End-of-life management for ICT equipment

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Executive summary

The growing volumes of end-of-life (EOL)and near end-of-life ICT equipment around the globe is becoming a matter of concern, particularly as ICT equipment is characterized by high demand and a relatively short life-span. The failure to close the loop on e-waste leads not only to significant adverse environmental impacts, but also to the systematic depletion of the resource base of secondary equipment.

This document provides a definition of EOL management of ICT equipment, an outline of the various EOL stages (and accompanying legislation that applies to the stages), and a checklist that assists an organization in creating a framework for environmentally-sound management of EOL ICT equipment.

When equipment no longer satisfies the initial user's needs, we should not assume that it is in poor operational condition or has become obsolete. Instead, it may be possible to extend its life through use for the same purposes by other users. Or, it can be reused (in part or whole) for other purposes. Or, the materials contained within it can be recovered and recycled.

Decisions relating to whether the life of a piece of equipment can be extended starts with its owner, but extends to a large group of stakeholders who deal with the manufacture, transport, reuse, refurbishment, recycling, and disposal of ICT equipment.

Once it is decided that a piece of equipment is waste, it helps to apply a "waste hierarchy" to minimize the generation of waste. This requires using alternatives such as waste prevention, reduction, reuse, recycling and recovery of equipment before considering the possibility of disposal. Alongside these issues are related management issues, such as valuing the EOL assets and dealing with the security of the data that might be stored on those assets. A check-list is provided as a guide so that each of the EOL stages are dealt with, and not overlooked.

The document provides guidance for the recovery and recycling of materials contained in ICT equipment, and also discusses issues surrounding the use of conflict minerals in the context of clean supply chains.

Ultimately, for many organizations, their actions on EOL and e-waste are often tied to the choices they make regarding corporate social responsibility. In effect, smart management of their EOL assets can help them fulfil their duty to society. But, such actions should also lead to competitive business opportunities.

The toolkit

This document on End- of-life management of ICT equipment is part of a set of documents that together form the Toolkit on environmental sustainability for the ICT sector. The toolkit is the result of an ITU-T initiative, carried out together with over fifty partners, which provides detailed support on how ICT companies can build sustainability into the operations and management of their organizations. The documents in the toolkit cover the following:

- *Introduction to the toolkit*
- *Sustainable ICT in corporate organizations*, focusing on the main sustainability issues that companies face in using ICT products and services in their own organizations across four main ICT areas: data centers, desktop infrastructure, broadcasting services and telecommunications networks.
- *Sustainable products*, where the aim is to build sustainable products through the use of environmentally-conscious design principles and practices, covering development and manufacture, through to end-of-life treatment.
- *Sustainable buildings*, which focuses on the application of sustainability management to buildings through the stages of construction, lifetime use and de-commissioning, as ICT companies build and operate facilities that can demand large amounts of energy and material use in all phases of the life cycle.
- *End-of-life management*, covering the various EOL stages (and their accompanying legislation) and provides support in creating a framework for environmentally-sound management of EOL ICT equipment.
- *General specifications and key performance indicators*, with a focus on the matching environmental KPIs to an organization's specific business strategy targets, and the construction of standardized processes to make sure the KPI data is as useful as possible to management.
- *Assessment framework for environmental impacts*, explores how the various standards and guidelines can be mapped so that an organization can create a sustainability framework that is relevant to their own business objectives and desired sustainability performance.

Each document features a discussion of the topic, including standards, guidelines and methodologies that are available, and a check list that assists the sustainability practitioner make sure they are not missing out anything important.

1 Introduction

Nowadays ICT equipment is characterized by high demand and relatively short life-span. The growing volumes of end-of-life and near-end-of-life ICT equipment around the globe is becoming a matter of concern. That is why it is important to specifically consider the end-of-life (EOL) management of ICT equipment, in particular, its aspects dealing with the sustainable use and disposal methods. End-of-life electronic and electrical equipment or e-waste is often viewed from a negative angle as simply another waste problem causing environmental and health adverse impacts, if not dealt with appropriately. However, the enormous impact of ICT equipment on resources is widely overlooked.

The failure to close the loop on e-waste leads not only to significant adverse environmental impacts, but also to the systematic depletion of the resource base of secondary equipment. Even though telecommunications is an industry of considerable energy consumption, it can also be a potential source of environmental benefits. Thus, it is critical to identify the key factors of success for the minimization and control of negative environmental impacts. This includes impacts generated by potentially inadequate solutions that could also represent contradictions to today's governmental environmental targets and standards, as well as to global trends and efforts specific to the ICT industry.

This document on End-of-life management is part of the ITU-T's Toolkit on environmental sustainability for the ICT sector.

1.1 Target audience

The target audience of this document are public and private organizations that manufacture, possess, commercialize, or use ICT equipment as part of their final product, offer services or as part of their functional infrastructure to transmit, support or deliver those services, products and supply chain.

The document provides a definition of the end-of-life management of ICT equipment and e-waste, followed by a description of EOL stages for ICT equipment and the applicable legislation. This ensures proper procedures and apportions responsibility to the stakeholders involved in the EOL through the provision of a checklist with specific questions and pointers for an environmentally sound management of EOL ICT equipment.

This document lists basic and minimum requirements for the EOL management that the actors engaged in this field should comply with, thus offering an important tool for decision-making for the EOL stage of the management of ICT equipment. It also introduces the reader to today's global efforts on the development of a clean supply chain and conflict minerals for ICT equipment as well as a brief description of the socio-economic issues.

Finally, this document describes the existing off-setting opportunities, possibilities for the development of future markets and several success stories on the reuse, refurbishing and recycling of ICT equipment.

1.2 Objectives

First, this document aims to give directions on how to find an environmentally sustainable solution for EOL equipment by providing a checklist that allows full monitoring of the decisions made in relation to ICT EOL management practices. For this purpose this document is designed to:

- describe the EOL management stages for ICT equipment and their hierarchy based on the principle of waste prevention (e.g. reuse, recycle, recovery, refurbishment, disposal) in order to protect human health, the environment as well as to support sustainable development;
- identify key challenges, opportunities and limitations faced by an EOL management provider at the different stages of ICT equipment management.

Secondly, this document aims to present different initiatives relevant to the EOL management which may be of interest to different companies, associations and other interested organizations (e.g. operators, manufacturers as well as end-users) and which may prove to be useful when looking for an EOL management solution. Such a solution should not only support the economic growth but also take into consideration the extended responsibility of producers and generators in relation to their ICT equipment on the local, national, regional and global scale.

This document identifies social, economic and environmental aspects related to the EOL management of ICT equipment.

Finally, this document intends to illustrate how the end-of-life management and its environmental aspect can be integrated into the design process as part of the life-cycle approach within the framework which is developed by the ITU-T Study Group 5 (SG 5).

2 End-of-life management

2.1 Definition of end-of-life for ICT equipment

Equipment reach its end-of-life once it becomes dysfunctional for the owner/user, becoming what some classify as waste for the particular need the user has, according to Morselli et al., 2006. The Basel Convention[1] on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (the 'Basel Convention') defines waste as substances or objects which are disposed of or are intended to be disposed of or are required to be disposed of by the provisions of national law.

However, when the equipment no longer satisfies the initial user's need, this does not necessarily mean that it is in poor operational condition or has become obsolete. On the contrary, this could be an opportunity for its life to be extended by either being used for the same purposes by other users whose needs can be satisfied with this equipment, or by reusing the equipment or its parts and components, in which case it is necessary to dismantle the equipment to recover its parts. It is also possible to extend the use of the material contained within it through part, component or material recovery and recycling, better known as the end-of-life management of ICT equipment.

Decisions related to extending the life of ICT equipment or choosing providers for ICT EOL practices belong to the owner or possessor who will decide to carry out this work on its own or commission a specialized company.

Whether the decision is made to either extend the life of equipment or to proceed with recovery and recycling, it must be done in compliance with environmentally sound management practices and techniques. In this regard, it is important to ensure that the service provider possesses high environmental performance capabilities.

Thus, it is important to employ the best available techniques and environmental practices for EOL of ICT equipment, which will determine the success of an environmentally responsible and sustainable outcome, without compromising economic goals. This also applies to the end-user equipment which needs to enter the collection system for the environmentally sound management reuse, recycling and disposal.

The end-of-life management of ICT equipment provides for different options offered to ICT users regarding how to recover value, securely remove data and dispose their equipment in a responsible and sustainable manner. However, end-of-life management should not be mistaken for end-of-use of ICT equipment which

[1] See Annex II of this document.

is no longer used as intended by the previous owner, but may be fully functional and used appropriately by others.

It is advisable to conduct a functionality test, as suggested in ***Annex I:*** *Table 1: Example of functionality tests for used computing equipment*, as it can help to determine the best available options for either the extension or end-of-life treatment according to the state of the particular item.

One should bear in mind that in certain cases the entire item may not be considered in good operational conditions; however, its parts and components would, most of the time be in a good operational condition, which can be determined by running specific tests, usually in specialized facilities. To treat those parts and components as waste and directly dispose of them may be detrimental to the environment and a potential economic loss. There is an ongoing work as per Decision BC-10-3 of the Basel Convention to provide legal clarity of terms related to the implementation of the Basel Convention, including waste/non-waste, second hand goods, used goods, reuse, direct reuse.

Certain ICT products use complex technology and require more specialized testing methodologies that may be not available for general use. Telecommunication base stations and commercial mass storage systems are typically recovered directly by the manufacturer or through their trusted specialist decommissioning companies from around the world.

Transboundary movements of functional used ICT equipment destined for reuse (and not for operations listed under section B of Annex IV of the Basel Convention) are usually not subject to the control procedures of the Basel Convention (see 2.1 for more information). Under the Basel Convention certain Parties consider ICT equipment destined for repair, refurbishment or downgraded to waste, while others do not. If one of the countries concerned considers this equipment to be waste, the procedures on transboundary movements of e-waste should be followed.

Currently, technical guidelines on transboundary movements of e-waste are being developed by the Basel Convention Secretariat which, when adopted by the Conference of the Parties to the Basel Convention, will provide clear guidance on procedures for transboundary movements of used e-equipment and e-waste for different purposes.

Some argue that adding procedures, whether voluntary or mandatory, that aim to prevent illegal traffic of e-waste would add cost, time and resources needed for good management and performance. However, clear and predictable rules would reduce the risks associated with uncertainty for companies which transport in good faith used goods intended for resource recovery, recycling, disposal, etc., and would discourage producers or other players who look for "easier" solutions.

2.1.1 Definition of environmentally sound management of e-waste

There are a number of definitions of e-waste used by various institutions and organizations; however, for the purpose of this document, the definition of e-waste would be the one suggested by Morselli, et al. in their 2009 publication "*Waste Recovery, Strategies, Techniques and Applications in Europe*" that reads as follows:

> ***E-WASTE:*** *"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".*

Other definitions of e-waste include:

> "Waste electrical and electronic equipment' or 'WEEE' means electrical or electronic equipment which is waste within the meaning of Article 1(a) of Directive 75/442/EEC, including all components,

subassemblies and consumables which are part of the equipment at the time of discarding (EU WEEE Directive (EC/2002/96)).

Electrical and electronic equipment that is no longer suitable for use or that the last owner has discarded (Guidance Document on the Environmentally Sound Management of Used and End-of-Life Computing Equipment, Partnership for Action on Computing Equipment (PACE)).”

The question of whether the ICT equipment is to be considered functional or waste is of fundamental importance to all stakeholders dealing with the manufacturing, transport, reuse, refurbishment, recycling, disposal of ICT equipment as the control measures set up by the relevant legal regimes differ for functional product or equipment and waste. In the case of ICT equipment, there are challenges to determine whether/when the equipment should be considered waste. Therefore, the technical guidelines on transboundary movements of e-waste, as referred to in subsection 1, aim to give guidance on how to clarify this issue. One important aspect of the transformation of equipment into waste is the intent of its owner. If equipment is disposed of, intended to be or required to be disposed of using one of the operations listed in parts A or B of Annex IV of the Basel Convention[2], this equipment will be defined as waste, and its transboundary movements shall be subject to the Basel Convention[3] control procedure. Companies in the ICT sector may choose to engage a specialized asset management company to evaluate the equipment and to certify ICT equipment as waste, if necessary. For further clarification, one may contact the Basel National Competent Authorities with questions regarding the classification of the equipment as waste (for the purpose of transboundary movements) and any relevant national definitions of waste.

In addition to the requirements of the Basel Convention, one must pay special attention to the applicable national legal framework, in particular instances where the Basel Convention provisions (e.g. the definition of “waste”) are further elaborated in the relevant rules and regulations, or where additional requirements are established concerning procedures for transboundary movements (as permitted under paragraph 11 of article 4 of the Convention). The following specific elements may be taken into account at the national level:

- The equipment or its components can be reused for the item’s original purpose;
- There is a market or demand for the equipment or its components and the equipment satisfies the technical requirements of the industry;
- The reuse of the equipment complies with the applicable requirements and does not lead to environmental or social risk;
- Contributes to climate change prevention by reducing and mitigating the effects of gas emissions;
- The market that demands the equipment or components for reuse or recycling has in place policies and legislations to control and ensure environmentally sound EOL management practices;
- The reuse or recycling of the equipment or components has no adverse effects on human health and the environment and no negative impact on economic growth and the development of healthy markets.

2.2 General description of the end-of-life management chain for ICT equipment

Once it is established that the equipment has become waste, the reverse supply chain that will allow a proper and environmentally sound management of e-waste is recommended. This process consists of three main subsequent steps:

1. The first fundamental step is identification and collection (categorized into 6 steps in the next section). The aim is to ensure that wastes that are generated are dealt with appropriately, whether that is for

[2] See Annex II of this document.

[3] For more information on the Basel National Competent Authorities visit the website: www.basel.int/Countries/CountryContacts/tabid/1342/Default.aspx.

final disposal or recycling. Particular attention should be given as to where and how waste is generated, collected and can undergo a proper treatment process. Appliances in use can indeed acquire the status of waste due to their technical specifications related to life-time, requests for new functionalities or failure (e.g. in the case of infrastructures), as well as due to consumer behaviour (e.g. in the case of end-user equipment, such as mobile phones). It is crucial to distinguish between waste generated and waste actually collected (for instance, consumers may choose to keep discarded appliances in drawers), and to highlight that distinction in each of the subsequent steps of the end-of-life management chain. Improper management could occur as a result of the stakeholders' improper behaviour as well as a lack of the appropriate technical infrastructure of the reverse supply chain.

2. After identification and collection, e-waste should enter a plant where sorting, dismantling and pre-processing (sometimes called just pre-processing) occurs; the aim is to liberate and direct e-waste to environmentally sound subsequent treatment processes. Hazardous substances have to be removed (the so-called "de-pollution phase") and stored or treated safely while components/materials that may be reused or recycled need to be taken out for reuse or to be directed to efficient recovery processes. This step could indeed include preparation for reuse and refurbishment activities for suitable components or appliances.

3. At the final phase, end-processing occurs for those fractions or components that are not destined for reuse. The aim is to ensure that final recovery of material is taking place (or safe disposal of hazardous components/substances), in order to ensure that raw materials are re-entering the economic cycle as new products.

The efficiency of the entire reverse supply chain and its ability to meet social, economic and environmental needs depends on the efficiency of each step and on how well the interfaces between these interdependent steps are managed. This means that all stakeholders involved in the different steps should properly interact and all responsibilities should be clearly defined.

In order to enhance the perception of sustainability within the EOL management, it is also important to look at the complexity of the structure of the ICT sector and its dynamics. Doing so will prevent overlooking opportunities that can arise when creating a closed loop cycle between the design of products or equipment and their disposal as a part of a global sustainable ICT solution.

There are companies that can perform either some or all of the processes associated with the EOL management of e-waste within their facilities. There are two considerations to be taken into account:

- The removal of hazardous components or substances. This is often done during the so-called the de-pollution phase and, sometimes, in specific high-tech processes as part of the downstream activities.
- The separation and recovery of the maximum possible amount of the main recyclable fractions (e.g. ferrous metals, copper, aluminium, glass, plastics), which is carried out in the pre-processing phase as well as in the further refining processes as part of the downstream activities.

