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SERIES L: CONSTRUCTION, INSTALLATION AND PROTECTION OF CABLES AND OTHER ELEMENTS OF OUTSIDE PLANT

Life-cycle management of ICT goods

ITU-T L-series Recommendations – Supplement 5

ITU-T

Supplement 5 to ITU-T L-series Recommendations

Life-cycle management of ICT goods

Summary

Supplement ITU-T L.Suppl.5 has been developed to provide information for the practical implementation of the life-cycle approach in companies, facilities and plants as well as distributors, including chapters on best practices with a specific focus on material usage and selection.

The information on facilities and the different stakeholders includes:

- ICT product design issues, supplementing international standard IEC 62430 on environmentally-conscious design for electrical and electronic products, with a focus on practical implementation;
- ICT life-cycle approach to address health, environment and socio-economic aspects including avoiding hazardous emissions from uncontrolled disassembly, burning or disposal of e-waste, occupational health and involvement of the informal sector;
- reduction of the end of life impact through technical guidance applicable to refurbishment and repair facilities;
- reuse and end of life management;
- marketing of used ICT goods, including risk prevention, minimization measures and eco-environmentally sound processing;
- donation of ICT goods, including quality control for donated equipment, technical support in the country of destination, following international procedures on transparency and documentation of contracts, notifications and consent prior to delivery;
- management of equipment and components destined for reuse.

History

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Keywords

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

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

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

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1 Scope

This Supplement provides information for the practical implementation of the life-cycle approach in companies, facilities and plants as well as distributors, including chapters on best practices with a specific focus on material usage and selection.

2 Definitions

This Supplement uses the following terms:

2.1 pre-consumer material: Material diverted from the waste stream during a manufacturing process. Excluded is reutilization of materials such as rework, regrind or scrap generated in a process and capable of being reclaimed within the same process that generated it.

2.2 post-consumer material: Material generated by households or by commercial, industrial and institutional facilities in their role as end-users of the product which can no longer be used for its intended purpose. This includes returns of material from the distribution chain.

2.3 recovered and/or reclaimed material: Material that would have otherwise been disposed of as waste or used for energy recovery, but has instead been collected and recovered and/or reclaimed as a material input, in lieu of new primary material, for a recycling or a manufacturing process.

2.4 recycled content: Proportion, by mass, of recycled material in a product or packaging. Only pre-consumer and post-consumer materials should be considered as recycled content.

2.5 recycled material: Material that has been reprocessed from recovered [reclaimed] material by means of a manufacturing process and made into a final product or into a component for incorporation into a product.

3 Abbreviations and acronyms

This Supplement uses the following abbreviations and acronyms:

BFR Brominated Flame Retardants

BOF Basic Oxygen Furnace

CO_2 Carbon Dioxide

DfE Design for Environment

DfR Design for Recycling

DfRE Design for Resource Efficiency

EAF Electric Arc Furnace

EPR Extended Producer Responsibility

ESM European Stability Mechanism

ICT Information and Communication Technology

LCA Life Cycle Assessment

ME Material efficiency

PCB Printed Circuit Board

WEEE Waste Electrical and Electronic Equipment

WLAN Wireless local area network

4 ICT goods covered by this Supplement

The Supplement addresses mainly the following equipment:

– Cellular radio base stations
– Fixed access network (for Internet services)
– WLAN
– Routers
– Business telephony equipment
– Mobile phones
– Personal computers and laptops
– Scanners, printers and peripherals
– For more examples see [b-ITU-T L.1410]

5 Material selection for products

5.1 Resource efficiency

Resource efficiency is about the optimization of selection, use, reuse and recycling of materials throughout the product life cycle.

$$ME = \frac{Economical\ benefit}{Impact\ from\ material\ extraction, usage\ and\ end\ of\ life\ treatment}$$

The equation for material efficiency (ME) is derived from the eco-efficiency definition in [b-ISO 14045]. It includes the optimal use of materials across the product lifecycle and value chain starting from raw material extraction and conversion, product design and manufacture, transportation, use and re-use ending to recovery, disposal or recycling. This total life cycle approach of resource efficiency also includes the energy needed to create a certain material. The opportunities to improve the resource efficiency of a product are not limited to a certain stage of the lifecycle and improvements at one stage can have a significant impact on another.

The "Economical benefit" describes the positive impact from the usage of the material in a certain product and its resulting services. The usage of a certain material might improve the performance and hence value of a product considerable compared to an alternative material.

Resource efficiency basically means that "more is achieved with less". In this way a smaller amount of material is needed to produce a product and raw materials are kept in use for a longer time once they have been extracted. Improvement in resource efficiency is a constant objective of companies as they strive to improve their economic and financial performance (cost reduction and increased competitiveness). Increase in resource efficiency may come from raw materials production, product manufacturing, use and/or end-of-life.

Proper product design, material selection and using of recycled material are means to improve resource efficiency. Full product lifecycle needs to be considered to get the full impact from materials.

5.2 Design for resource efficiency

There are already approaches for design for environment (DfE) (also terms environmentally conscious design (ECD) and eco-design are used) and design for recycling (DfR). Recently design for resource efficiency (DfRE) has received increasing interest. Depending on the definition, resource efficiency can retain raw material consumption only, or the consumption and pollution of natural resources. Resources are not only an eco-environmental concern, because raw material availability is a critical issue for many industrial sectors. Design for environment blends eco-environmental aspects into product design and development to enhance environmental performance throughout the product's lifecycle.

Design for environment can be roughly divided into development work, which seeks new, more eco-environmentally aware basic technical solutions (e.g., materials, processes, structures, manufacturing methods). Design for environment could include many research features, and activities aiming to reduce the adverse eco-environmental impacts of existing structures and basic solutions.

Design for recycling is an important sector of design for environment. It aims to facilitate and increase after use recycling and enable other ways of utilizing components. Design for recycling is a method that implies the following requirements of a product: easy to dismantle, easy to obtain 'clean' material-fractions, that can be recycled (e.g., iron and copper should be easy to separate), easy to remove parts/components, that must be treated separately, use as few different materials as possible, mark the materials/polymers in order to sort them correct, avoid surface treatment in order to keep the materials 'clean'.

Resource efficiency pursues three objectives:

- reducing eco-environmental impacts,
- improving material supply security including lowering import dependency e.g., for metals,
- saving costs in production.

The necessity of sustainable use of raw materials is widely accepted, but there is no consensus on how material use should be measured. This measurement can be made based on definition of physical indexes such as mass and material input per service unit, or mid-point impact assessment indicators of Life cycle assessment (LCA) such as mineral resource depletion or fossil fuel depletion. From the perspective of life cycle based sustainability assessment, DfR approaches are not always sustainable, because they only look at the output side of a product and try to make it easy to deal with the waste at the end-of-life. From a sustainability perspective, it is necessary to look at the input side, e.g., how much of these materials actually replace virgin materials. Sometimes recycling increases overall eco-environmental burdens and resource demands.

Weight reduction is a critical objective in design for resource efficiency in any product. It reduces the cost of manufacture, installation and logistics, saves materials and energy and there is less material to be recycled or disposed of at the end of product's life. System miniaturization has been a long-time trend in the electronics industry.

5.3 Resource efficiency indicators in life cycle assessment

LCA is based on life cycle thinking which means taking into account the whole life cycle of the product. This begins from raw material extraction and conversion, continues to manufacturing, distribution and use. The life cycle ends with so called end-of-life stage, including re-use, recycling of materials, energy recovery or disposal. The core of life cycle thinking is to avoid eco-environmental burden shifting. This means minimizing impacts at one stage of the life cycle, or in one eco-environmental impact category, while avoiding increases elsewhere. [b-ITU L.1410] defines the attributional LCA method in detail for ICT goods.

In the LCA study impact assessment phase, some parts of the inventory are classified into selected mid-point eco-environmental impact categories as shown in Figure 1.

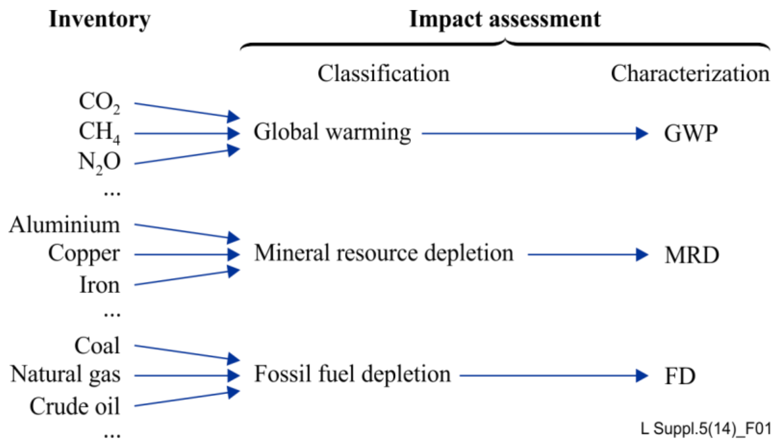


Figure 1 – Example framework of the impact assessment steps and impact categories at the mid-point level

In design for resource efficiency three impact categories are very important for Telecom goods: climate change, mineral resource depletion and fossil fuel depletion.

5.4 Eco-environmentally informed material choices

The engineering properties of materials, i.e., their mechanical, thermal and electrical attributes, are well characterized. They are measured with sophisticated equipment according to internationally accepted standards. Additional metrics are needed to incorporate eco-environmental objectives into the design process.

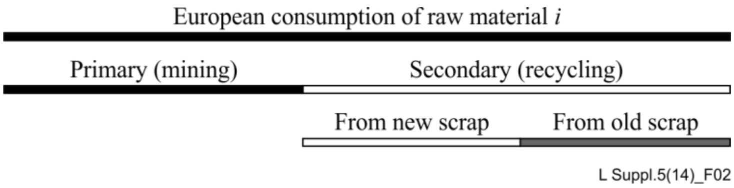
In Table 1, three example eco-environmental attributes of materials are presented. Recycled material content is one attribute, because enhancing the recycled material content when producing new raw materials is important. The main eco-environmental impacts of enhancing recycled material content are to reduce mineral resource usage and also reduce fossil fuel depletion. The next eco-environmental attribute embodied energy means primary energy (renewable and non-renewable) used in making one kilogram of material. The environmental impact of minimizing embodied energy is fossil fuel depletion. The third eco-environmental attribute is carbon dioxide (CO_2) equivalents which refers to climate change environmental impact and is closely connected to embodied energy.

