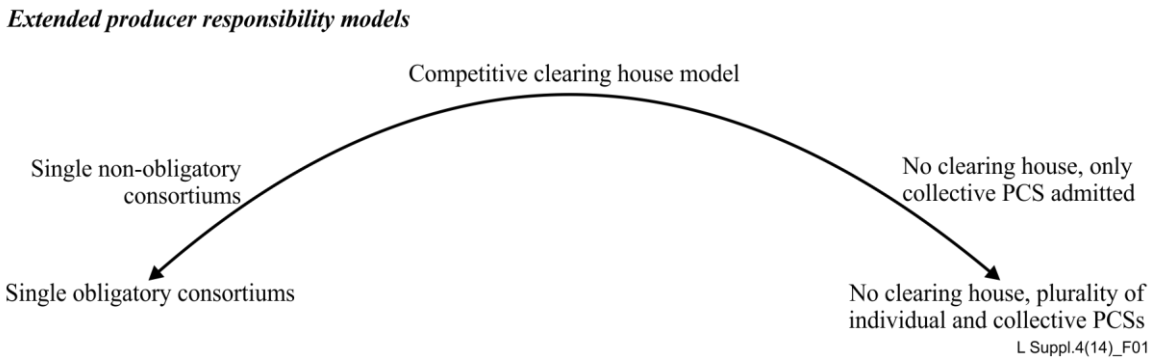

Figure 1 – Extended produce responsibility models

Before drafting provisions on producer responsibility, policy makers should decide which system design suits better the country's conditions: a "non-competitive" or more "competitive" one [b-Hester] relative to the number of PCSs operating on 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].

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

In order 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 all over the national territory and it allocates responsibility on e-waste generated among PCS [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 exercise fully 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 to the appropriate authority a feasibility plan 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 audits to operators involved in the network.

If deemed acceptable by all parties involved, and only after consultations, policy-makers 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.

7.1 Use of manufacturer and equipment identifiers

Manufacturers' 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.

Serial number or other identifiers, including RFID tags, QR codes and Handle IDs shall also be associated to equipment and components.

Reference could be made to [b-ITU-T L.1100] standardizing procedure for recycling rare metals in information and communication technology 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 [b-ITU-T L.1100].

Furthermore, policy makers could encourage tracking mechanisms aimed at:

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

7.2 Financing models

Upon consultation with all relevant stakeholders, having analysed the country-specific characteristics (refer to clause 8), policy makers 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;

   e.g.,: manufacturers, importers, customers, final users;

2) the method of calculation of the fee;

   e.g.,: 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;

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

On top of 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 in a deposit made by manufacturers and importers upon putting the EEE 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]. They 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.

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

7.3 Collection phase

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.

Provisions should be made to ensure that manufacturers, importers, retailers and service operators take back e-waste from final 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 Appendix III)
8) deposit area for WEEE destined to repair and refurbishment.

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

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

7.3.1 Distributors responsibilities

Distributors should be compelled to take back e-waste at the sales point 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 in consideration the national distribution situation);
2) the product has been 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.

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 end of life yet.

On-line distributors each need to be considered based on the distributor's volume of sales.

7.3.2 Engaging and handling the informal sector

In many countries the informal sector is a key stakeholder that policy-makers cannot and should not ignore. It is widely acknowledged that the informal sector should be integrated in the formal e-waste management system. Indeed, 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, where 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.

7.4 Processing phase

The national e-waste legislation should mandate that WEEE is recycled only if reuse, repair, reconditioning 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 reiterated 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

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 (refer to clause 7.6).

7.5 Information responsibility

Policy makers 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 with 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 [b-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.

7.6 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 refurbish 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.

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 a duplication of efforts and buck-passing, policy makers are encouraged to identify the public authority responsible for the 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 environment agencies are entrusted with the responsibility to audit and grant licenses to collection facilities, repair and refurbish 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 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.

7.6.1 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 to provide incentives for illegal smuggling.

Exporters should be compelled to prove that the shipment is not destined for disposal or improper treatment.

Exporters should be requested to accompany the equipment with:

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

7.7 Targets and reporting obligations

Policy-makers 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 nor inventories are available.

In order to assess progress towards 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.

Policy-makers 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 the responsibility to keep a register of the weight of WEEE recovered, as well as its components, materials and substances. The environment agency should also monitor progress towards minimum collection, reuse and recovery targets.

8 International standards

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

This Supplement suggests policy-makers adopt the following ITU-T Recommendations:

1) [b-ITU-T L. 1000], (Universal power adapter and charger solution for mobile terminals and other hand-held ICT devices) 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 82.000 tons of redundant chargers and at least 13.6 million tons of CO2 emissions annually [b-ITU-T E-waste].
2) [b-ITU-T L.1001] (External universal power adapter solutions for stationary information and communication technology devices) establishes technical specifications for a universal power adapter (UPA) designed to serve the vast majority of stationary ICT devices. The standard 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].

9 List of indicators

1) EEE Put on the Market (kg/inhabitant)

2) WEEE generated (kg/inhabitant)

3) WEEE collected through formal channels (kg/inhabitant)

4) WEEE exported for reuse (kg/inhabitant) [b-PMID]

5) WEEE exported for recycling (kg/inhabitant).

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

Appendix I

Definitions of waste electrical and electronic equipment

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 1 000 volts for alternating current and 1 500 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".

Reference	Definition
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".
EU WEEE Directive [b-EU, 2012]	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".

Reference	Definition
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.
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".

Reference	Definition
[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".

Appendix II

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

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]

Appendix III

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

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.	[b-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; 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);	Annex III to [b-ITU-T L.1100]; [b-EU, 2008/98/CE]; [b-Wang 1]; [b-Wang 2]; [b-Adediran]; [b-SwitchAsia]

Key components for dismantling:	Source
– HBCDD (hexabromocyclododecane); – MCCP (medium- chained chlorinated paraffins); – 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]

Appendix IV

SWOT analysis of baseline conditions for e-waste system design

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 of 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; – legal 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.

Appendix V

Hazardous materials contained in e-waste

The table contains the list of international recognized list of hazardous materials at the publication date. The table can be update in future.

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
– chlorofluorocarbon (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

Substance	Occurrence in e-waste
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]

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