2.2.1 Transboundary movements of hazardous wastes and other wastes

The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (the 'Basel Convention') was adopted on 22 March 1989 and entered into force on 5 May 1992. As of today, the Basel Convention has 178 Parties. The Basel Convention aims to protect human health and the environment against the adverse effects which may result from the generation and management of hazardous and other wastes. It emphasizes, amongst other principles, environmentally sound management (ESM) of hazardous and other wastes. ESM is defined as taking all practicable steps to ensure that hazardous wastes or other wastes are managed in a manner which will protect human health and the environment against the adverse effects which may result from such wastes. The Convention stipulates a number of specific requirements, including the following:

- the minimization of the generation of hazardous and other wastes;

- the reduction of transboundary movements of hazardous and other wastes subject to the Basel Convention to the minimum consistent with the environmentally sound and efficient management of such wastes;
- specific conditions and a detailed control procedure for any proposed transboundary movement of hazardous and other wastes;
- cooperation to promote transfer of technology and use of low-waste technologies.

Key elements of the control procedure under the Basel Convention include prior notification and informed consent; prohibition of exports to or imports from countries which are not Parties to the Convention (except when a specific agreement exists as provided for by the Convention, see below); prohibition of exports to Parties that have prohibited imports under their national legislation; establishment of a duty to re-import when a movement cannot be completed as stated under the contract; and responsibilities of Parties when undertaking or involved in transboundary movements, including in the event of illegal traffic of wastes. The Basel Convention requires the state of export to notify (or require the generator or exporter to notify) in writing and obtain consent from all import and transit countries before any movement of hazardous or other wastes begins. Parties have adopted a notification document for this purpose.

It should be recognized that all Parties have the sovereign right to prohibit or restrict transboundary movements of hazardous and/or other wastes and can impose additional requirements on such movements in their territory.

Parties are required not to allow transboundary movements of wastes to proceed if they believe that the wastes in question will not be managed in an environmentally sound manner. Each shipment under the Convention must also be accompanied by a movement document from the point at which a transboundary movement begins to the point of disposal. The wastes must be transported according to generally accepted and recognized packaging, labelling and transport international rules and standards, such as the United Nations Recommendations on the Transport of Dangerous Goods and Model Regulations.

In addition to these provisions, at the second meeting of the Conference of the Parties to the Convention (COP) in March 1994, Parties adopted a decision to prohibit immediately all transboundary movements of hazardous wastes destined for final disposal operations from OECD to non-OECD States. By the same decision, Parties also agreed to phase out by 31 December 1997, and prohibit as of that date, all transboundary movements of hazardous wastes destined for recovery or recycling operations from OECD to non-OECD States (decision II/12). At its next meeting (COP-3) in 1995, Parties adopted a further decision III/1 in this regard as an amendment to the Convention (the 'Ban Amendment').

The Ban Amendment prohibits transboundary movements of hazardous wastes covered by the Convention and intended for final disposal from States listed in the Annex VII (Parties and other States which are members of the OECD, EC and Liechtenstein) to those not listed in Annex VII. It also prohibits transboundary movements of hazardous wastes covered by paragraph 1 (a) of Article 1 of the Convention to States not listed in Annex VII and that are destined for reuse, recycling or recovery operations.

At the COP 10 meeting in October 2011, Parties agreed on an interpretation of Article 17(5) of the Convention. Consequently, amendments to the Convention, including the Ban Amendment, enter into force between Parties having accepted them on the ninetieth day after the Depositary receives the relevant instruments of ratification, acceptance, approval or formal confirmation from at least three fourths of the Parties that were Parties at the time of adoption of the amendment. The Ban Amendment has not yet entered into force but it is already implemented by those Parties who ratified it.

Article 11 of the Convention concerns bilateral, multilateral and regional agreements or arrangements regarding the transboundary movement of wastes. As mentioned above, Parties cannot export to or import from countries that are not Parties to the Convention unless they have entered into an agreement or arrangement under Article 11. Parties may enter into such agreements or arrangements, resulting in transboundary movements with non-Parties, so long as those agreements or arrangements do not derogate from the environmentally sound management of hazardous wastes as required by the Convention, and those agreements or arrangements stipulate provisions which are not less environmentally sound than those provided for by the Convention, in particular taking into account the interests of developing countries.

Waste electrical and electronic assemblies or scrap containing certain components are listed in Annex VIII of the Basel Convention and can be considered as hazardous waste[4] (Entry A1180) or non-hazardous waste (Annex IX as B1110):

> **A1180** Waste electrical and electronic assemblies or scrap[5] containing components such as accumulators and other batteries included on list A, mercury-switches, glass from cathode-ray tubes and other activated glass and PCB capacitors, or contaminated with Annex I constituents (e.g. cadmium, mercury, lead, polychlorinated biphenyl) to an extent that they possess any of the characteristics contained in Annex III (note the related entry on list B, B1110).[6]

> **B1110** Electrical and electronic assemblies:

- ◊ Electronic assemblies consisting only of metals or alloys.
- ◊ Waste electrical and electronic assemblies or scrap[7] (including printed circuit boards) not containing components such as accumulators and other batteries included on list A, mercury-switches, glass from cathode-ray tubes and other activated glass and PCB-capacitors, or not contaminated with Annex I constituents (e.g. cadmium, mercury, lead, polychlorinated biphenyl) or from which these have been removed, to an extent that they do not possess any of the characteristics contained in Annex III (note the related entry on list A A1180).
- ◊ Electrical and electronic assemblies (including printed circuit boards, electronic components and wires) destined for direct reuse[8], and not for recycling or final disposal.[9]

Electronic equipment will often contain hazardous components examples of which are indicated in the entry A1180 of Annex VIII. E-waste will therefore be assumed hazardous unless it can be shown that it does not contain such components.

While the used ICT equipment will not be subject to the Basel Convention’s control mechanism, unless national legislation and measures provide otherwise, the challenge is to distinguish between what is waste and non-waste. The lack of clarity in defining when used equipment and equipment is or is not considered waste has led to a number of situations where such equipment was exported, in particular to developing countries, for reuse. On arrival, a large percentage of the shipment was in fact discovered to be waste rather than functional equipment and it had to be taken back by the State for export or be disposed of in the country of import or transited as waste. The frequent presence of hazardous substances and components in this equipment or waste and a shortage of adequate installations to treat these in an environmentally sound manner have led to serious problems for human health and the environment in the countries receiving this e-waste.

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[4] Wastes listed in Annex VIII of the Basel Convention are considered hazardous unless the hazardous characteristics in Annex III are used to demonstrate that the wastes are not hazardous.

[5] This entry does not include scrap assemblies from electric power generation.

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

[7] This entry does not include scrap from electrical power generation.

[8] Reuse can include repair, refurbishment or upgrading, but not major reassembly.

[9] In some countries these materials destined for direct reuse are not considered wastes.

2.3 End-of-life Management: steps for the organization

2.3.1 From an Internal Perspective

For successful e-waste management it is necessary that each organization not just understands what types of wastes it generates, but also streamlines the processes for its safe reuse, recycling or disposal. Here are 6 steps that will nudge organizations to grapple with the challenge of responsible e-waste disposal.

1. Who is responsible for End-of-Life within the organization?

   Identifying departments which are responsible is very important. Typically, within large corporates, e-waste that is generated (such as computers, monitors and telecommunication equipment) is the IT department's responsibility. These assets will be tagged and an inventory of such equipment is usually available with the IT department. Other types of electrical and universal wastes like fans, coffee machines, and printer cartridges could come under the jurisdiction of the Facilities department. Universal wastes, such as batteries, compact fluorescent lamps (CFL) mercury containing lamps, would also come under the jurisdiction of the facilities department. As there may be more than one department responsible for different types of e-waste, such as facilities, house-keeping, or accounts, etc, clear responsibilities with respect to end-of-life management options need to be assigned to each department. An individual with defined roles and responsibilities must be identified for each department.

2. What do we track?

   Understanding the end-of-life management options for the waste that the organization will generate is key to the appropriate management of inventory. In this context, the inventory should consist of a list of all the items that could be classified by end-of-life management options. There should be information on the source of waste, the type of waste and the quantity of waste, and should track an item from purchase through to use and disposal. It can be confusing to an organization to know what is classified and tracked under end-of-life management options. Therefore, all the relevant departments need to have a complete list of all types of e-waste product generated in the organization. Suitable software could ensure complete tracking of the material, and identification of material which reaches the end of its life. Such software can help in maintaining the status of each item. Items which are bonded should be identified through the pasting of an appropriate sticker, with relevant details in terms of date and number.

   IT asset management solutions help organisations manage their IT assets from procurement to retirement. Such tracking mechanisms do exist within large organizations and can be leveraged to achieve end-of-life reporting and management requirements.

3. Where do we store e-waste?

   A suitable storage space is required which is sufficiently large to store all the e-waste safely. Storage norms are required for each category of e-waste. For example, CFLs and fluorescent lamps which are fragile should be safely placed in drums or returned to the original packing. Similarly, a dedicated bin is required for printer cartridges. This storage space should be separate from space allocated for other scrap, including old chairs and other metal scrap.

4. What permissions are to be sought?

   Companies who have independent facilities and are registered under current and applicable legislation have to apply to the Pollution Control Board(PCB) or similar regulatory body for registration to allow them to store hazardous waste (e-waste) as per relevant local and federal laws. This may vary from country to country. Typically, country-specific norms have to be adhered here.

5. How to provide end-of-life management solutions?

The company must identify a suitable e-waste recycler who is authorized to recycle e-waste, and enter into an agreement with this recycler. Groups of companies located with a common collection center can use such a facility to dispose of EOL products. Alternative options, such as upgrades on existing machines, or reuse of electronic equipment in different departments before final disposal, could be encouraged. A process to ensure which equipment can be reused before recycling is a good way to extend the life of the product. Used printer cartridges can be handed over for remanufacturing. This ensures that the entire shell of the cartridge is used again, instead of being crushed and recycled.

6. Documentation

The e-waste that is collected needs to be documented. This documentation is available from the recycler. The documentation is evidence of the total quantity of products handed over for recycling. A copy of this document is then also handed over by the company to the Pollution Control Board or relevant regulatory body. Relevant documentation varies from country to country. End- of-life reporting is now an added regulatory burden for most organisations worldwide.

The recycler would need to keep track of processes, volumes, and origin of the EOL products for routine regulatory check-up. It would be good practice for recyclers to share this report with the client company, separate to its reporting to the regulatory authorities. Companies could request the recycler to share the report for final destination of e-waste. This could be coupled with site visits at the recycling facility to ensure that proper e-waste handling and disposal is put into practice by the recycler.

2.3.2 From High-Technology Business Districts

In several IT-intensive parts of the world, such as India and China, governments have set up Special Economic Zones (SEZ) or Hi-Tech parks or business districts. SEZs enjoy special status which facilitates the exports of goods manufactured in these areas. Due to this status, all electronic goods which are purchased for use inside the SEZ are bonded. When they have to be disposed of, they need to undergo a process of de-bonding which is a cost to the company in the form of excise duty. This is an additional step that organizations operating out of an SEZ would need to adopt into their EOL management practices.

2.3.3 From a donations receptor perspective

Donations of used electronic equipment are carried out worldwide, thereby extending the life of these goods. Organisations that accept donations (donation receptor) need to understand how to responsibly dispose of these goods at the end of their life. It would be a good practice for the donor and receptor to mutually agree on the disposal of these goods through an authorised recycler. Keeping track of donated goods and received goods would therefore be required to ensure tracking and avoiding leakages.

2.4 End-of-life management: stages and waste hierarchy

In order to aim for the best goals and results when thinking of waste prevention and waste management, the principle of “waste hierarchy” provides the steps to follow based on waste desirability. This principle aims to minimize the generation of waste by using alternatives such as waste prevention, reduction, reuse, recycling and recovery of equipment before considering the possibility of disposal, which can have an environmental impact. Other principles such as environmental sustainability should also be considered when considering best environmental solutions for End- of-life management of ICT equipment.

Sometimes it is necessary to deviate from the hierarchy in order to achieve better environmental results. This, however, should be in line with the life-cycle approach and other principles such as prevention of waste and environmental sustainability.

In some cases, it is environmentally, socially and financially feasible to develop an EOL management procedure that follows the hierarchy principle. Other procedures can be customized to the EOL management according to global circumstances which can bring positive impacts on environmental as well as social and economic aspects of the EOL management for ICT equipment.

For instance, when equipment waste is generated in a location where there are no environmentally sound solutions for dismantling or recycling of the specific components, be they plastics, or metals, some argue that it would be advisable to transport them to a location where waste legislation is in place and the service provider delivers the service according to the national environmental legislation and international standard requirements. It is recommended that companies comply with the requirements of national legislation and global standards.

Understanding the goals of environmentally sound management of EOL ICT equipment will help us to highlight the importance of the different stages individually, to demonstrate how they are linked together, to identify their risks, limitations and opportunities as well as the legal requirements associated with the process. A general example that provides an overview of the different stages of EOL is presented in Figure 1: EOL Management for computing equipment[10].

2.4.1 General legal framework

There are international, regional and national regulatory regimes (e.g. global treaties, multilateral environmental agreements (MEAs), statutes, laws, regulations, international standards) that regulate the interaction between activities associated with the environmentally sound EOL management of ICT equipment with the purpose of reducing the adverse impacts of these activities. They aim to provide an appropriate protection to human health and the environment from unsound practices as well as to support the economic performance of the EOL management.

Given the global focus of this study, a full definitive list of laws, regulations and directives is not only unreasonable but also not practical. Annex III provides guidance for the general legal framework that applies to the process of EOL management. The list of documents contained in the annex is not exhaustive and it is recommended to regularly verify for amendments or revised documents ANNEX III: List 1: General References to the legislation, international standards and guidance documents

It is strongly recommended that when making use of this guidance and especially when consulting Annex III, the reader establish the documents applicable to the specific case and follow the indications according to the type of material (e.g. mobile phones, batteries, monitors, others, location, volumes and required documentation with regard to transport, storage and reporting procedures to the respective environmental authority, etc.).

2.4.2 Asset management

Asset management is understood as a practice that aims for a maximum return on obsolete or excess ICT equipment designated for the end-of-life. This is the stage where the owner of the equipment intends to recover value through requesting and approving the procurement process of life cycle extension before dismantling and EOL management processes, or when the owner intends to send the equipment directly to EOL processes (e.g. recycling, refinery and disposal).

Asset management involves the administration of the physical components of ICT equipment such as parts of computers and networks for acquisition as well as software asset management, which is a similar process, focusing on software assets, including licenses, information and prototypes.

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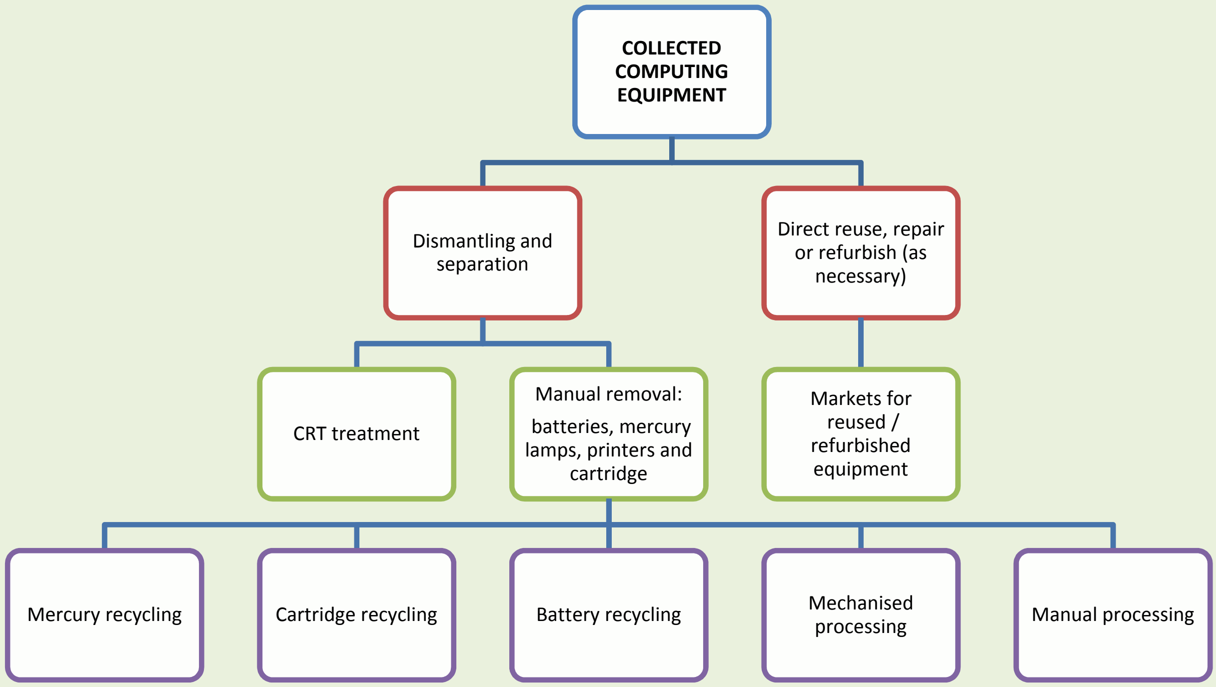
[10] Based on figure 1 in the Guideline on Environmentally Sound Material Recovery and Recycling of End-of-Life Computing Equipment, PACE, 2011.