Table 1 – Example eco-environmental attributes of materials

Eco-environmental attribute	Eco-environmental impact
Recycled material content	Mineral resource and fossil fuel depletion
Embodied energy	Fossil fuel depletion
CO_2 -equivalents	Climate change

5.5 Primary and secondary material usage in production

The raw material production of metals can make use of a combination of primary and secondary sources and both pathways need to be understood as complementary. Whether the recycled metals are used in the same product group or in another application does not really matter, since both primary and secondary metals are traded on a global scale and any quantity of recycled metal directly impacts its demand supply balance. For most metals their recycling does not lead to deterioration in quality, meaning that in theory such cycles could continue forever.

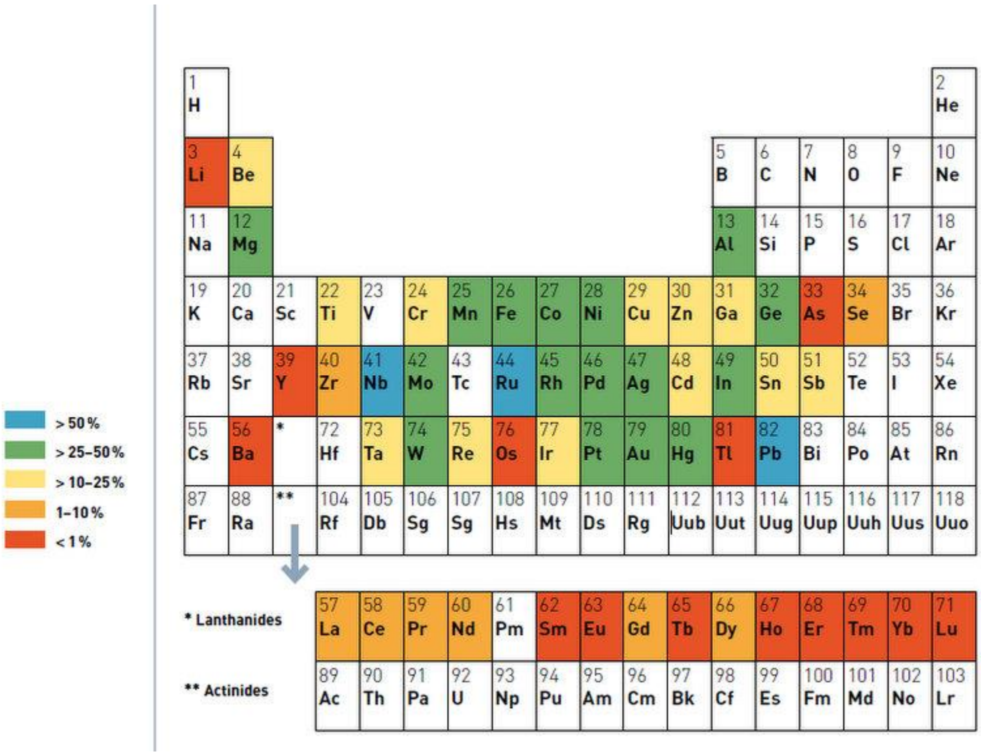


(Source: European Commission 2010)

Figure 2 – Materials recycled content rate

In Figure 2, new scrap refers to scrap resulting from the processing of raw material from primary sources and old scrap refers to raw material which has been recycled at the of the life products.

The new scrap availability depends on the degree of metal use and the process efficiency in manufacturing. The old scrap availability is a function of metal use a product lifetime ago, in use loss over the product lifetime and the efficiency of the end-of-life collection and recycling system. High growth rates in metal demand in the past, together with long product lifetimes, has resulted in availability of old scrap quantities being typically smaller than the metal demand of production. Thus recycled material contents are smaller than 100%.



(Source: [b-UNEP])

Figure 3 – The periodic table of global average recycled content

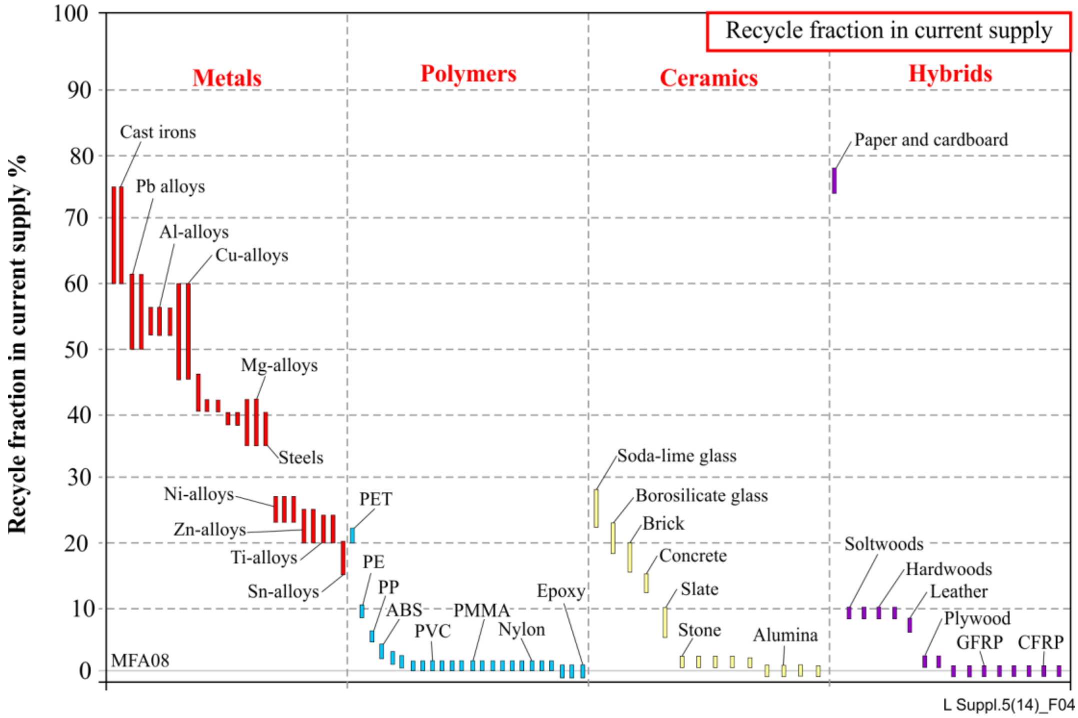
The recycling content is in the total metal input to metal production for sixty metals. Boxes that are not coloured indicate that no data or estimates are available.

In Figure 3 the recycled content is over 50% only for lead (Pb), niobium (Nb) and ruthenium (Ru). The recycled content is between 25-50% for the most generally used metals such as iron (Fe) and aluminium (Al).

Recycling efficiencies can be improved based on the fact that material's cycles should be transformed from open to closed, or at least less open compared to the present situation. Open cycles are typical to many consumer goods such as cars, electronics and small appliances. Closed cycles are typical for many industrial goods, such as machinery tools and process catalysts. Although the required recycling technology does not differ much from that for consumer goods, the recycling efficiencies are usually much higher due to a high awareness of involved stakeholders, economic recycling incentives, transparent and professional handling throughout the product life cycle, and a rather limited change of ownership and location of use.

There is generally no risk of geological depletion of raw materials. Industry's access to them could nevertheless be subject to a variety of other risks. The main issue concerns exploration and technological developments that will allow for a sustainable exploitation of resources rather than geological scarcity.

Figure 4 presents the data for recycle fraction in current supply. Recycling of metals is highly developed and its contribution to current supply is large. The same cannot be said of polymers. The community polymers are used in large quantities, many in products in short life, and they present major problems in waste management. However, the economics of polymer recycling is unattractive, with the result that their contribution to current supply is small.



(Source: [b-Ashby])

Figure 4 – Recycle fraction by chart

The recycled fraction that is referred to means the percentage of old scrap, together with the percentage of reutilization of materials, capable of being used within the same process that generated it.

5.6 Closed and open cycles

For many common basic metals it does not really matter whether the recycled metals are used in the same product group or in another application, since both primary and secondary metals are traded on a global scale and any quantity of recycled metal directly impacts its demand supply balance. And for most basic metals their recycling does not lead to significant deterioration in quality. These kind of open cycles are typical to many consumer goods such as cars, electronics and small appliances.

For plastics closed loop is usually a demand, because clean and sorted waste streams are needed for mechanically recycling of plastics.

The recycled content used when manufacturing materials depends on how much scrap is available. The new scrap availability depends on the degree of metal use and the process efficiency in manufacturing. The old scrap availability is basically depending on the efficiency of end-of-life collection system and recycling system. High growth rates in metal demand in the past, together with long product lifetimes result that availability of old scrap quantities are typically smaller than the metal demand in production and that hinders the use of old scrap usage in metals manufacturing. The recycled content used when manufacturing materials depends also on scrap's quality. Closed cycles that are typical for many industrial goods are a necessity that the scrap quality is good enough to be used in new material manufacturing. For many common basic metals the scrap quality is good enough also in open product cycles to be used in new material manufacturing.

Appendix I describes metals, plastics, and their recycled content in more detail.

6 Transport and packaging

Appropriate system boundaries and requirements for the transport of ICT goods is described in [b-ITU-T L.1410] and should be used for recycled goods accordingly.

7 ICT product usage

7.1 Material use for product maintenance

Material use for product maintenance is under study.

7.2 Energy consumption

The continuous increase of the number of ICT services, and the associated data traffic, offered by ICT networks, combined with the rise of the energy price, make the power consumption of ICT Goods one of the most important aspects to be taken into account.

Standards describing telecom network equipment power consumption measurements have been developed by ETSI, ITU-T for different types of ICT equipment and mobile networks. For example, see [b-ITU-T L.1310], [b-ETSI ES 201 554], [b-ETSI ES 203 136] or [b-ETSI ES 203 228].

The future activities information could be seen in Appendix IV.