Figure 1: EOL management for computing equipment



2.4.3 Secure information management

In relation to data security, it is the duty of organizations under the local data protection acts which require all information collected by an organization to be destroyed when the media (in this case computer hard drives) in which it is stored comes to the end-of-life. Organizations and individuals within these organizations must ensure that all confidential data is dealt with at the time when the storage media is disposed of and non-compliance can lead to significant fines as well as the risk to damage the organization brand image. There are two sure-fire methods to ensure that there is no data leakage at this point and these are either a data destruction software package or degaussing. Preferably utilizing Communications-Electronics Security Group and Ministries of Defence approved software, these data destruction packages offer certification per hard drive giving organizations a guarantee that all data has been dealt with in a speedy and appropriate manner. At this point, the asset can be redeployed into another area of business activity, sold for reuse or donated for charitable use. The other method of secure data destruction is by means of degaussing. This method utilizes electromagnetic fields that disrupt the surface area of the part of the hard drive where the data is stored making it unrecoverable. Computer hard drives cannot be reused after degaussing and should the equipment be offered for reuse, new hard drives need to be installed.

Asset management is a key element in the end-of-life cycle as it helps the organization in making business decisions based on meaningful and measurable financial objectives. However, financial decisions cannot lift in any way the responsibility with regard to finding an optimal environmental solution to ICT equipment at this stage.

Specialized facilities around the world deal with this type of equipment achieving outstanding solutions in both areas, financial and environmental, making sure that the problem is not being shifted to other locations generating uncontrolled socio-environmental effects as well as risking the waste generator's brand management image either on the local or global scale.

2.4.4 Reverse logistics

In this phase, appliances are transported from different locations to the warehouses where they are stored (in case logistics optimization is needed for further transport) or pre-processed (including segregation, dismantling and preparation for reuse).

There is a fundamental difference between consumer products and professional equipment. Usually consumers bring discarded products to municipal collection points or to retailer shops, which means that the equipment can be collected in large quantities and picked up in full loads by logistics providers. In case of professional equipment, when companies decide to discard equipment, a request is made to the logistics providers for a pick-up so that waste can be collected at user's premises.

In both cases, it would be advisable to test the equipment in order to evaluate the possibility for its reuse from technical and cosmetic characteristics.

In some countries, the informal sector will collect used or end-of-life ICT equipment either directly from consumers or from informal stockpiles, as used and end-of-use equipment have value for reuse. In some countries, formal collection takes place by municipal authorities where there are "bring" or "take-back" schemes to effect collection of used and end-of-life ICT equipment. In some cases these are funded through extended producer responsibility schemes. Collection of used ICT equipment from business, commerce and public sector organizations is important because of the large numbers that may be involved; this equipment may be a particularly good source of used, end-of-use and end-of-life equipment for refurbishment as well as for material recovery.

It is possible to run specific software on a personal computer or laptop that wipes or purges the hard drive to Ministry of Defence acceptable standards. Care should be taken that workers at refurbishment facilities are trained in wiping hard drives before the computing equipment is tested, so that no information stored on the hard drive is accessed inappropriately. If the hard drive cannot be successfully wiped or purged, then the drive should be destroyed physically.

In the case of mobile phones, collection of used mobile phones through telecom operators, retailers or manufacturer distribution channels should be a key element in an efficient collection system. Other collection methods may also be considered. In the case of collection by mail, postage may also be paid by the collection system, especially where a large number of used mobile phones are being sent in shipping packages. Manufacturers, telecom operators and mobile phone distributors should consider the possibility of sharing, as part of Extended Producer Responsibility (EPR) systems, the physical and/or financial obligations entailed by the collection and management of used mobile phones. This is particularly necessary and should be implemented as soon as possible in countries where the legislation and infrastructure for the collection of used mobile phones is lacking.

During handling and transportation, the equipment should be handled with care to avoid damaging and reducing their reuse and refurbishment potential or increasing the need of cosmetic refurbishing. Some of the aspects that need to be taken into account when thinking of reverse logistics are volumes, collection points and transboundary movements as well as the final destination of the collected items.

ICT equipment usually contains large percentages of plastics with a large volume but very little economic value, making the collection of equipment expensive even before the real value of such equipment can be determined by specialized companies.

Preparation for reuse typically involves disassembly, inspection and cleaning, electrical safety and function testing, component retrieval, component repair, component exchange, software installation and reassembly (see more detailed information in section 2.2.6).

2.4.5 Dismantling and segregation

The next step in the life cycle approach is dismantling and segregation. Careful manual separation of equipment components such as cathode ray tube (CRT) monitors, LCD displays, printers, laptops and desktops is a necessary first step. Each type of equipment will then be further segregated for separate recycling and material recovery processing, following the procedures that are appropriate for that type of equipment. For example, processing of printers will begin with the manual removal of ink and toner cartridges, so that these cartridges can be recycled in their own way, e.g. by refilling and rebuilding. CRTs require unique handling and attention to their vacuums, phosphors and lead. Some particularly problematical contents must be carefully manually removed from laptops, LCD screens and some older scanners: e.g. batteries, and mercury lamps. This is important because these components may complicate other material recovery streams if not removed at the start, and/or are likely to release hazardous substances into the remaining electronics, the workplace, and/or the environment during subsequent material equipment recovery processes.

This initial dismantling and removal of certain components from computing equipment may also be required by law, such as the EU WEEE Directive.

Removal of problematic components can be potentially possess hazardous for human health and environment. For example, removal of mercury lamps from LCD monitors is very likely to cause breakage, and release of mercury. The lamps are located along the sides of and behind LCD screens, and are long thin fragile glass tubes. Some lamps will almost certainly break during removal and handling; as a result, the dismantling operation should be well prepared to test its working atmosphere for mercury vapour, and to clean up visible mercury spills. Some facilities have decided not to remove the mercury lamps because of fear of breakage, and decide to send the entire LCD screen to licensed mercury treatment facilities, which have special expertise.

After the removal of the problematic components, the equipment should be further disassembled, sorted into various material streams, e.g. steel, aluminium, circuit boards, and plastics. These streams should then be sent to specialized material recovery processes.

Disassembly and separation can be done by continued use of manual labour, or by mechanized processes, or by both.

The decision of which methods to use depends primarily upon the economics, taking into account the initial cost of the machinery, the cost of manual labour, the availability of downstream processors with proper, environmentally sound recovery techniques, and the available market value of the components and equipment produced. Avoidance of high hazardous waste disposal costs can also be an economic incentive. In developing countries and in countries with economies in transition, if the costs of manual labour are low, the manual disassembly path is often taken. In industrialized countries, too, manual disassembly is often used, because it can produce more reusable computing equipment and very clean separated equipment for efficient further material recovery.

Disassembly by manual labour does not require significant technological skills, although worker training to safely carry out specific manual tasks is always important. It provides employment for workers, and can produce clean sorted material components that can be sold. It can also facilitate a careful removal of working components for additional value.

Careful separation to avoid losses is important for environmental reasons, because the recovery and recycling of metals requires significantly less energy and ecosystem disruption than in the extraction of these metals from ores. For example, the energy required to produce aluminium from scrap is only 5% of the energy required for production from ore. Gold is present in many computer circuit boards at a 40-70 times higher concentration than ore, and does not have to be mined at very low concentrations, e.g. as low as one gram of gold per tonne of rock, with great use of energy and chemicals such as cyanide.

To summarize, as ICT equipment represents a broad range of devices, dismantling and pre-processing activities mainly focus on:

- removal of hazardous components, such as ink cartridges (where present), printed circuit boards (PCBs) containing capacitors, mercury containing switchers and batteries (NiCd, NiMH Li-ion and Li-Polymer);
- removal and recovery of valuable or reusable components like HDs or fractions, e.g. PCBs.

ICT appliances do not present critical issues with regard to occupational health and safety during the pre-processing steps as long as massive exposure to dust is avoided. Consequentially, manual dismantling could be a very effective and efficient way to recover the economic and environmental value in such an e-waste stream.

Section highlights

Figure 2: Understanding dismantling and segregation

Issue	Dismantling and segregation
Definition	Careful manual separation of equipment parts and components. Tools such as electric or pneumatic screwdrivers can be applied to accelerate the speed of dismantling
Actors	Authorized recyclers, specialized authorized refurbishment company
Scope	Local to global
Equipment	EEE : obsolete, excesses and end of life
Challenges	• Effectiveness and efficiency of manual/mechanized processes • Removal of hazardous components, and batteries • Removal and recovery of value or reusable components avoiding value lost • Health and safety employee and facilities requirements • Technical knowledge and training • Legal compliance according to facility operations
Risk / Opportunities	• Time/cost efficiency and effectiveness of manual/mechanized processes • Facilities labour legal requirements • Reduction of energy demand and raw material
Best practices	• Well-trained labour to minimize value lost • Endure clean sorted material components that can be sold • Careful removal of working components • Licensed treatment facilities

2.4.6 Refurbishment

The process of refurbishment of ICT equipment is twofold. The first step in the refurbishment process is to verify hardware functionality through initial testing, removal of old data and software, and instalment of new hardware (parts), as needed. During this preparatory process, digital data destruction software might also remove all software including the basic set of instructions called an operating system. It is helpful to imagine equipment at this point as a polished mirror, awaiting a new set of instructions. The second step is to install the required instruction sets (software, both the operating system and applications) that control the hardware and provide the desired user functionality.

Refurbishment facilities should ensure that components and other equipment removed from ICT equipment, which are destined for reuse, are handled in a suitable manner that preserves their value. It is encouraged to minimize the landfilling of ICT components and equipment and arrange for an appropriate recovery and recycling where practicable.

In the case of domestic movements, refurbishment facilities should ensure that ICT equipment and its components (e.g. batteries) and residuals destined for recovery and recycling are prepared for shipment and transported in a safe and secure manner that complies with applicable hazardous equipment and/or dangerous goods transport regulations of the country and/or region.

In the case of transboundary movements, refurbishment facilities should ensure that ICT equipment and its components (e.g. batteries) and residuals destined for material recovery are prepared for shipment and transported in full compliance with the Basel Convention. Where refurbishers or other parties are exporting refurbished equipment, care should be taken to ensure compliance with all applicable laws governing equipment trade.

Refurbishment facilities dealing with equipment that is potentially hazardous to the health and safety of their workers or the environment are required to have processes in place, documented or otherwise, to ensure that this equipment is regularly inspected and monitored as required by the regulatory authorities of their country. For example, refurbishers of printers are often exposed to toner dust and therefore appropriate safety measures need to be applied.

If equipment and materials to be refurbished are defined as "waste" by the country in which they are being refurbished, the refurbishment facilities must hold all relevant waste management permits, licenses or other authorizations required by the regulatory authorities of their country. Also, refurbishment facilities should be in compliance with all applicable local regulations and permits or other authorizations that are related to the environment or human health and safety.

In developing countries, refurbishing of all types of electrical and electronic equipment, including ICT equipment, is an important economic activity in providing consumers with lower priced equipment. In some countries, the refurbishing sector has become the sector that provides income for thousands of small, partly informal enterprises in urban areas. Workers engaged in refurbishing of used electrical and electronic equipment often have a comparably high education and most of them went through a sector-specific apprenticeship system. It is worth noting that many of these enterprises are registered with the local authorities and pay taxes to local and regional administrations. In Africa and some countries in Asia in contrast the collection and recycling of e-waste is almost exclusively carried out by non-registered individuals commonly referred to as "scavengers", the refurbishing sector operates partly under formal conditions.

As for the adverse health and environmental effects from refurbishing, in addition to the safety measures described above, refurbishers in the context of a developing country not connected to a stable electricity supply are dependent on generators, which are often placed in such a way that exhaust emissions negatively affect the air quality of the workplace.

Section highlights

Figure 3: Dealing with refurbishment

Issue	Refurbishment
Definition	Any operations to allow and EEE considered as waste to work again includes both hardware and software operations
Actors	Refurbishment companies Manufacturer's authorized repair centers, authorized recyclers and specialized test centers. Informal sector (in emerging countries) Distributors (for collection)
Scope	Global
Equipment	EEE : obsolete, excesses and end- of-life
Challenges	• Refurbishment company to be authorized and hold: waste management permits, licenses or equivalent authorization required by the regulatory authorities of the country. • Identify minimum global requirements for equipment's second life: complete technology, components. • Responsible and traceable contribution to digital gap reduction in emerging countries • Reporting schemes in develop countries to control leakages • Capacity building in emerging countries • Close the loop and reduce natural resources demand (metals, rare earth)
Risk / opportunities	• EEE programmed obsolescence (limited software upgrade)
Best practices	• Secure information management • Actors environmental and legal compliancy (e.g. hazardous, permits, local authorizations, traceable processes)

2.4.7 Reuse

Reuse of ICT equipment, described as the extension of the life of the equipment or its components to be used for the same purpose for which it was initially conceptualized, may or may not involve change of equipment ownership, or support its life cycle towards a more optimal use of environmental and economic resources. However, it does not constitute a solution to the e-waste problem in its own whilst reducing the amounts of waste generated. Generally, it also involves a combination of specific after-use services like data destruction and environmental compliance certification.

The functionality tests should be performed for used ICT equipment to confirm that the equipment is fully functional and is suitable for reuse. From a sustainable point of view, the reuse of ICT equipment brings benefits by not only extending its life cycle and reducing waste generation and creating an income for the owner once the equipment reaches the market, but also by reducing e-waste by not shifting geographically to locations where its negative impacts will be maximized in the long run either due to the lack of control and legislation or the infrastructure for specialized treatment. Successful reuse operations should be completed in accordance with the General Material Recovery and Recycling Facility Guidelines described later on in this document.

There is also a need to review reuse and recycling rates of ICT proposed by some directives such as the European directives Restriction of Hazardous Substances (RoHS) and the Registration, Evaluation, Authorization and Restriction of Chemical substances (REACH) regulation, allowing not only the possibility of lower human health risk and environmental impact.

Section highlights

Figure 4: Handling reuse

Issue	Reuse
Definition	Equipment or its components' life extension for the same purpose for which it was initially conceptualized, may or may not involve change of equipment ownership. Aims to support a more optimal use of environmental and economic resources
Actors	Manufacturers, equipment owner, refurbished authorized recyclers
Scope	Global
Equipment	EEE : obsolete, excesses and end of life
Challenges	• Standardized functionality tests to identify optimal second life spam • Limited solution for EEE waste streams according to technological needs • Report and traceable processes • Second life market must have e-waste management capabilities
Risk / opportunities	• Waste generation reduction • Lack of environmental legislation in developed countries may shift e-waste problematic to other geographical locations where no legislation or infrastructure is in place
Best practices	• Successful reuse operations should be completed in accordance with the General Material Recovery and Recycling Facility Guidelines described later on in this document • Governments shall maximize efforts to develop and enforcement of legislation from local to global (e.g. hazardous, permits, local authorizations, traceable processes)

2.4.8 Recycling and recovery

Recycling is responsible for the recovery of equipment; manual and semi-manual dismantling can be efficient to further disassemble the components including power supply, hard discs and disc drivers. Tools such as electric or pneumatic screwdrivers can be applied to accelerate the speed of dismantling.