8 End of life treatment

8.1 Used ICT goods collection

ICT goods that are discarded in household trash can cause severe eco-environmental impact, and is lost for further use. In some countries, informal scavengers may look at everything before it is finally discarded and used, and end-of-life computers often have enough value to be collected by them. This informal sector, however, must be transformed into a formal collection system, with standards and protections built in for everyone involved. Formal collection programmes frequently require significant effort and expense, and it may be necessary to find ways to subsidize collection systems in any country, in order to deliver computing equipment to envirionmentally sound management facilities for processing. Formal sector and governments should engage, employ, and empower the informal sector and help transition them into formal systems, which are consistent with applicable legal and other requirements including provisions that support protection of human health, worker safety and the environment.

Special collection events are often organized, or collection may be regularly on-going in retail stores, or by mail-in collection and also through consumers buy-back programmes. Charities sometimes collect computers for reuse. Collection of computers from large businesses provides an important opportunity due to both the large volumes of equipment available from one source, and the fact that a lot of this equipment is retired early and thus has significant value in the refurbishment market.

Collectors should ensure equipment is handled, packaged and stored in such a way to avoid damage during transit. This may include the following concerns:

– Packaging fragile equipment to avoid damage during collection and transport;
– separating equipment to be assessed for reuse from waste to prevent contamination or damage of the reusable equipment;
– pack heavier items so that they do not move or fall on and damage lighter items;
– avoiding leakage from used printer toner;
– uninterrupted power supplies (UPS) may contain residual electrical charge and other batteries at risk for unintentional discharge or leakage;
– secure loads from unauthorized access to avoid confidential data being lost.

8.1.1 Collection systems

ICT goods should not be deposited into regular household waste, which would result in the equipment being disposed of in landfill or incinerated. ICT goods should be collected separately by the municipal waste collection system or an alternative waste collection system and Telecom operators and distributors can make a proportional contribution to raise users' awareness by informing and educating customers about potential eco-environmental impacts of equipment and to ensure that new and used ICT goods and accessories are responsibly managed throughout their life cycle.

As reuse or recycling value may drop quickly, users should be encouraged to avoid storing or setting aside unneeded ICT goods and to deliver them promptly to a collection system. However, if a collection system is not available or the collection point is not convenient, a user should hold the ICT goods in storage until the next opportunity arises to deliver it to a collection point.

A used ICT goods collection system should have collection points conveniently located for users so that they can bring their ICT equipment to such collection points. In addition, the collection system should be free of charge for users.

Collection of used ICT equipment through distribution channels (e.g., telecom operators, retailers or manufacturers) should be a key element of the 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 ICT equipment are being sent in a shipping package.

Collection systems for used ICT equipment should be accountable in a way that is practical and transparent to audit. This may require keeping a written record of the actual number of used mobile phones received, currently in storage, and shipped. Information about the reuse, recycling and final disposal of used ICT equipment and accessories is usually obtained directly from recycling and refurbishment companies.

8.1.2 Organization of collection points

Collection points must be an initial part of the collection system, which should also include appropriate facilities where evaluation and/or testing and labeling can be carried out to decide whether used ICT equipment destined for reuse are in working order and can be directly reused, or require repair, refurbishment or upgrading prior to reuse, or are to be sent for eco-environmentally sound material recovery and recycling.

In addition to collection points for consumers, it is important to consider collection from the repair sector, both formal and informal, to ensure that parts and ICT goods scrap do not end up in landfills. Such collection schemes could be undertaken by paying a price per kilogram of scrap collected and is likely to be funded from recoverable commodities.

Depending on the capacity available in particular countries and the logistics involved in managing used ICT equipment, the separate collection of used ICT equipment is recommended in order to preserve the working characteristics and resale value of those collected.

A collection point should ensure the security of the ICT goods collected. Where the collection point conducts a preliminary evaluation of potential for reuse, appropriate packaging material should be used to separate used ICT equipment from each another while in storage and during transportation to protect them from damage and to preserve their operational capability and market value for possible reuse. The type of material would depend on the availability of space at the point of sale.

Authorities should develop operating conditions and requirements that are uniquely applicable to used ICT goods collection systems, balancing any risks to human health and the environment against any perceived need for oversight and accountability.

8.1.3 Handling at the collection points

After preliminary evaluation, used ICT equipment which are destined for reuse should be packaged in such a way as to protect their integrity.

Whenever possible, used ICT equipment should be collected with their batteries, chargers and accessories. However, it should be noted that in some markets, phones, batteries and other accessories may be returned separately. It should be assumed that every battery retains some degree of electrical charge... If the batteries are removed, they should be packaged in such a way as to avoid contact with their terminals, to avoid short-circuits and fires. Batteries should be sent only to facilities that are specially qualified to recycle or process batteries for materials recovery, and should be protected against extremes of temperature. Care should be taken to ensure that the transportation of batteries complies with all applicable regulations or courier requirements, i.e., IATA regulations for the handling of lithium metal and lithium-ion batteries.

The collected used ICT equipment should be sent only to eco-environmentally sound facilities, having the relevant agreements for such activities, whether for intermediate accumulation, refurbishment and repair or for materials recovery and recycling.

8.1.4 Incentives for setting up collection systems

Consideration should be given to providing incentives to users to participate in a used ICT goods collection system.

Sellers of new ICT equipment should consider offering appropriate incentives for the collection of used ICT equipment when needed. Discounts on the purchase of new phones, free air time and free SMS are some of the possible incentives to be considered.

Manufacturers, telecom operators and ICT equipment ICT goods 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 ICT equipment. This is particularly necessary and should be implemented as soon as possible in countries where the legislation and infrastructure for the collection of used ICT equipment is lacking.

Any financial mechanism established to hold and manage money collected either as a pre paid fee, advanced recycling fee (ARF), advanced disposal fee (ADF) or as a refundable deposit should be transparent to all concerned persons, including governments and the public.

If a direct and transparent fee is charged to the original buyer of an ICT equipment / ICT goods and the used ICT equipment / ICT goods is are exported for reuse, it may be necessary for some portion of that fee to follow the used ICT equipment / ICT goods to an importing country to provide for its eco-environmentally sound management there at the end of its life.

8.1.5 Optimizing capture of WEEE by existing collection points

To reduce theft in waste disposal facilities it is first of all to pursue financial operational measures (video surveillance / closed-circuit television systems, WEEE tracking, etc.).

A complementary action plan concerns the frequency of removal of WEEE in some big cities where collection rates are particularly low in waste disposal.

a) Improving the sorting of WEEE in waste collection facilities:

   Beyond greater awareness of guards and employees in Waste collection facilities, a more precise characterization of scrap bins could be an interesting line of action to limit the impacts of errors in sorting waste disposal.

b) Reduce the "leaks" in distributors collection channel:

   The introduction of a computerized system for better tracking WEEE stream taken in store, and especially delivery since they are dealing with the largest volumes, would better track the flows involved.

   Faced with the rise of "pure players" among the distribution channels, it is necessary to ensure that they meet their obligation to return "one to one", with the implementation of effective solutions for the recovery, whether the delivery or recovery of small appliances (free postal return, etc.).

c) Improve the WEEE sorting in households:

   Finally, a significant part of the deposit still remains poorly sorted by households. This mainly small WEEE are sometimes discarded with household waste. These quantities can certainly be further reduced through awareness and education of households to new practices (to be effective, communication must be based on specificity of the collection scheme).

8.2 Reuse

8.2.1 Processing and management of equipment and components destined for re-use

This section addresses the environmentally sound management of ICT equipment ICT goods that are accepted by a refurbishment organization for refurbishment and/or repair. The best possible outcome for any device accepted by a refurbisher is for that equipment to be reused either as designed or purposed.

Recent advances in computer operating system (OS) software require significantly less "computing power" than previous OSs. If computing equipment is not appropriate for general use it may have another life as a single task system, such as a print server or file server, or be completely repurposed for a task such as monitoring the electrical grid.

The physical life of the equipment is significantly longer than that of software. Care should be taken to differentiate between software problems (that are typically correctable) and hardware issues (that require greater expertise to correct).

When used ICT goods are refurbished or repaired, any hazardous substances, or parts containing hazardous substances that are being replaced, consideration should be given to replace them with readily available parts containing benign substitutes (nonhazardous) and in line with national legislations, and regional and international conventions prescribing phase out strategies. Discarded or broken parts and hazardous materials should be handled as described in clause 8.4.

8.2.2 Testing of equipment and components (hardware) prior to reuse to ensure full functionality

a) Used ICT equipment

Facilities should undertake an initial sorting of ICT equipment and components in order to identify and separate that which has potential for reuse as a whole or for re-use of parts, from equipment that should be recycled.

Refurbishment facilities should accept only equipment that they are prepared to reuse/refurbish or send to an eco-environmentally sound material recovery operation. Personnel must be trained to handle equipment that can be fully processed.

The following functionality tests are proposed for used ICT equipment to confirm that the equipment is fully functional and is suitable for re-use (see Figure 5).

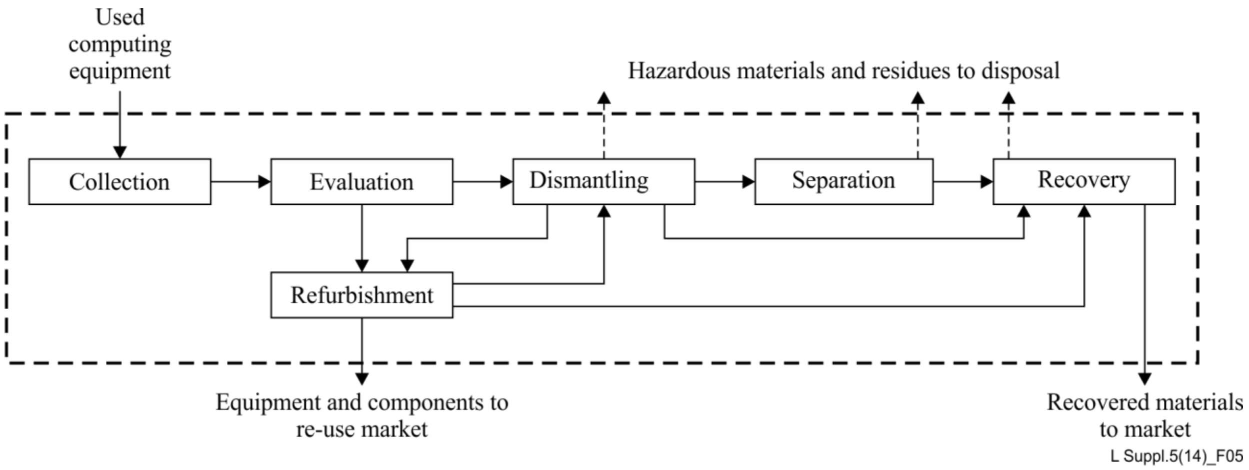


Figure 5 – Flow diagram of environmentally sound management of used computing equipment [b-PACEtrr]

b) Batteries

It is important to note that there are a wide variety of battery sizes, capacities and technologies currently in use in computing equipment, although almost all new laptop batteries are of lithium-ion type with some older laptops based on nickel metal hydride or occasionally nickel cadmium (Ni Cd). While this section is concerned with the assessment of laptop batteries, it is worth noting that there are also other multiple uses for batteries in computing equipment, such as small button cell batteries that are attached to circuit boards, and additional batteries that are used in devices such as wireless keyboards and mice. There are also battery back-up systems in use in some countries to provide an uninterrupted power supply, and which provide emergency power to desktop computers when the principal power source fails. In contrast to the batteries used in the actual computing equipment, these electricity supply back-up system batteries are typically lead-acid.