The benefit of carrying out manual dismantling is that after the disassembly of the equipment, it can be easily grouped into different fractions in its complete and intact forms, which could reduce the separation effort in the end-processing phase and enable the reclaim of the reusable parts. For example, printed circuit boards which are not mixed with any other fractions can give a higher metal yield during the end-processing. A stream line assigning a specific dismantling division to different workers would greatly improve the dismantling efficiency. This approach is eco-efficiently preferable in areas with a lower labour cost and abundant workforce.

Notwithstanding eco-efficiency in manual dismantling, preprocessing and even automated processes for treating these items based on shredding, followed by a mechanical separation, have been developed. Such processes use multiple stage shredding steps to reduce the equipment in size. Different metal fractions are then extracted from the shredded equipment using a magnetic belt to remove ferrous metals followed by an eddy current separator which removes non-ferrous metals.

The non-ferrous material is further separated into copper, aluminium, brass, etc., using optical sorting, density separation, eddy current separation or vibration separation among other methods. The remaining non-metallic material is then processed in order to separate circuit boards and wire, while the other remaining fractions are landfilled. It must be emphasized that from a resource perspective it is better to recover the high-grade printed wiring boards (PWBs) prior to shredding to avoid high losses of precious metals. Furthermore, extensive shredding of PWBs and plastics can generate dust containing (brominated) flame retardants as well as dioxins within the hot shredder equipment. Exposure of the workers to these substances can be avoided by removing the PWBs before shredding and by taking adequate occupational hygienic measures.

Recycling of batteries

Battery recycling aims to minimize the environmental impact generated by the heavy metals and toxic chemicals found in batteries that are disposed of as municipal solid waste. This practice has dramatically increased the risks of soil contamination and water pollution.

According to DEFRA (the UK Department for Environment, Food and Rural Affairs) in its document *Battery Waste Management Life Cycle Assessment* published in 2006, the ten most commonly used batteries in America and Europe are recycled through three specialized processes including: Cryogenic, Pyrometallurgical and Hydrometallurgical recycling routes as shown in Figure 5: Common recycling processes for batteries in America and Europe.

In computing and mobile telecommunication equipment, batteries are of two types; both are based on lithium chemistry.

There is a very small lithium battery in the primary circuit board (the “motherboard”), about the size of a coin and sometimes called a “coin cell” or “button cell.” There is a much larger rechargeable lithium-ion battery in a laptop/notebook/netbook computer that provides operating electrical power. Older computers used rechargeable nickel metal hydride (NiMH) batteries (and occasionally also NiCd), which will also be found in end-of-life computers. This larger battery must be removed and not shredded, unless the shredding equipment has the necessary pollution control equipment to manage such operations, and is licensed and permitted to do so. If this large battery remains in the equipment when it is shredded, it will break and will leak caustic electrolyte, causing a risk to the workers, a risk of fire, damage to the equipment, and contamination of other materials. Batteries may also still contain an electrical charge, and if their handling brings them into contact with a conducting metal, they will rapidly discharge (a “short circuit”), causing heat and possibly a fire.

Batteries have different compositions depending on their type, as shown in Table 2 Battery composition. These differences would require different processes, hence the difficulty and cost variations.

For recyclers the main difficulties regarding battery recycling are finding built-in batteries in ICT equipment and the high cost to process batteries due to very limited cost-effective methods developed in the industry.

This problem will be minimized by promoting the use of rechargeable batteries as they are made of more valuable material and the methods for recycling them are more effective in recovering valuable metals for reuse.

Figure 5: Common recycling processes for batteries in America and Europe

Battery type	Typical use	Current Battery Recycling routes
Silver Oxide (AgO)	Cameras, pocket calculators	Mercury distillation and silver recovery UK
Zinc Air (ZnO)	Hearing aids and pocket paging devices	Pyrometallurgical and Hydrometallurgical
Lithium Manganese (LiMn)	Pocket calculators	Cryogenic North America. Pyrometallurgical and Hydrometallurgical processes recently developed in Europe
Lithium (Li)	Photographic equipment, remote controls and electronics	Cryogenic North America. Pyrometallurgical and Hydrometallurgical processes recently developed in Europe

Zinc Carbon (ZnC)	Torches, toys, clocks, flashing warning-lamps	Pyrometallurgical and Hydrometallurgical processes recently developed in Europe
Alkaline Manganese (AlMn)	Radios, torches, cassette players, cameras, toys	Pyrometallurgical and Hydrometallurgical processes recently developed in Europe
Lithium Ion (Li-ion)	Mobile phones, lap- and palmtops	Cryogenic North America. Pyrometallurgical and Hydrometallurgical processes recently developed in Europe
Nickel Cadmium (NiCd)	Emergency lighting Cordless phones, power tools	Pyrometallurgical EU
Nickel Metal Hydride (NiMH)	Mobile and cordless phones	Pyrometallurgical EU
Lead Acid (PbA)	Hobby applications	Pyrometallurgical EU
Source: www.epbaeurope.net/090607_2006_Oct.pdf – June 2011		

Recovery of metals

ICT equipment contains many substances, many of which are metals. Some of these metals are used in the equipment in relatively large amounts, e.g. steel in millions of desktop computer cases, while some metals are used only in very small amounts, e.g. indium in the inside coating of LCD display screens. There are ways in laboratory science to recover every type of metal contained in computing equipment, but the actual recovery of useful amounts is more difficult, especially from complex substances, and recovery of all metals is simply not possible. Recovery of some metals will cause inevitable losses of others. Furthermore, recovery of any metal, especially with environmentally sound management, costs of course money.

There may be many steps required for final recovery, and it is necessary for a metal recovery facility to pay for equipment, pollution control systems, labour, supplies and operating expenses, etc. If the amount of a specific metal in ICT equipment is small, and/or the market price of that metal is low, that metal is usually not recovered. For example, although indium has a fairly high current market price, the amount in an LCD display screen is very small, and the cost of recovery is high; as a result, indium has traditionally not been recovered from end-of-life computing equipment. Lithium does not currently have a market price high enough to pay for the costs of recovery, and so the lithium contained in batteries, although available in relatively high amounts, has traditionally not been recovered, even if this is technically possible in the current battery recycling processes.

On the other hand, although the amount of gold and silver in a circuit board is quite small, the current market price of gold is much higher, and it has traditionally been recovered. In some cases, alloys can be recycled directly back into the same alloys, which improves the economic return and can be important with critical metals.

The decision of which metals to recover is thus traditionally commercial – if a specific metal can be fully recovered by a facility and sold for a profit, it will be recovered. As key and strategic metals from environmental and resource perspective are present in ICTs, perspectives different than the pure economic ones should be considered, especially by policy makers. Final metal recovery from ICT equipment has been done only by the private industry for more than fifty years, always on this commercial profit basis. Participants in the business of metal recovery should be aware of the metals in their equipment and the sound environmental management of those metals, and should also be aware of their commercial options, and should consider metal recovery processes and business partners who, while using environmentally sound management, will efficiently recover those metals.

Figure 6: Battery composition

Battery type	Alkaline manganese	Zinc carbon	Mercuric oxide	Zinc air button	Lithium button	Alkaline button	Silver oxide	Lithium manganese	Nickel cadmium	Nickel metal hydride	Lithium ion	Lead acid
Component	Percentage											
Silver							31.0%					
Iron and steel	24.8%	16.8%	37.0%	42.0%	60.0%	37.0%	42.0%	50.0%	35.0%	20.0%	22.0%	
Aluminium											5.0%	
Manganese	22.3%	15.0%	1.0%		18.0%	23.0%	2.0%	19.0%		10.0%		
Mercury			31.0%	1.0%		0.6%	0.4%					
Nickel	0.5%		1.0%		1.0%	1.0%	9.0%	1.0%	22.0%	35.0%		
Zinc	14.9%	19.4%	14.0%	35.0%		11.0%				1.0%		
Lead		0.1%										65.0%
Lithium					3.0%			2.0%			3.0%	
Cadmium									15.0%			
Cobalt										4.0%	18.0%	
$H2SO_4$ + water												16.0%
Alkali	5.4%	6.0%		4.0%		2.0%	1.0%		2.0%	4.0%		
Carbon	3.7%	9.2%	1.0%	1.0%	2.0%	2.0%	0.5%				13.0%	
Paper	1.0%	0.7%										
Plastic	2.2%	4.0%	3.0%	4.0%	3.0%	3.0%	2.0%	7.0%	10.0%	9.0%		10.0%
Water	10.1%	12.3%	3.0%	10.0%	6.0%	2.0%	5.0%	8.0%				
KOH			2.0%									
Other metals	1.3%	0.8%					4.0%			10.0%	11.0%	4.0%
Other non- metals	14.0%	15.2%		3.0%	13.0%	14.0%	4.0%	19.0%	11.0%	8.0%	28.0%	
Other material			7.0%									5.0%

Taken from: www.epbaeurope.net/090607_2006_Oct.pdf – June 2011.

Recovery of substances and components

Cathode ray tube (CRT) and non-leaded glass management and recovery

Some CRTs removed from ICT equipment can still be used as CRTs in rebuilt computer monitors, or can be used as CRT components of television displays. If a CRT monitor cannot be reused as a monitor or other display screen, it may still be recycled for its copper and glass. There is still some manufacturing of new CRTs, where the recovered glass can be used, although it is limited and diminishing and the market will be replaced in the future by other screen technologies, i.e. LCDs.

Plastics management and recovery

As with metals contained in ICT equipment, recovery of plastics involves an economic question – will the value of the recovered plastics exceed the costs of recovery, and provide a profit? Some types of plastics used in ICT equipment are high value engineered thermoplastics, types which can be repeatedly softened by heat and hardened by cooling, and hence are valuable to recycle. If these engineered thermoplastics can be recovered in a consistent, steady stream of raw material, they can be sold for a profit. However, it is necessary to also separate plastics that contain flame retardants, such as the plastics commonly used in CRT cases, and especially brominated flame retardants (BFRs) such as tetra-, penta-, octa- and deca-brominated biphenyl ethers from plastics that do not. Many buyers will not accept plastics with BFRs, and those buyers who can accept them must use processes that will not release the BFRs or create substances such as brominated dioxins and furans. There may still be some markets for plastics that contain BFRs, where they will be used in the same way, as flame retardants. Nevertheless, it should be noted that some BFRs are prohibited in some countries, e.g. pentabrominated diphenyl ether and octabrominated diphenyl ether, and in those countries should not be reused in the production of new plastics, and must be disposed of in an environmentally sound manner. The plastic recovery processing described below may create exposures to BFRs, and perhaps dioxins in low temperature processing, and precaution is necessary.

Manual disassembly of some ICT equipment can produce reasonably well-separated streams of plastics in the cases of laptop/notebook computers and peripheral equipment. Mechanized disassembly can also produce high volumes of plastics separate from other components, and is commonly used to recover large volumes. After removal, the plastic pieces may need to be further cleaned, particularly of contaminating substances such as paints, labels, and imbedded metal pieces.

To maximize resale value, plastics must then be sorted by polymer type (e.g. HIP, ABS thermoplastic), and by colour (e.g. white, black). Identification of polymer type can be difficult, especially for older computing equipment. The United States coding ISO 11469 system may be useful for some plastic, using a 'Recycle Triangle' with numbers and letters, but many plastic parts in the computing equipment are not identified. In addition, some plastics are made up of more than one type, or may have a fibre added for strength. In mechanized recovery operations, there are increasingly sophisticated scientific techniques for polymer recognition and separation.

If plastic types cannot be separated by type, a mix of different types of plastics may have little if any economic value, although some mixed plastics may be used for materials such as lumber or pallets. If no use or market as plastic can be found, smelters with appropriate emission control systems may use a limited volume of plastics in the metal recovery process, where they serve as a source of heat and substitute for other hydrocarbon fuels and as a reducing agent. Alternatively, incinerators with energy recovery systems, as well as appropriate emission control systems, may recover energy content from plastics.

Mercury lamp management and recovery

Monitors that use flat screen liquid crystal display (LCD) technology contain one or more small lamps for illumination, usually located along the outside edge of the screen. While new technology sometimes uses light emitting diodes (LEDs) for these lamps, most LCD screens contain fluorescent mercury vapour lamps. These mercury lamps will often break during the handling and mechanized processing, and will release their mercury vapour. Therefore they must be carefully removed, by manual labour, and must undergo mechanized processing such as shredding, provided the shredding equipment has the necessary pollution control equipment to manage such operations, and is licensed and permitted to do so, such as at mercury treatment facilities. Even with careful removal, some breakage is very likely to occur, and engineering controls or personal protective equipment to prevent inhalation of mercury vapour should be used at all times. Some facilities may decide not to remove the mercury lamps, of fear of breakage, and decide to send the entire LCD screen directly to mercury treatment facilities.

Once removed, mercury lamps (as well as spill collection and cleaning residues) should be sent to mercury recovery facilities. These specialized facilities will heat the lamps and mercury-bearing residues, in a closed furnace (a retort), driving the mercury vapour into a cooling chamber where it will be condensed and collected as pure mercury.

After removal of mercury lamps, LCD screens are generally not hazardous, and can be safely disposed of, such as by state-of-the-art incineration techniques. The critical metal indium is used in small amounts to coat the inside of these screens, and research is being undertaken to see if efficient recovery, now or later, may be achieved.

Ink and toner management and recovery

Printer cartridges from end-of-life printers consist of an outer plastic case and typically contain residual amounts of ink or toner, plastic and metal parts, and integrated print heads or smart chips. Some contain circuit boards. These printer cartridges are recyclable and in some cases may be reusable or refillable. Opinions differ as to how many times a cartridge can be reused, with some people saying that the quality of printing will deteriorate after the original use, and others saying that a cartridge may be reused up to six times. Some commercial cartridge remanufacturing companies will only accept OEM cartridges that have never been previously recycled. Because some inks and toners (and therefore cartridges) contain materials of concern, cartridge remanufacturing should only be undertaken by specialized companies that utilize environmentally sound management techniques and provide occupational and environmental protections. In all cases of intended reuse, a cartridge should be washed, examined for cracks or worn parts, and key parts that are defective affecting quality and performance should be replaced with new components. Only compatible ink should be used for a refill. After refilling, they should be tested individually for print quality.

2.4 A guide to best practice

The checklist provided below aims to guide the user suggesting the best way to approach each sub-stage within the EOL of ICT equipment assessing considerations that must not be overlooked. The checklist is based on the life-cycle assessment methodology. It intends to help asset management and recycling companies involved in the management of EOL ICT equipment ensure consistency and completeness of their operations by carrying out the evaluation of environmental impacts during the EOL phase of ICT' life cycle.

This checklist is complemented by a list of "General references to legislation" that includes international standards and guidance documents as well as examples of local or regional legislation that the reader could refer to. The list is intended as guidance and it is not exhaustive. Readers are recommended to check for the latest updates or revised versions of the references. See Annex III: General references to the legislation, international standards and guidance documents.

Figure 7: Check-list of EOL considerations					
Life cycle phase	Facet	Considerations	Comply Y/N	Aspect(s) impacted	Description of impact, unconformity or improvement actions to be taken
Deployment, asset management, life extension, disposal	Information – security	Has the company managing your ICT equipment developed a secure policy to protect your information?			
		Has your organization been informed about the information security policy for asset management and end-of-life processes?			
		Is there an action plan for the implementation of that security policy?			
		Is access to details of asset management and end-of-life processes of ICT equipment being controlled?			
	Risk management	Is asset management minimizing the risk for your organization in regards to brand management and environmental performance a priority?			
		Is strategic decision-making being supported by asset management?			
		Has efficiency on inventory controls been improved for strategic decision making?			
		Has the life cycle of your organization's ICT equipment been improved by the practice of asset management?			
	Environmental performances	Is the ICT life cycle of the equipment being improved?			
		Has the ICT equipment life cycle been extended (tractability of destination, brand management)?			
		Are the environmental impacts being reported?			
		Are any losses of ICT assets being identified?			
		Are processes being documented for equipment life cycle improvements?			