A used laptop battery's current charge capacity relative to its original capacity can provide important information for the user or refurbisher because over time, the capacity of a battery to hold charge deteriorates. A battery's current capacity can be measured as a percentage of the amount of charge the battery was able to hold when new.

See Appendix V for more details on battery re-use.

8.2.3 Final testing

Final testing should be conducted by the refurbisher after the computing equipment has been refurbished or repaired to full functionality and is ready for reuse, and prior to sale, donation or export for reuse. Final testing of computing equipment and newly installed software should ensure the device and software conforms to user needs and will help to ensure compliance with controls in importing countries if the equipment is exported. This generally includes a Power on Self Test.

System boot with all drivers resolved and some applications tests to ensure software functionality.

8.2.4 Labelling/documentation for refurbished and repaired computing equipment

In addition to keeping on-site records of the diagnostic testing results, repairs and upgrades completed and final test results, there are additional types of documentation that refurbishers should provide. Information should clearly inform the subsequent purchaser/recipient of used equipment ICT goods that the products goods are used and/or refurbished/repaired.

Refurbishers should provide detailed documentation of each device or components going for reuse (directly or indirectly from the refurbisher). It is intended that these labeling and/or documentation provisions will provide the subsequent purchaser/recipient with the contact and product information necessary in the case of a faulty product. This information can be communicated to subsequent purchasers by way of a label placed on the product or on an invoice. Additional information can be provided on the product packaging, or through a product information insert.

For more details about labeling and documentation of refurbished and repaired ICT equipment ICT goods see Appendix VI.

8.2.5 Repair and refurbishing

Recommendation for proper refurbishing process details, such as: erasing of personal data, software licenses issues, end-of-life treatment of replaced components, substances used for cleaning and polishing etc., guidance applicable to refurbishment and repair facilities.

8.2.5.1 Repair

Given the complexity and specificity of personal computer components, repair requires a high level of skill and training. On-line manuals and tools exist to assist with some of the techniques involved. Most often personal computing equipment is returned to functionality by replacing non-working components with tested, working components. Once a component has been determined to be faulty, care should be taken to have it repaired or properly recover the materials.

Disposal is a last resort. Where replacement components are required to replace a missing or faulty component to enable the equipment to be reused, the reuse organization should ensure that the use of such replacement components does not impair product safety.

Particular care should be taken with the removal of potentially hazardous or dangerous components such as the fluorescent lights used for backlighting liquid crystal displays (LCDs), batteries, capacitors or sharp components or parts in order to avoid risk of damaging worker safety and health or damage to the environment.

Removal of faulty mercury lamps from LCDs is a particularly specialized activity and, given the hazardous and fragile nature of this component, should only be undertaken by facilities with the necessary knowledge, expertise and authorizations required for their eco-environmentally sound management of mercury-containing wastes.

Where such lamps are removed, stored or transported, extreme care should be taken not to break the lamps, as these contain mercury vapour and fine powder contaminated with small amounts of mercury. Such fluorescent discharge lamps should be managed by a specialized and appropriately authorized facility.

Where batteries are removed, the electrical contacts should be sealed with insulating tape and/or wax, or otherwise insulated from each other, in order to prevent unintentional discharge, short circuits or fires.

Repair operations involving the soldering of printed circuit boards or replacement of faulty capacitors should be undertaken only by workers with the necessary knowledge, experience and training. Additional requirements may exist.

8.2.5.2 Refurbishment

The process of refurbishment of a computer is twofold. The first step in the refurbishment process is to verify the hardware functionally through initial testing, remove old data and software, and install new hardware (parts), as needed (see repair clause 8.2.5.1). During this preparatory process, digital data destruction software can remove all software including the basic set of instructions called an operating system. It is helpful to imagine a computer 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 desired user functionality.

Prior to installing a new operating system, sufficient hardware functionally can be tested with a class of software know as utilities. There are tens of thousands of different hardware components that can be combined in a personal computer. Each piece of hardware requires a unique set of instructions (know as drivers or software drivers) unique to each operating system. Drivers and operating systems need to be updated on a regular basis to correct programming errors. Given the large number of permutations of hardware and software, refurbishment has been difficult and costly. Recently there have been significant advances made that allow for automating the refurbishment process such as one company's Refurbishers Preinstall Kit. These can include testing utilities, driver selection, driver injection and software selection during the refurbishment process. These advances should make refurbishment easier and more reliable.

Information and instructions on the type and use of software programmes and packages would normally be delivered with the software product itself. Further information may be available through the manufacturer's website or from other on line sources.

Specific example of product handling and refurbishment of mobile phones is provided in Appendix VII.

Recommendations Relating to the Refurbishment / Repair Process of computing equipment:

a) Facility managers should establish a policy specifying what used computing equipment is accepted into their facility for refurbishment or repair based on their technical capacity.

b) Facilities that refurbish or repair used computing equipment should take steps to identify and sort used computing equipment that is to be refurbished or repaired from that which should undergo recycling and materials recovery.

c) Refurbishers should adhere to selling, transferring or transporting only computing equipment that is evaluated to be refurbishable or that is appropriately tested to assess the equipment's functionality.

d) RRFs should store and handle used computing equipment prior to refurbishment in a manner that protects the computing equipment and reduces the potential for toxic releases into the environment and injuries to workers.

e) Refurbishers should take care not to allow the release of data stored on used computing equipment they receive and process, and should seek to destroy such data through electronic means.

f) RRFs should ensure that proper labeling or documentation of refurbished/repaired equipment is undertaken. The labeling or documentation is intended to cover, where appropriate and possible, the type of equipment, the model and serial numbers, the year manufactured, the refurbishment/ repair date, possible evaluation and testing that was performed, an overall confirmation that the refurbished/repaired equipment is fit for re-use.

g) Refurbishment facilities should use the Basel Convention guidance documents to ensure that downstream materials recovery and recycling facilities operate in a manner that is protective of the environment and worker health and safety and is compliant with the requirements of the Basel Convention. Such recycling facilities should take into consideration the PACE Guideline on Material Recovery and Recycling of End-of-Life Computing Equipment [b-PACEmrr] and ILO Guidelines on occupational safety and health management systems [b-ILO-OSH].

h) Refurbishment facilities should ensure that, in the case of transboundary movements, all computing equipment, components (e.g., batteries, CRT devices, mercury-containing devices, circuit boards) and residuals destined for materials recovery, recycling and disposal are prepared for shipment and transported in full compliance with all applicable laws, including national implementation of the Basel Convention and other multi-lateral waste trade agreements.

A 'minimum' specification for computing equipment is an attractive target, but hard to achieve in practice as base computer specifications evolve constantly. It is likely that any such specification will be driven more by customer (i.e., receiver) software operating system demand than by hardware, and as is noted earlier in this guideline, end user demands are changing, with recent advances in operating system (OS) software requiring significantly less "computing power" than previous OSs.

Overall therefore, the receiver should receive refurbished/ repaired equipment capable of operating the current operating system. At a minimum, this should be the previous two generations.

Principles for Donors of Functional Used ICT Equipment:

Provide a useful product: Donor will provide only equipment that is expected to have a significant life-span and is functional under the expected conditions and needs in recipient countries and communities.

Provide an appropriate product: Donor will ensure that the hardware and software can operate and be operated within the limitations and conditions of the recipient country and community.

Ensure and verify availability of technical support: Donor will encourage a maintenance/technical support programme exists in the recipient community – either from donor or in recipient community.

Test, certify and label functionality: Donor should provide proof of testing for functionality.

Ensure availability of training: Donor may support the recipient with training or training programmes.

Ensure full transparency, contract and notification and consent prior to delivery: Donor will ensure that the recipient community consents in writing to receiving the material in accordance with the terms and conditions of the contract.

Export controls: Donor should export in accordance with applicable national and international controls.

8.2.6 Good practice case studies

A number of good practice case studies for the donation, refurbishment and re-use of used ICT equipment are included in Appendix III.

8.2.7 E-waste quantification, disassembling, separation and end-of-life treatment

a) Improvements to be performed by treatment actors

In view of the WEEE tonnage recovered by metal recyclers and waste treatment facilities (mills, grinders, smelters), it is essential to ensure that WEEE concerned are properly treated to remove pollutants and that their origin and final destination are known.

There is a need to involve these actors as collection points to include the volume of WEEE taking into account non-selective collection (i.e., direct collection from owners by artisans /

installers, who may not be working on behalf of a distributor, or direct collection from private scrap collection that collect such WEEE from private individuals, etc.).

b) Improving the measurement of quantities of electrical and electronic equipement (EEE) placed on the market and generated WEEE.

c) Conducting studies to obtain national statistics to bridge gaps in knowledge.

   Conducting consumer surveys can increase the body of knowledge related to consumer usage of EEE devices and help predict future WEEE demands, including the amount of WEEE that remains within the household.

d) Adjust the data statements to the needs of estimated field

   In certain cases, the type of information used in a WEEE registry may need to be adjusted to consider the type of equipement and content of material to be processed. The usage of existing nomenclature (for example the SH4, (harmonized) system) may not be sufficient. Some organizations are considering the use of HS8 (reference needed).

e) Update knowledge of market refurbishment and exports of computer and office equipment

   It would be interesting to obtain more information about: the volumes that pass through the 'broker' market, their final destinations and how the equipment is transported.

f) Get reliable data on exports of used EEE

   It would be necessary to more clearly identify the destinations of exports of used EEE from developed countries. Exports are, to date, poorly documented.

To identify these data, there is need to strengthen cooperation between the competent authorities in the fight against illegal sectors (Ministry of Interior, Customs, Department of Ecology). To strengthen customs actions, there is a need to consider systematic transmission of information from eco-organizations, such information will be centered at the Department of Ecology, such as:

– Companies having practices that do not conform to national regulations;
– Suspicion of illegal exports documented (WEEE exported under cover of used EEE exported for reuse).

8.3 Recycling

8.3.1 Recycling of metals

ICT goods contain as many as sixty substances, many of which are metals. Some of these metals are used in computing 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 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 would cause inevitable losses of others. Furthermore, of course, recovery of any metal, especially with eco-environmentally sound management, costs 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 computing 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, and so 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. On the other hand, although the amount of gold 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. Final metal recovery from computing equipment has been done only by private industry for more than fifty years, always on this commercial profit basis. It should be noted that the recovery of critical materials can be encouraged through the concept of using the valuable metals in the equipment to help pay for their recovery.

The actual final recovery of metals is accomplished through a series of steps which concentrate and separate them from other metals and from other materials until they are sufficiently pure to be put onto a market to be sold. In some cases, alloys are recycled back into the same alloys, which can be important with critical metals.

These steps are sometimes categorized as pyrometallurgical and hydrometallurgical processes, but they all have the purpose of concentrating and separating one or more desired metals from other materials, and they are frequently used, one after the other, by the same metal recovery facility to finally achieve a marketable metal product. However these processes are quite often in metal-specific businesses and facilities, e.g., a steel company will only produce steel and its alloys, an aluminum company will only produce aluminum and its alloys, and they will not produce copper or gold. Some facilities will produce multiple metals, such as an integrated non-ferrous metal smelter, but there is no company or facility that recovers and produces all metals.

8.3.1.1 Pyrometallurgical processing

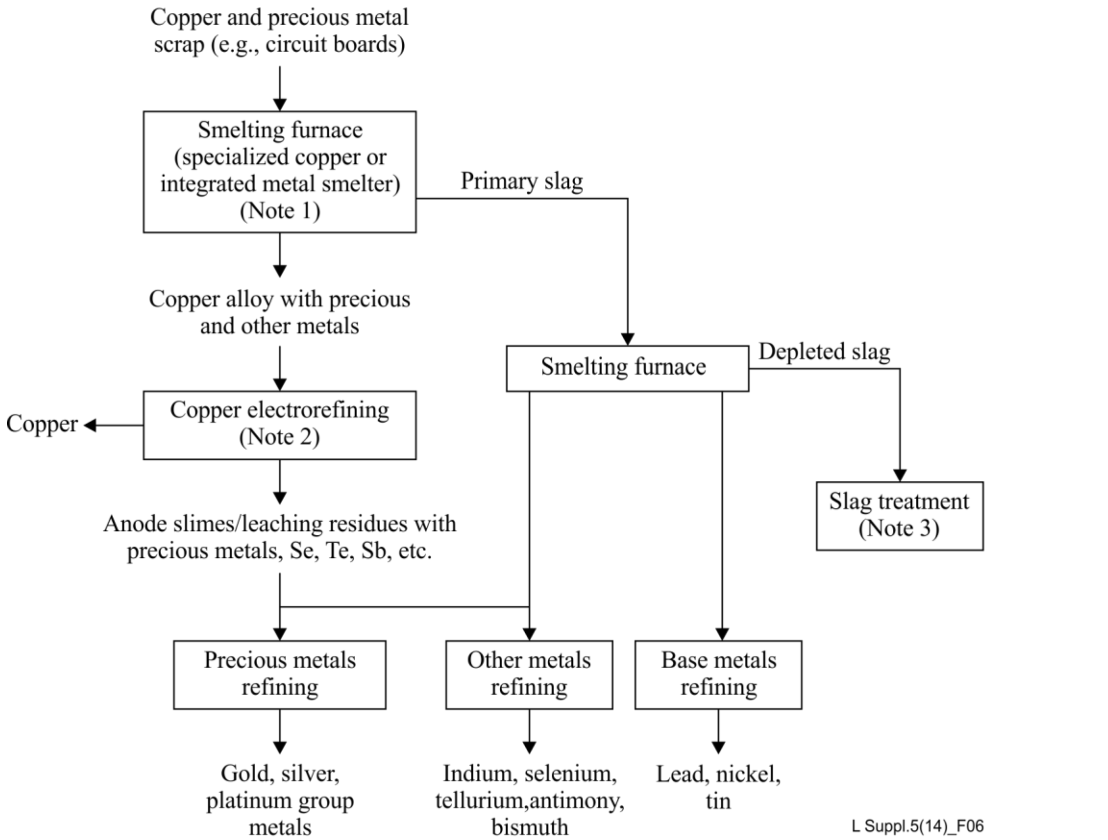
For many years, high volume metal recovery from computing equipment has used large scale pyrometallurgical processes for steel, for aluminum and for copper and non-ferrous metals.

Pyrometallurgical processing involves the use of heat to reach the melting temperatures of the material mix and the temperature at which chemical reactions can take place to separate and extract the desired metals at a higher concentration. Many types of metal scrap are commonly processed in smelting furnaces designed and operated for the specific metal they treat. Smelting is a pyrometallurgical process in which metals and/or metal-bearing materials are melted at high temperature, and then, while molten, other materials are added to achieve separation through oxidation and/or reduction, or to change the metal alloy composition. As described in more detail below, strong eco-environmental, health and safety concerns are raised by these operations, and these eco-environmental concerns should be minimized and controlled through engineered systems, such as scrubbers and bag houses, and through good material management practices. Due diligence should be performed by suppliers of computing equipment to these operations to ensure eco-environmentally sound management. Examination of a facility's track record of eco-environmentally sound management and tracking of all incoming and outgoing materials and wastes can inform such due diligence.

Scrap steel, such as steel in computer cases, can be used in electric arc steel furnaces to produce new steel. Facilities should be aware that impurities in their steel scrap fraction, especially copper, could reduce the value of this scrap and even lead to it being rejected by steelmakers if it is too contaminated with certain elements. While this guidance cannot go into detail regarding the production of steel in such furnaces, a facility that produces steel scrap from computing equipment should know that steel furnaces create their own eco-environmental concerns, including dust and gas emissions, and production of slag. These eco-environmental concerns can be minimized and controlled through engineered systems, such as scrubbers and bag houses, and through good material management practices.

Aluminium will be used in secondary aluminum furnaces to produce new aluminum. As with steel, facilities should be aware that impurities could affect the economic viability of recycling this scrap fraction. Also, for aluminium there can be a significant economic advantage in keeping certain alloys separate, which should be taken into account when operating a dismantling and separation facility. Aluminium furnaces melt scrap aluminium and remove impurities with fluxes, often chlorine-based, and as with steel furnaces, will create slags and air emissions in the process. Air emissions can be minimized and controlled through selection of flux materials and through emissions control equipment, such as scrubbers and bag houses.

Scrap copper, scrap precious metals, and some other non-ferrous metals are commonly recovered from computer circuit boards and other components/fractions in integrated smelting-refining processes or in a copper smelting process, followed by metal-specific refining at other locations or companies. This has been the established high volume method of non-ferrous and precious metal recovery from computing equipment. The typical steps are shown in Figure 6 [b-PACEmrr]. The smelting-refining process is particularly useful and efficient for very complex articles such as circuit boards, which contain many metals in relatively low concentrations and in small pieces that are tightly bonded to a plastic substrate and that cannot be efficiently separated through mechanized shredding and technological separation processes.



NOTE 1 – Smelters differ in process flow and metals produced. For treatment of materials with plastic content, e.g., circuit boards, special emission pollution control treatment is required for all smelters.
NOTE 2 – Either (1) copper anode directly electrorefined to cathode, and electrorefining residues (slimes) are further treated, or (2) copper alloy is leached, leachate is then electrorefined to cathodes, and leaching residues are further treated. Residues without value are disposed.
NOTE 3 – Slag is stabilized and made suitable for construction products. Residues without value are disposed in controlled disposal operations.

Figure 6 – Metal recovery – Pyrometallurgical recovery of copper and precious metals

It is an efficient process for circuit boards because, in general, it allows for a quick separation between valuable (copper and precious metals) and less valuable materials, though specifics on smelting processes will vary between plants based on furnace design and operating conditions, and will determine which materials and how much of them a plant is able to process.

The primary product of smelting is a relatively pure metal, called blister copper, which is not quite market grade, and still containing the dissolved precious and other non-ferrous metals in a complex alloy. This complex copper alloy is poured from the smelting furnace into slabs that are treated by electrorefining or granules that are treated by leaching and electrowinning to recover pure copper. At the end of this copper production, the precious and some other non-ferrous metals remain behind, and will then be processed in a number of additional metal-specific steps, usually a series of distinct hydrometallurgical steps (see description below) which may be complemented by pyrometallurgical processes, by which individual precious metals are refined to their market grades.

Additional metals can also be extracted along the way, each metal with its own chemistry and separation processes, either from reprocessing primary copper smelting slag, or from processing copper cell residues, or from flue dust captured in the offgas system. As said above, whether this additional metal recovery takes place depends upon market demand and price, process technology available, and the cost of additional process steps. Successful copper/integrated smelters operate a number of refining processes in close proximity to the smelting operation, to minimize transaction and process costs, and maximize profitable recoveries.