Life cycle phase	Facet	Considerations	Comply Y/N	Aspect(s) impacted	Description of impact, unconformity or improvement actions to be taken
Reverse logistics	Operations	Is the equipment well packaged in order to avoid damages in case it is collected for reuse or refurbishment?			
		Is the transport company administering the required documentation and authorization requested by law to transport the equipment?			
		Is the equipment being directed towards a company authorized to manage it?			
	Environmental performances	Has the equipment been classified according to waste legislation?			
		Is it an authorized waste management facility?			
		Does the facility provide a complete solution for the equipment type?			
		Would the equipment need to be redirected to a third location to finalize treatment?			
		Does transport means used to move the equipment, support and encourage the reduction of CO_2 emissions and pollution control?			
	Reporting	Have notifications been sent to environmental authorities?			
		Has the movement being authorized or notified, as applicable?			
Reverse logistics	Operations	Is the equipment well packaged in order to avoid damages in case it is collected for reuse or refurbishment?			
		Does the transport company comply with requirements and have the necessary authorization requested by law to transport the equipment?			
		Is the company to which the equipment is transported authorized by law to carry out EOL operations?			
		In case of transboundary movements, will the Basel Convention prior notice and prior consent procedures apply to a shipment?			

Life cycle phase	Facet	Considerations	Comply Y/N	Aspect(s) impacted	Description of impact, unconformity or improvement actions to be taken
	Environmental performances	Has the equipment been classified according to international and national waste legislation?			
		Is it an authorized waste management facility?			
		Does the facility provide an environmentally complete and sound solution for this type of equipment?			
		Would the equipment need to be redirected to a third location to finalize treatment (e.g. recycling, disposal)?			
		Does the transport mode that was used to transport equipment, support and encourage the reduction of CO_2 emissions and pollution control?			
Reverse logistics	Reporting/ compliance	Have notifications been sent to environmental authorities?			
		In case of transboundary movements, did the generator (of waste) (e.g. ICT company) conclude a contract with the disposer (e.g. waste management facility) for the disposal of wastes in an environmentally sound manner?			
		Did the generator (of waste) or exporter (e.g. ICT company, asset management company) inform the Basel Competent Authority of the country of export of this proposed movement?			
		Have notifications been sent by the Basel Competent Authorities of the country of export to the Basel Competent Authorities of the concerned countries (countries of transit and import)?			
		Did the Basel Competent Authorities of the concerned countries (countries of transit and import) express their consent to the proposed movement? Did the Competent Authority of the country of export issue the movement document which contains detailed information about the shipment and authorize the shipment to proceed?			

Life cycle phase	Facet	Considerations	Comply Y/N	Aspect(s) impacted	Description of impact, unconformity or improvement actions to be taken
Dismantling and segregation	Operations	Time spent vs. value of equipment recovered?			
		Cost of manual working hour vs. value recovered?			
		% of equipment recovered.			
		Quality and marketability of equipment recovered.			
		Commodity markets and economic value of the equipment recovered.			
		Different categories of equipment at the end (of the operation?)			
		Have the goals been set in a measurable and tractable manner?			
	Environmental performances	% of contaminated equipment removed?			
		% of non-contaminated equipment recovered?			
	Reporting	Has the process been documented?			
		Is the reported data comparable and measurable?			
Reuse	Operations	Has any information contained in any memory/hard disk been wiped?			
		Do the reuse percentage rates meet the requirements of the national and regional legislation?			
		Is benchmarking development according to volumes processed (models, brand)?			
		Is the system economically feasible?			
	Environmental performances	Does the reuse market have environmental policies to deal with the end-of-life of the extended life of ICT equipment?			
		Does it contribute to the minimization of waste generation?			
		Is the reporting and tractability of equipment possible according to national/regional legislation?			
	Reporting	Is the reporting and tractability of equipment possible according to national/regional legislation?			

Life cycle phase	Facet	Considerations	Comply Y/N	Aspect(s) impacted	Description of impact, unconformity or improvement actions to be taken
Recycled and recovered equipment	Operations	Can percentages be met according to the national, regional or local policy on waste management?			
		Is the information contained in any memory/hard disk being wiped?			
		Do the reuse percentage rates meet the requirements of the national legislation?			
		Benchmarking development according to volumes processed (models, brand)?			
		Is the system economically feasible?			
	Environmental performances	% of the equipment weight/volume landfilled in compliance with requirements of the national legislation?			
		% of the equipment weight/volume incinerated in compliance with requirements of the national legislation?			
		% of equipment weight/volume being recovery in compliance with requirements of the national legislation?			
	Reporting	In accordance with the WEEE directive in the European Union or in accordance with ITU-T L.1410?			
		Is traceability possible for the report?			

3 General material recovery and recycling facility guidelines

EOL ICT equipment will generally be treated by facilities that engage in raw material recovery and recycling, which requires compliance with existing requirements contained in national and international legislation as these operations are associated with environmental risks. Environmental management systems become an important aspect of these operating facilities.

To be able to comply with the legislation and employ the best technology available for environmental sound management of the EOL ICT equipment, facilities need to bear the expenses that some actors active on the market, such as traders, middle-men and even service providers which are neither certified nor legalized, do not always incur. It would be important to keep in mind that offers which provide attractive financial returns may not always reflect the true costs as they dismiss environmental responsibilities.

It is of critical importance to ensure that service providers, middlemen and traders are capable of supporting the financial gain as well as offering a sustainable solution for the e-waste problem. By looking at the aspects described below, the waste producer needs to ensure that its decision with regards to waste management is to be made responsibly towards the environment as well as to social issues, while unsupportive of unethical practices and illegal traffics.

Although the EOL management in most cases adds a positive financial value to generators' revenues, they should not seek EOL management as a main profitable stream for their businesses, unless their companies have a commercial objective to deliver such services.

3.1 Environmental management system, licences and permits

The recovery and recycling facility should possess and maintain a documented environmental management system to ensure adequate control over impact on the environment. The environmental management system may be based on, ISO 14001 or ITU-T L.1410 and the other formally recognized standards for environmental management systems prevailing in specific countries or regions, e.g. BS 7750 in the U.K. and EMAS (Environmental Management and Audit Scheme) in Europe.

In case no formally recognized standards are used, the system should also incorporate record-keeping of shipping documents, bills of lading and chain-of-custody information in the form of audits on equipment destined for downstream markets.

The facility should operate pursuant to written standards or procedures regarding operating methods for the plant and equipment, systems for management, control of site activities, site safety rules and requirements and methods for ensuring observation and monitoring (i.e. an overall operating, systems and safety manual).

The facility must comply with all applicable environmental regulations and standards (international, regional, local or municipal):

- material recovery and recycling facilities should be licensed by all appropriate governmental authorities;
- facilities should be required to operate according to best available technologies, while taking into consideration the technical, operational and economic feasibility of doing so. Licensing and permits should be consistent with governmental, regional and local regulatory requirements;
- specific permits required could be: storage permit, air emission permit, water permit, hazardous waste permit, and those required to meet landfill and other disposal regulations. Processes should be in place to ensure continued compliance with the requirements of the permits.

Legal requirements such as authorizations, licenses, permits or standards should address facility operations, workers' health and safety, control of air emissions, land and water as well as waste management. The licence or permit should describe and authorize specific facility capacities, processes and potential exposures.

3.2 Monitoring and record keeping

Material recovery and recycling facilities should develop adequate monitoring, recording and reporting programmes. Such programmes should be maintained to track:

- key process parameters;
- hygiene-risk elements such as beryllium;
- compliance with applicable regulations;
- generation of any emissions or effluents;

- movement and storage of waste, especially hazardous waste.

The facility should have adequate record-keeping systems to ensure compliance and have records of employee training, including health and safety leaflets, bills of lading and chain-of-custody of all equipment, emergency response plans, closure plans in case a plant or operation closes, record-keeping policies, fire prevention and suppression procedures, equipment failure backup plan, and security plans.

3.3 Emergency planning

The facility should have a regularly updated emergency plan that provides guidelines on how to react to emergencies such as fires, explosions, accidents, unexpected emissions and weather-related emergencies. The emergency plan should also indicate what reporting and monitoring is required in specific instances.

The plan should be communicated to the local emergency response authorities.

3.4 Occupational health and safety: best practices to ensure workers' safety

The facility must comply with all applicable health and safety regulations and must ensure occupational health and safety of employees by:

- providing continuous health and safety training of personnel;
- providing ergonomic work areas with safe and effective tools;
- avoiding heavy lifting, where possible, and training employees to lift in a safe manner. in some cases lifting tools may be required;
- making available and enforcing the use of personal protection equipment;
- labelling all hazardous materials;
- safeguarding dangerous mechanical processes;
- avoiding exposure to unacceptable occupational risks such as airborne dust and fumes through the use of process dust collection systems;
- periodic air monitoring to monitor elements of risk including but not limited to lead, cadmium and beryllium;
- providing process fire suppression equipment and systems where appropriate;
- considering policies that prohibit eating food or smoking in processing areas;
- providing for worker health benefits or insurance and long-term disability and death benefits;
- providing liability compensation for accidents;
- encouraging the development and implementation of an environmental liability regime for recycling facilities to prevent environmental damage.

3.5 Personal protective equipment

Plant personnel should be provided with the appropriate personal protective equipment (PPE) to ensure employee safety. The level of PPE required will depend on the level of potential risk to which the employee is exposed and the type of equipment with which the employee works. The assessment and decision on occupational health and safety measures, including the selection of appropriate PPEs should be under the supervision of a competent occupational health and safety (OHS) specialist.

- Eye protection: Safety glasses should be worn to prevent eye injuries. Eye washing stations should be available in areas easily accessible by employees and as regulated by local legislation.

- Head protection: Hard hats may be required in certain areas, such as in proximity to overhead racks and around automatic dismantling machines and smelting furnaces.
- Hand protection: When opening boxes, using safety knifes, handling sharp objects or using pallet jacks, gloves may be required. When manually dismantling equipment or handling chemicals, gloves should be also be worn. Gloves help protect hands from cuts, scrapes, chemical burns and infection by blood-borne pathogens.
- Skin protection: In certain conditions, such as working in proximity to furnaces, chemical equipment and some types of automated equipment, a fire-resistant work smock may be necessary to protect exposed skin from burns or chemicals.
- Foot protection: Steel-toed shoes should be worn to prevent foot injuries from falling objects, pallet jacks, chemical spills, etc.
- Hearing protection: Earplugs should be worn in work areas where prolonged noise exposure would lead to hearing damage.
- Respiratory protection: Dust masks or face masks should be worn in areas where there is a risk of dust inhalation. Where indoor pollutants other than dusts or particles, such as toxic gases and vapours known to affect employees at a work place, proper respirators should be made available and worn by the employees. Working in confined spaces where there is oxygen deficiency, may require the use of air supply apparatus.

3.6 Employee training

The facility should provide employees with periodic training to safeguard their occupational health and safety. The training should address safe work practices, required safety precautions and required personal protective equipment. Employees should be trained in the proper identification and handling of any hazardous material that may be present in the equipment to be recycled. Training should be documented, recorded and updated as conditions merit.

3.7 Financial guarantees

Material recovery and recycling facilities should establish an appropriate plan for closure and aftercare which ensures that the financial means for such closure are available. A financial mechanism should be maintained that will ensure that the facility is properly cleaned up in the event:

- of major pollutant releases or gross mismanagement of end-of-life electronics equipment, components, and scrap;
- of closure of the facility.

Figure 8: Material recovery and recycling guidelines

Life cycle phase	Facet	Considerations	Comply Y/N	Aspect(s) impacted	Description of impact, unconformity or improvement actions to be taken
General material recovery and recycling facility guidelines	Environmental management system				
	Licensing and permits	Material recovery and recycling facilities should be licensed by all appropriate governmental authorities.			
		Require that facilities operate according to best available technologies, while taking into consideration the technical, operational and economic feasibility of doing so.			
		Licensing and permits should be consistent with governmental, regional and local regulatory requirements.			
	Monitoring and record keeping	Specific permits required could be: storage permit, air emission permit, water permit, hazardous waste permit, and those required to meet landfill and other disposal regulations.			
		Processes should be in place to ensure continued compliance with the requirements of the permits.			
		Key process parameters.			
		Hygiene-risk elements such as beryllium.			
	Emergency planning	Compliance with applicable regulations.			
		Generation of any emissions or effluents. Movement and storage of waste, especially hazardous waste.			
	Occupational health and safety: best practices to ensure workers' safety	Provide continuous health and safety training of personnel.			
		Provide ergonomic work areas with safe and effective tools.			
		Avoid heavy lifting where possible and train employees to lift in a safe manner. In some cases, lifting tools may be required.			
		Make available and enforce the use of personal protection equipment.			

Life cycle phase	Facet	Considerations	Comply Y/N	Aspect(s) impacted	Description of impact, unconformity or improvement actions to be taken
General material recovery and recycling facility guidelines		Label all hazardous materials.			
		Safeguard dangerous mechanical processes.			
		Avoid exposure to unacceptable occupational risks such as airborne dust and fumes through the use of process dust collection systems.			
		Periodic air monitoring to monitor elements of risk including but not limited to lead, cadmium and beryllium.			
		Provide process fire suppression equipment and systems where appropriate.			
		Consider policies that prohibit eating food or smoking in process areas.			
		Provide worker health benefits or insurance and long-term disability and death benefits.			
		Provide liability compensation for accidents.			
		Encourage the development and implementation of an environmental liability regime for recycling facilities to prevent environmental damage.			
	Personal protective equipment	Eye protection: Safety glasses should be worn to prevent eye injuries. Eye washing stations should be available in areas easily accessible by employees and as regulated by local legislation.			
		Head protection: Hard hats may be required in certain areas, such as in proximity to overhead racks and around automatic dismantling machines and smelting furnaces.			
		Hand protection: When opening boxes, using safety knifes, handling sharp objects or using pallet jacks, gloves may be required. When manually dismantling equipment or handling chemicals, gloves should be also be worn. Gloves help protect hands from cuts, scrapes, chemical burns and infection by blood-borne pathogens.			

Life cycle phase	Facet	Considerations	Comply Y/N	Aspect(s) impacted	Description of impact, unconformity or improvement actions to be taken
General material recovery and recycling facility guidelines		Skin protection: In certain conditions, such as working in proximity to furnaces, chemical equipment and some types of automated equipment, a fire-resistant work smock may be necessary to protect exposed skin from burns or chemicals.			
		Foot protection: Steel-toed shoes should be worn to prevent foot injuries from falling objects, pallet jacks, chemical spills, etc.			
		Hearing protection: Earplugs should be worn in work areas where prolonged noise exposure would lead to hearing damage.			
		Respiratory protection: Dust masks or face masks should be worn in areas where there is a risk of dust inhalation.			
	Employee training	Is employee training, being recorded, signed and tracked?			
	Financial guarantees	Has the company acquired the insurances needed to protect, assets, employees and equipment handled including during transportation?			

4 Clean supply chain and conflict minerals

The demand of the ICT equipment manufacturing processes for rare metals such as tin, tungsten, gold and others can help support developing countries in their economic growth and lead the way out of poverty. However¸ it is necessary to introduce a responsible global supply chain management code to encourage industry suppliers and other stakeholders to be responsible and sympathetic towards conflict-affected and high-risk issues.

The ICT industry in general and, specifically, companies can ensure a proactive respect for human rights and contribute to the environmental protection by avoiding putting the ever increasing demand on the limited natural mineral resources which sometimes come from small–scale mining using artisanal practices without proper safety and risk control measures.

From the point of view of asset management and recycling industry, closing the loop on e-waste by introducing or reinserting precious and rare metals recovered or recycled from the unwanted ICT equipment to the supply chain represents an opportunity for manufacturers to:

- ensure a clean supply chain and reduce the demand on limited natural resources, which is auditable, measurable and tractable;

- reduce production costs of brand new product and the possibility to influence customer's purchasing power by offering a product that is verifiable conflict-free;
- manufacturers can support the effort that recyclers make to recover material by:
  - ◊ designing products that through their different life cycle stages reduce environmental impact and waste generation;
  - ◊ designing, producing, labelling and commercializing equipment that has a reasonable extensive life and that once it reached the end of life, it can easily be repaired or dismantled for reuse or its value recovered via recycling or its life finalized in the best environmental possible manner without influencing economic growth.