The copper smelting process, and subsequent refining processes for copper and precious and other non-ferrous metals, can also present significant eco-environmental concerns, if not equipped with appropriate technology and well-managed in an eco-environmentally sound way. Copper smelting is a high volume, high temperature operation that creates metal fume and metal oxide particulate. These may be released, exposing workers and nearby communities, unless the emissions are well controlled. The most problematic emissions from smelting of scrap from computing equipment are lead, beryllium, and polychlorinated dioxins and furans. These releases can be well-controlled, but only through properly engineered processes and emission control systems, and these systems are expensive to construct and operate, and require attention and sound management. Copper smelters have a particular concern with the formation of polychlorinated dioxins and furans, because their formation may be catalyzed by copper particles in the furnace air emissions. To prevent formation, the initial oxidation should be at a temperature of 850 deg. C. (1600 deg. F.) or higher, with a residence time of two seconds, with excess oxygen, to ensure destruction of hydrocarbons. Smelter exhaust emissions should then be rapidly reduced to a temperature of 200 deg. C. (400 deg. F.) or less at the inlet to a bag house or electrostatic precipitator. Most copper smelters do not install these systems, because they are very expensive to construct and operate, and they are not needed for mining concentrates and relatively pure copper scrap. It is the complex electronic components and/or halogenated plastics in computer circuit boards that require the specialized emission control systems. There are, in fact, relatively few smelters located in the EU, North America and Japan that do construct and operate such systems, and these smelters in turn receive circuit boards and other components of computing equipment from many countries that do not have such copper smelting operations. [b-ICSG] provides additional information regarding copper recycling.

8.3.1.2 Hydrometallurgical processing

Hydrometallurgical processes involve dissolving metals in strong acids, or in cyanide in the case of gold, and selectively precipitating the metals, one by one in specialized procedures in a pure form by adding other metals or reagents. For some metals such as copper, hydrometallurgical refining is used after smelting to achieve higher purity of copper, such as the electrolytic refining of copper mentioned above. Then, after the copper has been removed, the residues undergo a series of additional hydrometallurgical steps to extract additional metals.

While copper smelting, a pyrometallurgical process, is the established high volume method of non-ferrous metal recovery from computing equipment, some facilities are investing in hydrometallurgical metal recovery operations. In some cases, hydrometallurgical processes may be applied directly to some parts of computing equipment, without prior smelting, especially if the metal scrap is already higher grade or relatively pure. For example, gold-plated copper connectors are sometimes stripped of their gold before further processing to recover the copper. Similarly some of the gold on a circuit board may be visible and can be removed by immersion into cyanide or aqua regia, a combination of concentrated nitric acid and concentrated hydrochloric acid. However not all gold in computing equipment can be removed by direct hydrometallurgical processing without additional steps. Recovery of additional gold that is contained within circuit board components and interior layers, as well as other metals such as silver and palladium, requires first grinding of the board and its components into very small particles prior to such cyanide or acid leaching, during which, dust collection is imperative to prevent significant losses of precious metals. After dissolution of the target metals, the leachate solution is then filtered to remove unwanted material, and the target metals are electrolytically removed or selectively precipitated by addition of a metal, such as zinc, or a reducing agent, such as SO_2, hydrazine hydrate or ferrous sulphate.

Direct hydrometallurgical operations used for material recovery from computing equipment are smaller and less expensive to establish than large pyrometallurgical operations, because much less equipment is used, and fewer operations are performed. Processing of selected computing equipment is relatively quick, compared to smelting-refining, and it can produce a relatively pure form of gold, but the efficiency and range of further metals that can be recovered is limited. Residues of direct hydrometallurgical processing of computer equipment may be sent to integrated smelter-refiners for additional processing to complete recovery and to recover additional metals. Participants involved in metal recovery from computing equipment should evaluate eco-environmentally sound pyrometallurgical and hydrometallurgical operations for all aspects of processing and recovery and determine what best meets their needs.

Industrial hydrometallurgical operations that are permitted, licensed or otherwise authorized are required to take special measures to contain and handle the solid and liquid chemicals, fumes and vapors, and process residues in order to be eco-environmentally soundly managed. As with pyrometallurgical operations, strong eco-environmental, health and safety concerns are raised by these operations, and due diligence should be performed by suppliers of computing equipment to these operations to ensure eco-environmentally sound management. Examination of a facility's track record of eco-environmentally sound management and tracking of all incoming and outgoing materials and wastes can inform such due diligence.

8.3.1.3 Informal sector acid leaching

Informal material recovery operations are not licensed or permitted, and may operate without any government knowledge or oversight. Some of these recovery operations use cyanide or acid leaching processes on selected parts of computing equipment, such as visible gold-plated parts of circuit boards, to recover that visible gold. As some of the gold typically contained in a circuit board is not visible, however, but is contained inside of ceramics and plastic parts or resins in the circuit board, informal acid leaching is an inefficient method with gold recoveries being as low as 20-25%. Silver and palladium, often present in circuit boards, are generally not recovered.

Unfortunately, both the residue boards and spent process chemicals are discarded by informal operators after visible gold has been removed. There are serious worker health concerns, especially when this process is performed in informal operations. Cyanide is poisonous, especially in the form of hydrogen cyanide, and aqua regia is very corrosive and requires very careful handling. Aqua regia also gives off chlorine gas emissions, and its reactions with metals give off nitrogen oxides.

8.3.2 Recycling of plastics

As with metals contained in computing equipment, recovery of plastics from computing equipment 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 computing equipment are high value engineered thermoplastics, types which can be repeatedly softened by heat and hardened by cooling, and so 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. It is a good management practice 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, but 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 re-used in the production of new plastics, but must be disposed in an eco-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 computing 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 are commonly used to recover large volumes. After removal, the plastic pieces may need to be further cleaned, particularly of contaminating substances like 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 color (e.g., white, black). Identification of polymer type can be difficult, especially for older computing equipment. A United States coding system may be useful for some plastic, using a 'Recycle Triangle' with a numbers and letters, but many plastic parts in computing equipment are not identified. In addition, some plastics are made up of more than one type, or may have a fiber added for strength. In mechanized recovery operations, there are increasingly sophisticated scientific techniques for polymer recognition and separation, e.g., density separation of flame retardant plastics from regular plastics.

After plastic has been cleaned and sorted into a specific type, it will need to be reduced in size to make it manageable for storage, transportation, or further processing. This can be done by hand tools such as scissors, shears, etc., or by baling, shredding and size grading. Some mechanized operations combine heating, rapid cooling and cutting into grain. These smaller pieces are then typically heated and forced (extruded) through a die to form strings and pellets for final sale as plastic raw materials.

While initial collection and handling of unbroken plastic parts and cases should not involve any exposure to hazardous substances, subsequent processing that involves breakage of recovered plastics may cause concerns. Plastic particles, additives and brominated fire retardants may be released, causing exposures to workers. A common practice in informal operations of melting BFR plastics at low temperatures is highly likely to create halogenated dioxins and furans. Size reduction and granulation can also generate heat and, if not properly managed, open smoke and fire. After granulation, the plastic will be molded into a desired shape under elevated pressure and temperature, and there may again be exposure to substances contained in the plastic and new substances such as halogenated dioxins and furans. Even when BFRs are not present, workers should be protected with ventilation and personal protective equipment from inhalation of hydrocarbons and additive stabilizers.

If plastic types cannot be separated by type, a mix of different types of plastics may have reduced economic value, although some mixed plastics may be used for materials such as lumber alternatives or pallets. If no use or market as plastic can be found, smelters with appropriate emissions 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 emissions control systems, may recover energy content from plastics.

8.3.3 Recycling of batteries

8.3.3.1 Small batteries from mobile phones

Today, as mobile phone handsets are getting smaller and smaller, batteries typically constitute 1/3 of their weight. Three types of rechargeable batteries can be found in mobile phones: Nickel-cadmium

(NiCd), nickel-metal-hydride (NiMH) and lithium based (lithium-ion (Li-ion) or lithium-polymer (Li-Polymer).

The two systems mostly used in mobile phones applications are the NiMH and Li-ion. The last one, NiCd is an old product and is probably not used any more in new applications. However, it can be found in old end-of-life products and its recycling is, therefore, further discussed here. Also, it should be mentioned that management of end-of-life batteries should take into consideration the following: batteries should be separated from the handset; batteries can be treated in mixed composition, but this is not recommended; dedicated processes should be used; as of today, dismantling batteries is not recommended (no valorization of plastics or electrolyte).

For the separation of batteries from handsets, the material recovery and recycling processes for handsets and batteries are totally different, as the metals contained are different and cannot be recycled within the same flow sheet. The general objective of the separation of batteries is to recover the nickel, cobalt and/or other metals. So as a first step, the separation of the battery from the handset is a pre-requisite. Due to the composition of the batteries, crushing the whole material is also not recommended for eco-environmental and safety reasons; thus, this has to be avoided.

At present, there is no alternative to the manual separation of batteries from handsets. A few industrial processes exist for mechanical separation, although the economics range from very negative to break even ([b-MPPI], b-MPPIguide]. Further design for recycling of mobile phones could give rise to a greater potential for automatic dismantling.

8.3.3.2 Lead batteries require specific process

Batteries used in computing equipment are of two types, both now based on lithium chemistry. There is a very small lithium battery on 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 NiMH batteries, and occasionally also NiCd batteries, and so these 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 it remains in equipment when it is shredded, it will break open and will leak caustic electrolyte, causing risk to workers, risk of fire, damage to 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.

Once removed, batteries may be evaluated for further use, for which quality standards should be set. If batteries are not suitable for re-use, they should be sent for material recovery and recycling to specialized facilities. In order to prevent unintentional discharge of electricity remaining in unwanted batteries, which can generate heat, their individual contacts must be covered (e.g., with tape or wax), or individual batteries must be packaged separately so that battery contacts are not connected by some other conductor.

The primary metals of economic interest in these batteries are cobalt, nickel and copper. As demand for lithium increases, this may also become a valuable target for recovery.

At a battery recycling facility, fluid battery electrolyte should be removed before recovering metals. This can be done manually, or in a furnace by pyrolysis (decomposition using heat). There is no market for recycled electrolyte, which cannot be recovered as pure electrolyte, so it does not make sense to manually remove it. Plastic battery components can also be manually separated, but due to their contamination with metals they are not recycled as plastics. They can serve as a source of heat and carbon in subsequent processing, and so are more commonly not separated. The output of pyrolysis is a metallic alloy and a slag. The slag can be used as additive for concrete, stone wool or ceramics, and the metal alloy can be treated in a hydrometallurgical step to recover cobalt, nickel, copper and iron. Lithium will be concentrated in the slag, from where it could be recovered if lithium prices are attractive enough to make the process economically viable. Offgases from pyrolysis (and calcining, see below) require a thorough cleaning process, including dust collection, and the dust can be fed back into the furnace.