According to U.S. Environmental Protection Agency[11], the following factors illustrate the advantages of waste prevention through recycling and support the "closed loop" initiative through the use of recycled material over raw material production energy demands.

Aluminium

- Aluminium can be recycled using less than 5% of the energy used to make the original product.
- Recycling one aluminium beverage can save enough energy to run a 100 watt bulb for 20 hours, a computer for 3 hours, or a TV for 2 hours.

Plastic

- Producing new plastic from recycled material uses only two-thirds of the energy required to manufacture it from raw materials.
- Plastics require 100 to 400 years to break down at the landfill.
- Five 2-litre recycled PET bottles produce enough fibrefill to make a ski jacket.

Glass

- Producing glass from raw materials requires 30% more energy than producing it from crushed, used glass.
- The energy saved from recycling one glass bottle will operate a 100-watt light bulb for four hours.
- It takes approximately 1 million years for a glass bottle to break down at the landfill.

Steel

- Tin cans contain 99% steel.
- Recycling steel and tin cans save between 60 and 74% of the energy used to produce them from raw materials.
- According to the Steel Recycling Institute, steel recycling in the United States saves the energy equivalent to electrical power for about one-fifth of American households for one year.
- One tonne of recycled steel saves an energy equivalent of 3.6 barrels of oil and 1.49 tonnes of iron ore over the production of new steel.

Paper

- Producing recycled paper requires about 60% of the energy used to make paper from virgin wood pulp.
- Manufacturing one tonne of office and computer paper with recycled paper stock can save between 3 000 and 4 000 kilowatt hours over the same tonne of paper made with virgin wood products.

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11 www.epa.gov/osw/partnerships/wastewise/wrr/factoid.htm.

- Preventing 1 tonne of paper waste saves between 15 and 17 mature trees.

Copper

- Recycling a tone of copper uses 15% of the energy that would be used to mine and extract the same copper.

Many substances in the ICT equipment present little or no special hazard or concern particularly in the early steps of recycling such as manual dismantling of steel in the cases of CPUs, or copper in wire.

Some substances, however, may be quite hazardous, and facilities should obtain and maintain current Material Safety Data Sheets. Some materials can present a hazard when the ICT equipment is broken, crushed, shredded, melted, incinerated or land filled, unless environmentally sound management practices are used.

> The Organization of Economic Cooperation and Development, OECD, introduced *Due Diligence Guidance for Responsible Supply Chains of Mineral* as a voluntary proactive initiative in which companies can ensure that they respect human rights, assess their potential risks of contributing to conflict, make sure they comply with domestic laws, including those governing the illicit trade in minerals and United Nations sanctions.
>
> Amongst the challenges that the guidance may face for its use according to OECD are industries' flexibility, cooperation and participation, switching costs and integration to existing internal policies (for more information on the guidance, please see www.oced.org).

For example, beryllium in copper-beryllium connectors poses little or no risk when computing equipment is manually dismantled, but if beryllium is reduced to fine airborne dust, especially if it is melted, it creates a fume that is not controlled and is inhaled by workers; thus, it can permanently scarring the lungs, leading to serious health problems and death. In addition, it is not only the substances in ICT equipment, such as those listed above, that are of concern. Other substances may be used in recycling, or may be produced or arise as emissions. For example, poly vinyl chloride insulation in wires is not hazardous in normal handling, but if it is burned to recover copper without proper emission control equipment and systems, it may create dioxins, furans and other combustion emissions.

Three main groups of substances that may be released during recycling, incineration or landfilling, that should be of concern are:

i) original substances that are constituents of ICT equipment, such as lead, mercury, cadmium, etc.;

ii) added substances that are used in recycling processes, such as cyanide or strong acids; and

iii) new substances that may be formed (sometimes unintentionally) by recycling processes, such as dioxins.

One group of chemicals which should be mentioned in specific is persistent organic pollutants (POPs). POPs share four properties:

- they are highly toxic and can cause serious health problems such as cancer and birth defects in humans;
- they are persistent, lasting for many years before degrading into less dangerous forms;
- they evaporate and travel long distances through air and water, and
- they accumulate in fatty tissues.

The combination of these properties makes POPs highly dangerous. The international regime regulating POPs is the Stockholm Convention on Persistent Organic Pollutants which is a global treaty aiming to protect human health and the environment from the negative effects of POPs by restricting and ultimately eliminating their production, use, trade, release and storage. The list of chemicals currently controlled under the Stockholm Convention contains 21 POPs.

Three groups of POPs are of concern in relation to ICT equipment:

1) **Brominated flame-retardants** Hexabromobiphenyl, tetra- and pentabromodiphenyl ethers (components of commercial pentabromodiphenyl ether), and hexa and heptabromodiphenyl ethers (components of commercial octabromodiphenyl ether). Hexabromobiphenyl and commercial octabromodiphenyl ether have been extensively used in components of ICT equipment made of plastic (e.g. computer and television casings made of acrylonitrile-butadiene-styrene) and in circuit boards. Commercial pentabromodiphenyl ether has been commonly used in rigid polyurethane elastomers in instrument casings and in epoxy and phenolic resins in electrical and electronic equipment.

   Under the Stockholm Convention, the production and use of listed brominated diphenyl ethers (BDEs) are prohibited for all applications with the exception that Parties may recycle articles containing these chemicals. The production of listed BDEs has ceased in the developed countries but may still occur in other parts of the world. Furthermore, other brominated flame-retardants, such as decabromodiphenyl ether, remains widely used and may have the potential to be converted into listed BDEs.

2) **Perfluorooctane sulfonic acid (PFOS), its salts and perfluorooctane sulfonyl fluoride (PFOS-F)** These chemicals are considered to be critical for a number of applications in the ICT equipment industry such as photo resistant and anti-reflective coatings and etching agent for semi-conductors, photo masks in the semiconductor and liquid crystal display (LCD) industries and electric and electronic parts for some colour printers and colour copy machines. The Stockholm Convention allows the production and use of PFOS, its salts and PFOS-F for these applications until alternatives are identified or are phased-in.

3) **Polychlorinated dioxins and furans** These chemicals are among the most toxic chemicals known, and cause cancer in humans. These chemicals have no industrial use but are released from thermal processes and from industrial processes such as the production of polyvinyl chloride and other chlorinated substances. They may also be unintentionally formed and released from other sources such as uncontrolled burning of materials which contains halogenated organics and hydrocarbon (e.g. cables with PVC sheets), open burning of waste, fossil fuel-fired utility and industrial boilers, and special chemical production processes. The Stockholm Convention requires that governments identify sources of these POPs and apply measures to reduce their levels. To that end, best available techniques (BAT) and best environmental practices (BEP) should be implemented.

The Convention does not allow for recovery, recycling, reclamation, direct reuse or alternative uses of POPs, with the exception of the recycling of articles containing listed BDEs. Nevertheless, the convention requires that this recycling is carried out in an environmentally sound manner. However, a technical review of the implications of recycling listed BDEs indicated that preventing POPs from contaminating the general recycling stream remains technically challenging, especially in developing countries. The improper treatment of BDE-containing wastes can generate toxic brominated dioxins and furans. The technical review of the implications of recycling listed BDEs revealed that more information is urgently needed on BAT and BEP for preventing the release of dioxins and furans from the treatment of BDE-containing wastes. The ongoing use of PFOS, its salts and PFOS-F for critical applications, results in the generation of PFOS-containing wastes from industrial processes and from articles that reach the end of their useful life. Managing these wastes in an environmentally sound manner is important to minimize the risks posed by the continued use of PFOS.

Recycling rare metals in ICT equipment

ITU-T Study Group 5 identified the recycling of ICT rare metal components as an area demanding attention, and has responded with the new Recommendation ITU-T L.1100 detailing the procedures to be employed when recycling these metals. The Recommendation outlines key considerations in all phases of the recycling process, and provides guidelines as to how organizations may fairly and transparently report on rare metal recycling.

Rare metals are essential to the high-end functionality of ICT equipments, and the ICT industry has reached the point where it is not possible to omit these metals from product design. To further illustrate the need of recycling rare metals; let us take the case of mobile phones which contain no less than 20 rare metals. A tonne of gold ore yields 5 g of gold, compared to a staggering 400 g yielded from a tonne of used mobile phones.

It is well known that natural stocks of some semiconductor-compounds such as CIGS (copper, indium, gallium, selenide) or CdTe (cadmium, tellurium) will be depleted in the near future. The inelastic supply of these metals necessitates recycling from an environmental perspective, but it is their rarity and consequent value that provides ample economic incentives for such recycling. It is one of the rare cases where environmental and economic concerns are aligned precisely, and the need to recycle rare metals is surely one that will find support in all economic sectors.

The ICT equipment also contains “critical materials” or “special materials” such as platinum group metals, gallium, indium, rhenium, “rare earths”, cobalt and antimony. There has also recently been an increasing interest in the recovery of these metals. Because of their unique properties, these materials have an important role in modern applications and manufacturing, including ICT equipment. There is concern, however, that commercial access to these materials may become limited or even unavailable, for geological, economic and political reasons, and modern industry may thus be seriously disrupted. In some cases, e.g. platinum group metals, high market prices lead to profitable recovery. However for other metals, such as the rare earth elements for which recovery is technically very challenging, these concerns of scarcity have not caused market prices to rise to the point where a profit can be made from recovery. For the mix of metals contained in ICT equipment, some steps taken to recover precious metals enable the more efficient recovery of other “critical metals” in subsequent processing steps, with advanced technology, but not all of the “critical metals” contained in ICT equipment are recovered. However, there is ongoing research to more efficiently recover these materials, their market prices are currently rising, and there are proposals to subsidize their recovery, so there may be opportunities in the future to further broaden the scope of recovery from computing equipment.

5 Socio-economic issues

There is a wide range of social aspects that ought to be considered when thinking of the EOL management of ICT equipment. Their effect over the development of communities all around the world, and especially in developing countries, can be both positive and negative, depending on whether the EOL management of ICT equipment is managed responsibly or not.

Some developing countries are facing challenges in relation to e-waste imported under the disguise of second-hand equipment as well as generated domestically. It seems important for developing countries to adopt policies, legislation and standards in support of the creation of sustainable jobs and technology for environmentally sound management of EOL ICT equipment.

Even though refurbishing and reuse could be seen as a risk for manufacturers or traders, the regulated practices can support the protection of our global community and held to limit the operations of unlawful players on the market. One should be cautious of traders who call themselves “recyclers” and offer impressive economic benefits as a solution for the EOL management of ICT equipment by exporting equipment to places with low environmental and labour standards, low wages, and which render a relatively high value of recovered raw materials (achieved using such practices as burning of copper wires).

Uncontrolled disassembly, burning, and disposal cause a variety of environmental problems such as erosion of land, high water demands and contamination of ground sources and air pollution with carcinogens and neurotoxins. Fumes include dioxins and furans. Inappropriate methods of processing waste could lead to deforestation and the inevitable relocation of communities, animal life as well as the disappearance of ecological habitats. In addition, it could lead to health problems, including occupational health and safety issues, affecting the workers who are either directly or indirectly involved in processing waste.

Hard-rock mining of copper, silver, gold and other materials extracted from electronics is considered to have important damaging effects over different environmental aspects that can be considerably reduced when recycling that equipment.

The main problems recyclers face on a regular basis are items such as metal inserts in plastic, non-compatible plastic labels attached to plastic casings, rubber grommets and pads glued to plastic casings. All those items make it very difficult to economically recycle plastic. If those items are handled differently, then a variety of plastics would be recycled rather than land filled, especially plastics which contain a high proportion of fire retardants.

The time spent to dismantle the small piece of plastic from the component, whatever it may be, is not sometimes worth the labour as it has a very low value commodity.

One of the other areas that recyclers encounter in the disassembly process is the number of fixing to hold parts in place, especially battery fixings. It can make a huge difference on how the equipment is handled for best practice in reuse and recycling or simply plain shredding. Batteries need to be recovered easily, e.g. by a clip.

Sometimes, it is advisable for designers of new ICT equipment to work with future recyclers to understand how their products would be or are actually disassembled and recycled in the work place.

These are of course different concerns, depending on the type of materials used in manufacturing sustainable products, where designers can also play a crucial role:

- plastics: in particular the minimization of the number of polymers used and the marking of small pieces in order to facilitate identification;
- mercury containing backlights: work on easy and safe dismantling design, especially when fully-automated recycling solutions are available;
- provide easy removal for batteries, avoiding built-in batteries which are time consuming during the dismantling processes.

Ghana case study: social and environmental impacts of used ICT equipment and its end- of-life in developing countries with economies in transition

Social and environmental issues related to ICT, in particular used and end-of-life ICT equipment have a different dimension in the context of developing countries. The recently completed socio-economic assessment and feasibility study on sustainable e-waste management in Ghana which is a part of the E-waste Africa project coordinated by the Secretariat of the Basel Convention, suggested that the current e-waste management in Ghana leads to significant social and economic impacts on the informal workers.

Employment in the refurbishing and end-of-life of electronic and electrical equipment recycling sector involves exposure to rigorous and insecure working conditions and severe health hazards. Even children, sometimes as young as 5 years old, were observed to be involved in the recovery of materials from end- of-life of electronic and electrical equipment, earning less than USD 20 per month. Most of the people employed in the end-of-life of electronic and electrical equipment recycling, aged between 14 to 40 years, worked for 10 to 12 hours a day.

Despite the long working hours, most of the people employed in the refurbishing and end-of-life of electronic and electrical equipment recycling sector continue to live in extreme poverty. Monthly incomes of collectors were between USD 70 and 140, refurbishers between USD 190 and 250, and recyclers between USD 175 to 285. Expert opinion suggested that these incomes could go lower, in case regular supply or collection of end-of-life of electronic and electrical equipment was hindered. Hence, considering the partial or full dependency of family members – in urban areas of up to 6 people – on such incomes, it could be concluded that most of these workers lived below nationally and internationally defined poverty lines.

This is a significant revelation, especially considering that most of these workers originate from the northern part of the country where the majority of the poor live. Thus, even though engaging in the informal end-of-life of electronic and electrical equipment recycling did not necessarily ensure higher incomes, the workers preferred that sector as they had access to a regular income in the form of rapid cash flow – in contrast to agriculture-driven households in northern Ghana.

Valuing the recycling sector

In total, the informal refurbishing and end of life of electronic and electrical equipment recycling sector sustained between 121 800 to 201 600 people in Ghana. That represented about 1.04% to 1.72% of the total urban population, or 0.50% to 0.82% of the total population.

Due to the informal nature of refurbishing and end-of-life of electronic and electrical equipment recycling sector, its true value was not reflected in the national GDP. Nevertheless, based on the data of the total number of people employed in the refurbishing and WEEE recycling sector and their average salaries, the sector was estimated to contribute between USD 105 to 268 million indirectly to the national economy.

As for environmental impacts, during the informal e-waste recycling activities, high amounts of hazardous substances are released, with no thoughts given to the safety of the workers and the protection of the environment. This leads to significant negative impacts on the soil, air and water as well as on the human health.

The recycling activities at numerous small workshops within the scrap yard often take place directly on unfortified ground. Harmful substances released during dismantling therefore lead directly to discharges in the soil. Within the burning areas, scrap yard workers use numerous temporary fires to burn plastics, mainly from copper cables and wires and other mixed fractions.

The burning operations create an accumulation of ash and partially burned materials. Insulating foam from dismantled refrigerators, primarily polyurethane, or old car tyres were the main fuels used for the fires, contributing to acute chemical hazards and longer-term contamination at the burning sites. In order to quantify soil and ash as well as sediment contamination in Agbogbloshie, Greenpeace Research Laboratories carried out a small sampling campaign. The two soils and ash samples with the highest contamination showed copper, lead, tin and zinc concentrations over one hundred times higher than typical background levels. Concentrations of antimony and cadmium exceeded typical background soil levels by around fifty times and five times, respectively.

In addition to heavy metals, the samples also contained organic chemicals such as halogenated chemicals (e.g. polybrominated diphenyl ethers (PBDEs), used as flame retardants (mainly used in monitor and TV casings) and polychlorinated biphenyls (PCBs, often found in old condensers) as well as phthalates (commonly used as plasticizers in flexible PVC). The burning of PVC, in addition to releasing chemical additives including heavy metals and phthalates, can generate many organic chemicals itself. Dioxins and furans (PCDD/F) are formed as products of incomplete combustion of chlorinated organic materials, including PVC coated wires, with the reaction being catalysed by the presence of metals such as copper.

The Agbogbloshie market is situated on a flat ground alongside the Odaw River. During periods of heavy rainfall much of the site becomes flooded and it is likely that surface dusts and soils, along with any chemical contaminant they may contain, are carried into the adjacent, lower-lying lagoons and the Odaw River which ultimately flows into the ocean.

Although end-of-life treatment operations of e-waste give rise to further employment and income opportunities for a large group of people, they are also associated with severe environmental and health hazards, hence diluting the overall potentials and benefits to a large extent. Thus, the e-waste problem in emerging economies and developing countries needs a twofold approach:

- improvement of the local e-waste management capacities;
- better regulation of transboundary movements of used and obsolete ICT equipment.

6 Offsetting opportunities and mitigation

6.1 Corporate social responsibility (CSR)

Corporate social responsibility (CSR) is about how businesses align their values and behaviour with the expectations and needs of stakeholders – not just customers and investors, but also employees, suppliers, communities, regulators, special interest groups and society as a whole. CSR describes a company's commitment to be accountable to its stakeholders.

CSR demands that businesses manage the economic, social and environmental impacts of their operations to maximize the benefits and minimize the downsides.

Key CSR issues include governance, environmental management, stakeholder engagement, labour standards, employee and community relations, social equity, responsible sourcing and human rights.

CSR is not only about fulfilling a duty to society; it should also bring competitive advantages.

Through an effective CSR programme, companies can:

- improve access to capital;
- sharpen decision-making and reduce risk;
- enhance brand image;
- uncover previously hidden commercial opportunities, including new markets;
- reduce costs;
- attract, retain and motivate employees.

6.2 CO_2 management

The proliferation of e-waste legislation worldwide, as well as the actual momentum in the debate around climate change and the Kyoto Protocol, could lead to the opportunity of establishing market-based links between different environmental measures aiming at addressing at multinational level different societal problems and further promote and pave the road towards sustainable development and sustainable consumption and production. While global carbon markets are growing year-by-year, e-waste bills are in force in an increasing number of countries globally. Unfortunately, in the great majority of policy bills only a few types of products are covered by legislation. Specific targets on different WEEE categories are missing, particularly for those having a huge impact on the environment. All appliances are regarded as “equivalent” from an environmental perspective, while environmental priorities exist.

End-processing has neither specific targets, for instance, for ensuring proper recovery of precious and special metals from those appliances containing printed circuit boards, nor for ensuring a proper recovery of other relevant metals (iron, copper and aluminium particularly). Recovery of elements is usually regarded as a “weight perspective”: those elements present in few milligrams or parts per million in devices (such as special metals) are not addressed as a priority by policy makers in e-waste bills.

As seen in Figure 9: CO_2 emissions of precious and rare metals, the estimated CO_2 emissions for the primary production of some important metals used in the EEE industry (namely copper, cobalt, tin, indium, silver, gold, palladium, platinum and ruthenium) have been calculated to an annual CO_2 emission level of 23.4 Mt, almost 1/1 000 of the world’s CO_2 emissions. This includes neither CO_2 emissions from other metals used in electrical and electronic equipment as steel or aluminium, nor other CO_2 emissions associated with the manufacturing of electrical and electronic equipment.

Recovering metals from state-of-the art recycling processes generates only a fraction of these CO_2 emissions and has also significant benefits compared to primary mining in terms of land use and hazardous emissions. For example, the production of 1 kg of aluminium by recycling uses only 1/10 or less of the energy required for primary production, and prevents the creation of 1.3 kg of bauxite residue, 2 kg of CO_2 emissions and 0.011 kg of SO_2 emissions as well as the impacts and emissions associated with the production of the alloying elements used in aluminium. For precious metals, specific emissions saved by state-of-the-art recycling are even higher.

Figure 9: CO_2 emissions of precious and rare metals

Metal	Demand for EEE [t/a 2006]	% on global Prod.	CO_2 for primary prod. [t CO_2/ t metal]	CO_2 emissions [Mt]
Copper	4 500 000	30%	3.4	15.3
Cobalt	11 000	19%	7.6	0.08
Tin	90 000	33%	16.1	1.45
Indium	380	79%	142	0.05
Silver	6 000	30%	144	0.86
Gold	300	12%	16.991	5.10
Palladium	32	14%	9.380	0.30
Platinum	13	6%	13.954	0.18
Ruthenium	6	84%	13.954	0.08
Total				**23.4**

Considerations from the previous chapters lead to the need of investigation for establishing global allowance-based transactions, as well as carbon-offset projects, and voluntary carbon markets for the electronic industry as well as for the e-waste recycling industry.

The following considerations need to be taken into account for the three different scenarios mentioned above.

- First, there are potential, positive, environmental and economic benefits in allowing the *e-waste recycling industry to actively participate in the carbon markets*, which should be further researched in depth. Opportunities are related to the creation of market based and economic incentives to promote e-waste collection, while achieving simultaneously broader environmental benefits. At the same time, the creation of new business models for the recycling industry and the promotion of downstream valorization of material fractions having a greater potential of CO_2 equivalent emissions could be achieved and fostered. Moreover, the creation of new markets for actors having the obligation of surrendering a number of CO_2 allowances, meeting demand with new, environmentally sound EOL ICT equipment processes should be encouraged. This could be the case of carbon credits resulting from the recovery of GHG of C&F appliances or of precious and special metals which have a huge impact in primary mining.
- Secondly, there is a chance of *enabling project-based offsets for different stakeholders* (e.g. producers or recyclers) for setting up a take-back scheme in a country, or specific pre-processing or end-processing facilities, without legislative obligations (JI or CDM) with the following principles in mind: proving that the reduction of potential emissions have been verified according to existing standards (i.e. ensuring that carbon credits meet some general criteria and are validated and verified by an authorized body) and ensuring the environmental integrity (i.e. any emission reduction is real, measurable and additional to any that would have occurred in the absence of the project activity, preventing any free-riding).

  For the EEE industry or e-waste recycling industry to participate in CDM projects, they need to clearly address specific issues. At first, it is crucial to ensure the reductions of creating additional emissions over and beyond the business-as-usual scenario, ensuring that such projects would not have been implemented without the funding provided by carbon credits. Furthermore, a proper check of environmental integrity should be carried out; ensuring no escape route for free-riders is created, by giving the possibility for someone else to emit more e-waste.
- Thirdly, there is the option of *participation in voluntary markets*, enabling project-based offsets for different stakeholders (e.g. producers or recyclers) for setting up a take back scheme in a country without legislative obligations and enabling such credits to be part of the voluntary markets. A project has been launched recently in Brazil by Sens International, a Swiss-based organization, by setting up a recycling plant for refrigeration appliances and ensuring that CFC gases are destroyed, placing on voluntary markets the verified emissions reductions under the name of Swiss Charter Units (SCUs). The returns on the certificates are supporting operations of the facility and could be also invested in order to build other facilities.

The three different options described in the above paragraphs are not alternatives but rather complementary. Different implications exist in a full evaluation of the potential benefits of establishing such a link between carbon markets and e-waste management, particularly ensuring environmental integrity and a proper evaluation framework. It is clear that there is a need for multiple, complementary policy tools to address the global challenge of climate change.

7 Case studies

Computers for all

On 7 June 2007, UNIDO and Microsoft announced a joint initiative that would create a bridge between companies discarding used computer equipment and small and medium enterprises in Africa that could refurbish and repair the equipment for their own use. The Refurbished Computer Initiative for Small and Medium Entrepreneurs in Africa was signed by the Director-General of UNIDO and Dr Cheick Diarra, Chairman of Microsoft Africa at the first African subregional Forum on Information and Communication Technologies (ICT) Best Practices, held in Ouagadougou, Burkina Faso.

Microsoft and UNIDO have been working together since July 2006 to promote innovative uses of ICTs that support entrepreneurship and help promote investment and create business opportunities for SMEs in Africa. According to Dr Cheick Diarra, there is a great demand for affordable computers among the SME community in Africa. The UNIDO-Microsoft initiative sets stringent quality criteria for refurbished computers, including warranties and after-sales service. Since electronic waste is a global problem, the agreement also stipulates ways for the eventual disposal and recycling of obsolete computers.

In a subsequent development on 21 September 2007, a letter of intent was signed jointly by UNIDO, the Government of Uganda and Microsoft aimed at promoting the development of local software solutions in Uganda. The letter of intent followed a July 2006 memorandum of understanding between UNIDO and Microsoft in which both partners agreed on a new strategic collaboration to tackle the root causes of poverty by promoting innovative uses of information and communication technologies. These would, in turn, support entrepreneurship and help promote investment and create business opportunities, especially for small and medium-sized enterprises in Africa. Six district business information centres will provide rural businesses and those who operate them with integrated solutions, instruction in technology and entrepreneurial skills and Internet access. Under the second phase of the project, the number of these centres will be increased to eight. Microsoft has researched rural computing in India extensively and will now apply its knowledge in Uganda.

Microsoft: voluntary recycling

Despite the fact that there are no mandatory recycling laws in the US for gaming consoles, PC peripherals, and music players, Microsoft chose to extend its sphere of responsibility into electronics recycling. It implemented three methods by which its US customers can recycle their consoles, Zunes, and PC peripherals.

First, it partnered with Dell to support the collection/recycling of electronics equipment that is collected via the *Goodwill Reconnect Program*.[12] This programme enables Microsoft's customers to drop off their unwanted electronics at any of the 1 000+ participating collection points throughout the US.

Second, Microsoft began offering its customers the option of returning electronics to its brick and mortar stores. Like the Reconnect programme, Microsoft Stores accepts all brands of electronics, not just Microsoft branded equipment, to ensure that they are properly recycled.

There is also a third option for those customers who do not live near a participating Reconnect Goodwill drop-off location or Microsoft Store – customers can contact the company via email at: eRecycle@microsoft.com and Microsoft will provide a prepaid UPS label to send Microsoft branded equipment directly to the recycle station. All of the company's recyclers are ISO 14001 certified and have been audited by Microsoft and third party auditors to ensure they meet the company's standards to responsibly and completely recycle all equipment and follow all contractual guidelines.

GlaxoSmithKline: USD 1.8 million gain

"How often can you say that an IT department is generating revenue – seven-figure revenue – for its company?" asks Armin Jahromi, Service Development Manager, GlaxoSmithKline.

Like most large companies, GlaxoSmithKline (GSK) had ever-increasing amounts of outdated equipment (used computers, old printers, and abandoned scanners) cluttering its offices and – when that equipment

[12] Visit the site at: http://reconnectpartnership.com for more information.

remained plugged-in – consuming electricity. But unlike most large companies, GSK decided to do something about it. Working with PlanITROI, a commercial refurbisher, GSK launched an eCycling programme that removed the unwanted equipment, netted it USD 1.8 million in asset value recovery activities over two years, and reduced its carbon footprint by 143 tons.

Verizon Wireless' HopeLine Programme

HopeLine puts Verizon's technology to work in communities by turning no-longer-used wireless handsets and accessories into support for the victims of domestic violence, all while helping to protect the environment by disposing of phones in an environmentally sound way.

Since the HopeLine reuse and recycling programme was launched in 2001, Verizon Wireless has:

- collected more than 8 million phones through our stores and other points nationwide,
- awarded more than USD 14 million in cash grants to domestic violence agencies and organizations throughout the U.S.,
- distributed more than 123 000 phones with more than 406 million minutes for free wireless service to be used by victims of domestic violence,
- properly disposed of nearly 1.72 million phones in an environmentally sound way and refurbished the remaining units,
- kept more than 210 tons of electronic waste and batteries out of landfills.

Wireless phones given to HopeLine are refurbished and sold for reuse, generating proceeds for the programme. Refurbished phones, complete with 3 000 minutes of wireless service, are provided to local domestic violence prevention organizations or local law enforcement agencies for use with their domestic violence clients. If donated phones are unsalvageable, they are recycled in an environmentally sound way under a zero landfill policy.

8 Checklists

8.1 An internal prospective

For successful E-waste management it is necessary that each organization not just understands what types of wastes it generates but also streamlines the processes for its safe reuse, recycling or disposal. Here are 6 steps that will nudge organizations to grapple with the challenge of responsible e-waste disposal.

Who is responsible for end-of-life within the organization?

Identifying departments which will be responsible is very important. Typically within large corporates e-waste like computers monitors and telecommunication will be generated and will come under the IT department's responsibility. These assets will be tagged and inventory available with IT department. Other types of electrical and universal wastes like fans, coffee machines, and printer cartridges could come under the jurisdiction of facilities. Universal wastes like batteries, compact fluorescent lamps (CFL) mercury containing lamps, would also come under the jurisdiction of facilities. It is necessary to identify the departments who will deal with e-waste. There may be more than one department responsible for different types of e-waste such as facilities, housekeeping, purchase and accounts etc. Clear responsibilities with respect to End-of-life management options assigned to each department. Person with defined roles and responsibilities must be identified for each department.

What do we track?

Understanding the types of end-of-life management options that the organization will generate is the key to the inventory. Inventory is a list of all the items that could be classified as end-of-life management options. Inventory will have information of source of waste, the type of waste and the quantity of waste. Inventory of e-waste and tracking from purchase – use – disposal is vital step for managing end-of-life management options. Organizations departments and business enable functions may sometimes be confused what is classified under end-of-life management options. Therefore all the responsible departments will need to have a complete list of all types of e-waste product generated in the organization. Suitable software could ensure a complete tracking of the material and identification of material which reaches its end-of-life. This software will help in maintaining the status of each item. Items which are bonded should be identified through pasting of an appropriate sticker with relevant details in terms of date and number.

IT Asset management solutions help organizations manage their IT assets from procurement to retirement. The first step of e-waste management is therefore in the inventory of retired assets. Such tracking mechanisms do exist within large organizations and hence could be leveraged to achieve end-of-life reporting and management requirements.

Where do we store the e-waste?

A suitable storage space is required which is sufficiently large to store all the e-waste safely. Storage norms are required for each category of e-waste. For example CFLs and fluorescent lamps which are fragile should be safely placed in drums or put in the original packing. Likewise a dedicated bin is required for printer cartridges. This storage space should be separate from space allocated for other scrap including old chairs and other metal scrap.

What permissions are to be sought?

Registration with the environmental authority companies is needed. These companies have independent facilities and are registered under the current and applicable legislation, and have to apply to the pollution control board (PCB) or regulatory body for registration which allows them to store hazardous waste (e-waste) as per relevant local and federal laws. This may vary from country to country. Typically country specific norms have to be adhered here.

How can we provide end-of-life management solutions?

The company must identify a suitable e-waste recycler who is authorized to recycle e-waste. The organization must enter into an agreement with this recycler. Groups of companies located with the common collection centre can use this facility to dispose of end-of-life products. Alternative options such as upgrades on existing machines, or reuse of electronic equipment in different departments before final disposal could be encouraged. A process to ensure which equipment can be reused before recycling is a good way to extend the life of the product.

Remanufacturing of printer cartridges: used printer cartridges can be handed over for remanufacturing. This ensures that the entire shell of the cartridge which is made up of plastic is used again instead of being crushed and recycled.

What documentation do we need to collect?

The e-waste collected is documented, which will be handed over to the company by the recycler. This document is evidence of the total quantity of products handed over for recycling. A copy of this document is usually also handed over by the company to the pollution control board or relevant regulatory body. Relevant documentation varies from country to country. End-of-life reporting is now an added burden for most organizations worldwide.

The recycler would need to keep track of processes, volumes, and origin of the end-of-life products for routine regulatory check-up. It would be good practice for recyclers to share this report with the client company as well as the regulatory authorities.