As an alternative to pyrolysis, batteries can also be calcined (decomposition with heat, intended to remove organic material such as plastic components), but this yields a lower recovery compared to full pyrolysis and subsequent hydrometallurgical step. It also puts a higher burden on the environment, because the plastic components, which could contribute energy to the pyrolysis operation, are not optimally utilised, resulting in higher energy consumption and CO_2 generation. After calcination, batteries can be either opened or shredded and further separated by magnetic and/or eddy current separators to produce an iron/steel fraction (recycled in the steel industry) and a mixed fraction of cobalt and nickel that can be recovered by selective leaching and precipitation. Such shredding and grinding generates additional dust and creates a risk of losses of Co and Ni (as metal oxide dusts) to the environment, if dust suppression and collection systems are not used.

In case a calcining process is used, an advance sorting of batteries by their type of chemistry, especially for NiMH and Li-ion, is recommended to optimise material recovery and recycling efficiencies. State-of-the-art pyrolysis processes can cope well with mixed fractions of NiMH and Li-Ion cells, while still yielding high metal recovery rates.

8.3.4 Recycling of other materials

Recyling of other materials is for further study.

8.4 Waste treatment

There is need to ensure waste is well managed and treated from generation to disposal.

8.4.1 Dismantling and separation

Material recovery processes should begin with careful manual separation of equipment components such as cathode ray tube monitors (CRTs), LCD displays, printers, laptops and desktops. Then each type of equipment will be further separated for separate recycling and material recovery processing, following procedures that are appropriate for that type of equipment. For example, processing of printers will begin with 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 will be most efficiently recovered by themselves, 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 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 [b-EU2012/19/EU].

Removal of problematic components can be potentially hazardous. 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, so a 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 mercury lamps, because of the mercury problem with breakage, and are sending the entire LCD screen to licensed mercury treatment facilities, which have special expertise. At the same time, shredding units that claim to safely capture mercury during treatment are available on the market. With adequate precautions for human health and the environment, mercury does not need to be a barrier to effective material recovery from computing equipment.

8.4.1.1 Further disassembly – manual and mechanized processes

After problematic components have been removed, computing equipment should be further disassembled, sorted into various material streams, e.g., steel, aluminium, circuit boards, plastics and these streams should then be sent to specialized material recovery processes.

Disassembly and material separation can be done by continued use of manual labour, or by mechanized processes, or by both – a combined use of manual and mechanical steps. The decision of which methods to use is based primarily upon economics, taking into account the initial cost of machinery, the cost of manual labour, the availability of downstream processors with proper, eco-environmentally sound recovery techniques, and the available market value of components and materials produced. Avoidance of high hazardous waste disposal costs can also be an economic incentive. In developing countries and countries with economies in transition, if 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 materials for efficient further material recovery.

Typical steps involved in manual disassembly and separation are shown in Figure 7 [b-PACEmrr].

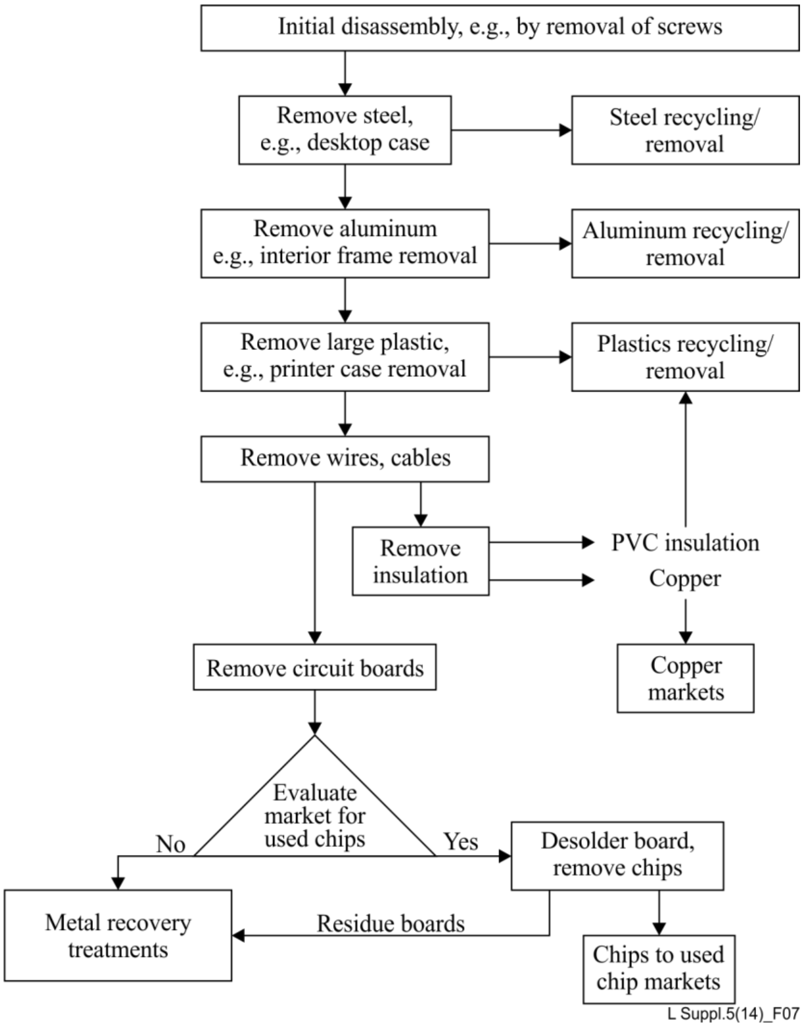


Figure 7 – Manual disassembly and separation of materials

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 materials that can be sold. It can also facilitate careful removal of working components, for additional value.

Chip recovery is sometimes a part of manual disassembly operations, because electronic chips may have higher value than raw materials, but it presents risks to worker health and to the environment that should be controlled through eco-environmentally sound management. In order to remove chips, it is necessary to heat the solder that holds a chip to the circuit board so that the solder softens. This requires careful attention to temperature. If not enough heat is applied, the solder will not soften and the chip will not come off of the board. If too much heat is applied, the chip will be damaged. Very often the correct temperature is set by melting a larger container of solder, then placing the underside of a circuit board in contact with that molten solder. This process is successful in removing chips, but it presents risks to workers and communities. The container of molten solder, and the softened solder on the circuit board, will give off some lead fumes, and the worker may breathe them. The substances in the circuit boards, such as tetrabromo bisphenyl A, may be released as well. The source of heat may be a small charcoal or coal fire, giving off its own hazardous particulate. A worker who must remove very small chips from the circuit board is likely to be very close to the heat source, the heated circuit board, and the molten solder, all of which are concerns. The best protection for the worker is to have the chip removal done under a controlled ventilation hood, or have all of these hazardous emissions drawn away by a fan, and pulled into a collection system, such as a bag house.

Wire and cable recovery is also sometimes a significant part of manual disassembly operations. Wire and cable that is not damaged can be reused directly. The high-grade copper can also be recovered by manual removal of insulation with simple tools, or by chopping wire into small pieces, followed by sink-float separation of the small pieces of insulation, from the copper. Clean insulation removed in this way might be useful as recovered plastic, and it can also be safely landfilled if necessary. On the other hand, open burning of cables to remove insulation and recover copper wire, which is widely practiced in informal operations, is dangerous and should be stopped, because the insulation is likely to use polyvinylchloride (PVC), perhaps with lead content as well, and burning will create hydrocarbon emissions and polychlorinated dioxins and furans.

Facilities that use manual disassembly should consider and ameliorate the many risks that are involved it those activities with computing equipment, such as exposures to hazardous fume and dust, strains from lifting of heavy objects and repetitive motion, cuts and abrasions from handling sharp materials and pieces, dangers to eyes from small objects, electrical shocks from batteries, etc.

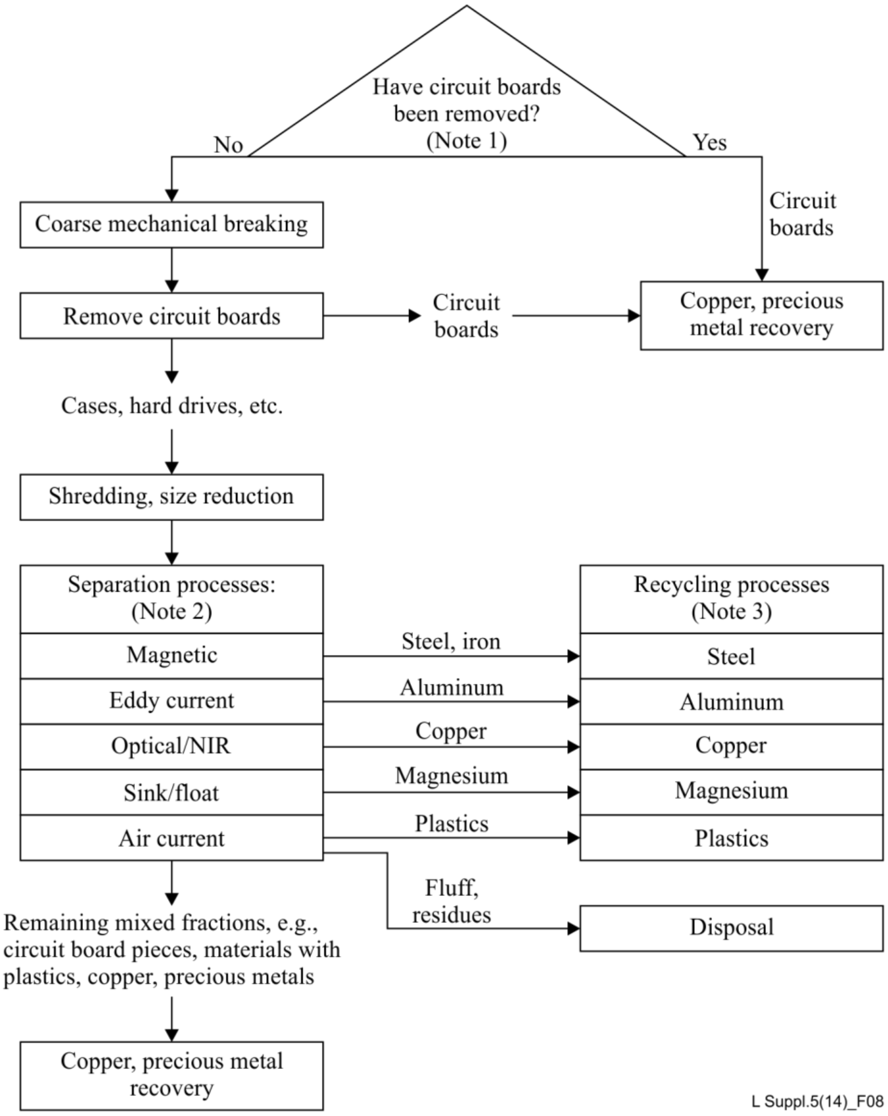
Hand tools powered by electricity or pneumatic air can make manual disassembly much more efficient, while helping workers to avoid strains and repetitive motion injuries.