1. Identification of responsibility for end-of-life within the organization	☐
2. End-of-life inventory, and tracking of items from the time of purchase	☐
3. Storage facilities for e-waste	☐
4. Sourcing end-of-life management solutions from recycler companies	☐
5. Registration with the relevant environmental authority, plus permissions	☐
6. Definition of documentation needed from recycler	☐
7. Flow of end-of-life and e-waste information into management systems	☐

8.2 The perspective of high-technology business districts

In several parts of the world which are IT-intensive, such as India and China, governments have set up special economic zones (SEZs). SEZ's enjoy a special status which facilitates the export of goods manufactured in these areas. Due to this status, all electronic goods which are purchased for use inside the SEZ are bonded and when they have to be disposed of, they need to undergo a process of de-bonding which is a cost to the company in form of excise duty. This is an additional process that organizations operating out of an SEZ would need to adopt into the end-of-life management.

8.3 The perspective of a donation receptor

The donation of used electronic equipment is practiced worldwide, thereby extending the life of these goods. Organizations that accept donations (donation receptor) need to understand how to responsibly dispose these goods at their end of life. It would be a good practice for the donor and receptor to mutually agree to dispose these goods through an authorized recycler. Keeping track of donated goods and received goods would therefore be required to ensure tracking and avoiding leakages.

9 Conclusions

As a general principle, ICT equipment management should follow a life cycle approach. This includes reuse, refurbishment, recycling and environmentally sound disposal operations as described in this document.

The scale of success of the ICT industry worldwide coupled with its regular refreshing of its product lines means that the quantities of end-of-life ICT assets is huge, and continues to grow. Organizations throughout the world need to set an enforce end of life policies, and build collaborative links with the recycling industries.

This is not just a problem within companies – consumers too need to understand and be aware of the issues surrounding end-of-life ICT assets. Clearly, ICT companies can play a significant role here in helping their customers gain such an understanding so that they act appropriately in this regard.

Ultimately, end-of-life management is about identifying and sticking to good quality processes regarding asset management, information management, reverse logistics, dismantling, refurbishing, reuse, recycling and recovery. The good news for organizations is that companies that do this well will meet their corporate responsibilities while acting as efficiently as possible in the context of business performance. Clearly, this should be a strong driver for more organizations buying into end- of-life management.

9.1 Suggestions to ITU-T SG 5

The suggestions listed below cover the areas where there is an opportunity to develop further work in order to achieve superior end-of-life performance development within the ICT sector, and are presented to ITU-T SG 5 for its perusal:

1. ICT product design issues

Clean supply chain; reduction of the demand on limited natural resources, which is measurable and tractable; designing products that through their different life cycle stages reduce environmental impact and waste generation; designing, producing, labelling in compliance to the requirements of legislation in place, commercialization of products that have a reasonable extensive life and that once they achieved the end of life, can easily be repaired or dismantled for reuse or its value recovered via recycling or its life finalized in the best environmental possible manner without impacting economic growth.

2. Technical guidance applicable to refurbishment and repair facilities as well as marketing of used ICT equipment

Risk prevention and minimization; processing and management of equipment and components destined for reuse; management of materials, components and residuals destined for recycling or disposal; and, record keeping and performance measurement (partly covered here).

3. Environmental and socio-economic aspects

Uncontrolled burning, disassembly, and disposal causes a variety of environmental problems affecting directly or indirectly human health such as erosion of land, high water demands and contamination of ground sources, air pollution with carcinogens and neurotoxins. Fumes include dioxins and furans. Inappropriate method of processing waste could lead to, deforestation and the inevitable relocation of communities, animal life as well as the disappearance of ecological habitats. In addition, this could lead to health problems including occupational health and safety issues, affecting those who are either directly and indirectly involved, due to the methods of processing the waste; etc. (partly covered here).

There must be a direct guidance to the industry in order to help governments and communities to end bad practices such us uncontrolled burning and to secure that material is being handled properly. This industry movement needs to take into account the micro-economics that have been developed around those practices harmful as they are to society and the environment, because they represent are the only income for thousands of families who cannot be excluded from employability access in the world.

4. Principles for donors of ICT equipment

Ensure that products are functional and that appropriate products are provided; availability of technical support in the country of destination; and, ensure full transparency, contract and notification and consent prior to delivery.

5. Development of national ICT policies

Ensure that the life-cycle approach is used for developing national ICT policies. This means that such issues, as, *inter alia*, green design, collection, recycling, disposal should be considered in the policy.

6. Map guidance document on ICT applicable standards and legislation

Develop a map or guidance document that lists all different end-of-life standards currently available around the world, highlighting the aim, resources needed, pros/cons, boundaries, expectations, possible overlapping or relation with others, as well as the differences among them. This document, which would need to be updated regularly, will be of help to the user to identify, differentiate, and make an independent decision over which standard to use according to the needs and objectives of the stakeholder on its specific role within the recycling chain.

7. Development of a global CO_2 – equivalent market

Developing a market for CO_2 trading will help to directly control and incentivize reduction on pollution emissions through the use of best practices available and technology, as well as making use of economic incentives and fees over the direct effect of the environmental impacts generated by inappropriate ICT disposal, locally or overseas.

8. Recovery of rare metals and green ICT supply chain

In the effort to achieve a green supply chain within the ICT sector, it is recommended that ITU-T SG 5 actively includes and facilitates access to the recycling and precious metals industry in the discussions and possible developments that aim to return such metals to the industry with the physical and technical characteristics needed to satisfy new equipment production requirements. It is this industry that has the practical knowledge on the technical aspects and feasibility opportunities and limitations of the recovery process.

10 Glossary

BAT	Best Available Technique
BDE	Brominated Diphenyl Ether
BEP	Best Environmental Practice
BFR	Brominated Flame Retardants
BS	British Standards
BSI	British Standards Institute
C&F	Cargo and Freight
CFL	Compact Fluorescent Lamps
CO_2	Carbon Dioxide
CPU	Central Processing Unit
CRT	Cathode Ray Tube
CSR	Corporate Social Responsibility
DEFRA	Department for Environment, Food and Rural Affairs (UK)
EC	European Commission
EEE	Electrical and Electronic Equipment
EMAS	Environmental Management and Audit Systems
EMS	Environmental Management System
EPA	Environmental Protection Agency
EPR	Extended Producer Responsibility
EU	European Union
GHG	Greenhouse Gas
GHGP	Green House Gas Protocol (of the WRI)
ICT	Information and Communication Technologies
ISO	International Standards Organization
ITU	International Telecommunication Union
LCA	Life Cycle Assessment
LCD	Liquid Crystal Display
LED	Light Emitting Diode
Li-ion	Lithium ion (battery)
MEAS	Multilateral Environmental Agreements
NGO	Non-Governmental Organization
NiCd	Nickel Cadmium
NiMH	Nickel-Metal Hydride (battery)
OECD	Organisation for Economic Co-operation and Development
OEM	Original Equipment Manufacturer

OSH	Occupational Health and Safety
PCB	Pollution Control Board
PCB	Printed Circuit Board
PFO	Perfluorooctane Sulfonic Acid
PFOf	Perfluorooctane Sulfonyl Fluoride
PFOs	Perfluorooctane Sulfonic Acid Salt
POP	Persistent Organic Pollutants
POST	Power on Self-Test
PPE	Personal Protective Equipment
PVC	Polyvinyl Chloride
PWB	Printed Wiring Board
REACH	Restriction, Evaluation and Authorization of Chemicals
RoHS	Restriction of certain Hazardous Substances
SCUs	Swiss Charter Units
SEZ	Special Economic Zone
SG 5	Study Group 5 (of the ITU-T)
SOx	Sulfur Oxides (various forms)
UK	United Kingdom
WEEE	Waste Electrical and Electronic Equipment (European Union Directive)

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12 Annexes

Annex I[13]

Table 1: Example of functionality tests for used computing equipment

Computing equipment	Functionality tests	Test results
Central processing units (CPUs), including desk top PCs	**Power on self test (POST)*** Switching on the computer and successfully completing the boot up process. This will confirm that the principal hardware is working, including power supply and hard drive. • A working monitor would need to be used if none present • Ensure that cooling fans are functioning • Remove dust as much as possible (e.g. delicately using a vacuum cleaner is possible), in order to ensure better cooling and stable operation	**Computer** should boot up successfully **Computer** should respond to keyboard and mouse input **Cooling fans** should operate normally. No strong mechanical sound denoting end-of-life of fans
Laptops/notebooks	**Power on self test (POST)*** Switching on the laptop and successfully completing the boot up process. This will confirm that the principal hardware is working, including power supply and hard drive. • Test screen • Test battery functionality and safety • Ensure the display is fully functional • Ensure cooling fan(s) is functional	**Laptop** should boot up successfully **Laptop** should respond to keyboard and mouse input **Display** turns on during boot up. Image should be clear and colours contrast and brightness correct with no screen burned images, scratches or cracks (see also below for display devices). **Laptop battery** able to retain a minimum of 1 hour[14] of run time; or battery tested to determine the full charge capacity in watt-hours also with a minimum of 1 hour remaining (see laptop batteries section below, paragraph 120). Check if connections are clean, no deformation due to heat on the battery pack, no hotspots during charge/discharge test
Keyboards	Connect to computer and ensure they successfully interface Test keys for functionality	Computer should respond to **keyboard** input **Keyboard** should have no missing or non-functioning keys

13 For more information, see PACE Guidance Document on the Environmentally Sound Management of Used and End-of-Life Computing Equipment, 2011.

14 One hour is a minimum charge a battery should hold, although some users of laptops may request more useable runtime. It should be noted that some end users will also be able to make use of batteries with less capacity. For example, a battery able to hold a 40-minute capacity need not be discarded, and can have use for those principally connecting the laptop to a reliable electricity supply using the charger. However, for the purposes of this document and for export, batteries must hold at least a one-hour charge.

Computing equipment	Functionality tests	Test results
Mice	Assess mouse casing, cable and parts Plug into computer or laptop to assess functionality	**Mouse** should have all parts present (e.g. the roller ball). Computer should respond to **mouse** input. Visible cursor on screen should not judder
Cables and power cords	Assess cable insulation and inspect plugs	**Cabling and plugs** should be complete and free of damage, e.g. has no cracked insulation Any detachable cable with damage should be replaced by a new one to avoid electric shocks or premature failures
Display devices	Plug in display and test the picture quality for pixels, colour, contrast and brightness. Software based diagnostic testing for display devices are readily available on line[15], and should be used Visual inspection for screen burn (CRTs) or "image persistence" (flat screens), scratches or other damage to screen or housing Cabling should be inspected and present	**Display devices** The picture should not be fuzzy, or have damaged pixels, or be too dark. LCD backlights should all function. Colours, brightness, hue and straightness of lines should be considered The software diagnostic test should be positive Cabling should be free from damage. Any detachable cable with damage should be replaced by a new one to avoid electric shocks or premature failures
Laser and inkjet printers	A test page can be successfully printed This can be standalone but also from a computer or local area network to assess connectivity For inkjet printers, check that the ink heads are not clogged with dry ink	**Printers** should successfully print a test page and not jam, or produce a smudged or incomplete copy
Components (removed from equipment) including mother boards, other circuit boards, sound cards, graphics cards, hard drives, power supplies and cords/ cables	Components should be gently wiped from dust to improve thermal exchange and allow better cooling Components should be tested for functionality either before removal from the host computer or laptop, or by insertion in a test bench computer using diagnostic software, or a known working device as applicable	**Components** should be fully functional **Power supplies and cords / cables** should be complete and free of damage, e.g. has no cracked insulation. Any detachable cable with damage should be replaced by a new one to avoid electric shocks or premature failures

[15] See for example: www.softpedia.com/progDownload/Nokia-Monitor-Test-Download-464.html.

Annex II

Disposal operations

(Annex IV of the Basel Convention)

A. Operations which do not lead to the possibility of resource recovery, recycling, reclamation, direct reuse or alternative uses

Section A encompasses all such disposal operations which occur in practice.

D1	Deposit into or onto land, (e.g. landfill, etc.)
D2	Land treatment, (e.g. biodegradation of liquid or sludgy discards in soils, etc.)
D3	Deep injection, (e.g. injection of pumpable discards into wells, salt domes of naturally occurring repositories, etc.)
D4	Surface impoundment, (e.g. placement of liquid or sludge discards into pits, ponds or lagoons, etc.)
D5	Specially engineered landfill, (e.g. placement into lined discrete cells which are capped and isolated from one another and the environment, etc.)
D6	Release into a water body except seas/oceans
D7	Release into seas/oceans including sea-bed insertion
D8	Biological treatment not specified elsewhere in this Annex which results in final compounds or mixtures which are discarded by means of any of the operations in Section A
D9	Physico-chemical treatment not specified elsewhere in this Annex which results in final compounds or mixtures which are discarded by means of any of the operations in Section A, (e.g. evaporation, drying, calcination, neutralization, precipitation, etc.)
D10	Incineration on land
D11	Incineration at sea
D12	Permanent storage (e.g. emplacement of containers in a mine, etc.)
D13	Blending or mixing prior to submission to any of the operations in Section A
D14	Repackaging prior to submission to any of the operations in Section A
D15	Storage pending any of the operations in Section A

B. Operations which may lead to resource recovery, recycling reclamation, direct reuse or alternative uses

Section B encompasses all such operations with respect to material legally defined as or considered to be hazardous wastes and which otherwise would have been destined for operations included in Section A.

R1	Use as a fuel (other than in direct incineration) or other means to generate energy
R2	Solvent reclamation/regeneration
R3	Recycling/reclamation of organic substances which are not used as solvents
R4	Recycling/reclamation of metals and metal compounds
R5	Recycling/reclamation of other inorganic materials
R6	Regeneration of acids or bases
R7	Recovery of components used for pollution abatement
R8	Recovery of components from catalysts
R9	Used oil re-refining or other reuses of previously used oil
R10	Land treatment resulting in benefit to agriculture or ecological improvement
R11	Uses of residual materials obtained from any of the operations numbered R1-R10
R12	Exchange of wastes for submission to any of the operations numbered R1-R11
R13	Accumulation of material intended for any operation in Section B

Annex III

General references to the legislation, international standards and guidance documents

- Basel Convention: Control of Transboundary Movements of Hazardous Wastes and Their Disposal – adopted 1989, with amendments;
- Regulation (EC) No 1418/2007 of 29 November 2007 concerning the export for recovery of certain waste listed in Annex III or IIIA to Regulation (EC) No 1013/2006 of the European Parliament and of the Council to certain countries to which the OECD Decision on the control of transboundary movements of wastes does not apply;
- Regulation (EC) No 967/2009 of 15 October 2009 amending Regulation (EC) No 1418/2007 concerning the export for recovery of certain waste to certain non-OECD countries. This regulation takes account of additional answers by non-OECD countries concerning their rules on import of green-listed non-hazardous wastes.
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- Future information systems for chemicals in products, in particular for EEE (a set of work under the lead of UNEP Chemicals Branch, still ongoing).
- ISO/IEC 27001:2005: Offers guidelines and general principles for initiating, implementing, maintaining, and improving information security management in an organization. The objectives outlined provide general guidance on the commonly accepted goals of information security management.
- Regulation (EC) No 1013/2006 of the European Parliament and of the Council of 14 June 2006 on shipments of waste – applicable since 12 July 2007.
- Regulation (EC) No 1379/2007 of 26 November 2007 This regulation includes in particular a revision of the forms for notification and movement documents and for the information to accompany shipments of green-listed waste.
- Special provisions for waste shipments to new Member States: Transitional rules are now contained in Article 63 of Regulation 1013/2006. Before, they were laid down for 7 new Member States in the respective Acts of Accession:
- Latvia: Annex VIII to the Act of Accession of 2003, chapter 10.
- Poland: Annex XII to the Act of Accession of 2003, chapter 13(B).
- Slovakia: Annex XIV to the Act of Accession of 2003, chapter 9(B).
- Bulgaria: Annex VI to the Act of Accession of 2005, chapter 9(B)(at p. 16).
- Romania: Annex VII to the Act of Accession of 2005, chapter 9(B)(at p. 21).
- Regulation (EC) No 1013/2006 of the European Parliament and of the Council of 14 June 2006 on shipments of waste – applicable since 12 July 2007.
- Council Directive 91/689/EEC: Hazardous waste.
- Directive 2006/66/EC: On batteries and accumulators and waste batteries and accumulators.
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