8.4.1.2 Mechanized dismantling

Mechanized disassembly and separation of computing equipment can operate at high speeds and volumes. It consists generally of shredding of computing equipment into small pieces, followed by a variety of technologies that identify specific materials in those pieces, and then still more technologies that separate those identified materials into streams that can be sold as concentrated feedstocks for final recovery treatment. As described above, some initial manual removal is necessary for batteries, mercury lamps and ink cartridges, because these may release hazardous substances and may also cause damage to mechanized equipment. Mechanized separation operations are complex, and increasingly sophisticated, and it is beyond the scope of this guidance to describe all processes in great detail. However some typical steps involved in mechanized disassembly and processing of computing equipment are shown in Figure 8 [b-PACEmrr], and are further described in following paragraphs.

The first mechanical operation may be a coarse shredding or breaking open of a personal computer or peripheral, leaving large pieces from which circuit boards can be manually removed. Because circuit boards are more likely to contain substantial amounts of copper and precious metals, with higher economic value than steel or plastics, this initial separation will be an effective way of obtaining higher overall value from a personal computer.

Subsequent shredding steps then reduce computing equipment to much smaller size, in the two to three centimetre range. These smaller pieces are then identified by type through a sophisticated set of technologies, and are separated, one from another, into feedstocks for final recovery.



NOTE 1 – Initial removal of circuit boards may be required by national law. If not required, may be removed for economic reasons, to avoid loss of precious metals into other fractions, e.g., steel.
NOTE 2 – This is not an exclusive list, and the types and order of separation processes will vary.
NOTE 3 – Recycling processes vary, and should be reviewed independently for efficiency and ESM.

ESM – Environmentally sound management

Figure 8 – Mechanical disassembly and technological separation of materials

Identification techniques other than colour are also used. X-ray Transmission (XRT) technology transmits X-ray energy, which is absorbed differently by different metals, e.g., copper and aluminium, based upon atomic density, and sensors can then identify particular metals and direct separation technology. Near infra-red (NIR) technology uses near infra-red light to distinguish among types of plastic, such as HDPE (high-density polyethylene) and PVC.

Magnetic separation uses magnets to divert magnetically susceptible pieces, such as carbon steel, from non-ferrous metals and plastics.

Eddy current separation creates an electromagnetic field around a conveyor belt of shredded pieces, which then induces an electrical resistance in moving pieces of certain metals that are electrically conductive, such as aluminium and copper. The force of that electromagnetic resistance will be stronger for more conductive metals, and that force can be used to separate them from other materials.

Sink-float separation uses technology in which a lighter material, such as plastic, can be separated from a heavier material, such as a metal, by putting the two materials into a liquid with a density chosen so that the plastic will float and the metal will sink.

8.4.2 Energy reuse of combustible materials

Energy reuse of combustible materials is for further study.

8.4.3 Transport to recovery facilities

When material streams that have been created in disassembly are transported to other material recovery facilities for further processing, they should be securely packaged to prevent releases and losses during transport. CRTs, for example, should be secured to pallets with shrink wrap or similar wrapping. Broken CRT glass should be packed into containers that will not leak, such as drums or supersacks. Smaller, dispersive fractions of shredded copper or circuit boards should be transported in properly closed containers with lining if needed. As with storage, it is particularly important to label containers according to their contents, so that they are not later mismanaged or processed incorrectly. Labels and packaging are often very specific legal requirements, under national and international law, and these requirements must be known and carefully followed. There may be specific prohibitions related to ICT goods and fractions thereof. For example, restrictions on the transportation of used lithium-ion batteries prohibit transport by air and require that they are protected against short circuit to prevent fire hazard.

8.4.4 Landfill

Also as set forth above, land disposal of end-of-life computing equipment may create a risk of direct human contact and ingestion of contaminants, and of contaminated soil and of water in landfills that are not controlled. Some landfills are often visited by scavengers, including small children, looking for valuable materials to salvage. Land disposal of computing equipment may also place them in contact with acids from other sources, such as rotting food and garbage. Over an extended period of time, these acids may leach out hazardous substances, which can travel long distances into ground waters, lakes, streams, or wells, leading to much wider impacts. Final disposal of computing equipment is only appropriate as a last resort in a well-engineered, properly controlled landfill,

9 Impact of ICT waste on developing countries and countries with economies in transition

This subject has been analyzed and described in "Strategies and policies for the proper disposal or reuse of telecommunication/ICT waste material", [b-ITU-D Strategies].

Appendix I

Sourcing of materials

Base metals – Fe, Cu, Al, Mg, Zn

Base metals form the backbone for our economic infrastructure and products and are used in large quantities. Iron when combined with carbon and other substances forms steel. Copper is mainly used in electrical wiring and cooling pipes in modern electronics. Moreover, steel and aluminium are often combined with manganese, magnesium and many other metals to create a vast spectrum of metal products.

Recycled material content in aluminium alloys

From a technical point of view a new aluminium product can be produced from the same used product. There are no quality differences between a product entirely made of primary metal and a product made of recycled metal. If all aluminium applications were grouped together, the average global recycled content (excluding fabricator scrap) would stand at around 33% overall. But, in reality, recycled content varies substantially from one product to another. With the continued growth of the aluminium market and the fact that most aluminium products have a fairly long lifespan (in the case of buildings, potentially more than 100 years), it is not possible to achieve high recycled content in all new aluminium products, simply because the available quantity of end-of-life aluminium falls considerably short of total demand. [Global Aluminium Association 2009 and European Aluminium Association 2008]

As long as there is a growing demand for aluminium castings worldwide, a shortage of high-alloyed scrap is closer to the truth. The supply situation may become even worse, since the automotive revolution is just in its starting phase in many developing countries. Furthermore, recycled aluminium is used where it is deemed most efficient in both economic and ecological terms. Directing the scrap flow towards designated products in order to obtain high recycled content in those products would inevitably mean lower recycled content in other products. It would also result in inefficiency in the global optimisation of the scrap market, as well as wasting transportation energy. [European Aluminium Association 2008]

All collected aluminium is recycled. Aluminium that cannot be collected includes the aluminium used in powder, paste and for de-oxidation purposes as, after use, it loses its metallic properties. The growing markets for aluminium are supplied by both primary and recycled metal sources. The increasing demand for aluminium and the long lifetime of many products mean that, for the foreseeable future, the overall volume of primary metal will continue to be substantially greater than the volume of recycled metal. The aluminium mass flow model enables the industry to calculate global recycling rates, including a recycling input rate 32% in 2007. Modelling predicts that this figure will stay constant in the future. [European Aluminium Association 2008]

To enhance the recyclability rate of aluminium following specific guidelines has to be taken into account:

- Contamination of aluminium alloys with copper (Cu), iron (Fe), Zinc (Zn) and silicon (Si) weakens the recyclability of aluminium alloys.
- It is very difficult to make wrought aluminium alloys out of cast aluminium alloys, because their low silicon (Si) content that is less than 1%, but it is possible to make cast aluminium alloys out of aluminium wrought alloys.

Removal of undesirable elements like iron (Fe), zinc (Zn) silicon (Si) and copper (Cu) that are picked up from the supply chain present a considerable technical challenge and is unlikely to be economically viable unless the price differential between prime metal and secondary alloys widens significantly.

Recycled material content in steel alloys

Basic question is whether the steel is made in a basic oxygen furnace (BOF) or an electric arc furnace (EAF). The recycled-content value is 28.9% for BOF steel (typically hollow sections, steel studs, and decks) and 72.6% for EAF steel (typically beams, columns, and angles).

The BOF process uses 20-25 to 35 per cent old steel in production. The BOF process produces materials for products – such as automotive fenders, encasements of refrigerators, and packaging like soup cans, pails, whose major required characteristic is drawability. The EAF process uses virtually 80-100 per cent old steel to make new. EAF process produces materials for products – such as structural beams, steel plates, and reinforcement bars, whose major required characteristic is strength.

To understand the recycled content of BOF and EAF steels, do not attempt to select one steel producer over another on the basis of a simplistic comparison of relative scrap usage or recycled content. Rather than providing an enhanced eco-environmental benefit, such a selection could prove more costly in terms of total LCA energy consumption or other variables. Steel does not rely on "recycled content" purchasing to incorporate or drive scrap use. It already happens because of the economics. Recycled content for steel is a function of the steelmaking process itself. After its useful product life, regardless of its BOF or EAF origin, steel is recycled back into another steel product. Thus steel with almost 100 per cent recycled content cannot be described as eco-environmentally superior to steel with 30 per cent recycled content. This is not contradictory because they are both complementary parts of the total interlocking infrastructure of steelmaking, product manufacture, scrap generation and recycling. The recycled content of EAF relies on the embodied energy savings of the steel created in the BOF.

Copper is sometimes added to confer corrosion resistance, but is the most troublesome of the residual metallic element in scrap steel since it occurs in larger concentrations than do other contaminants and it is not removed during steelmaking. The reason why place an upper limit on copper lies in the effects that it has on surface hot shortness. Zinc (Zn) from galvanized steel and brass can collected from flue gas in steel manufacturing process and then can be reused.

To enhance the recyclability rate of steel following specific guideline has to be taken into account:

- Contamination of steel allows with copper (Cu), nickel (Ni), molybdenum (Mo) and tin (Sn) weakens the recyclability of steel alloys.

In Figure I.1 [b-Heino], it can be seen that zinc (Zn) and lead (Pb) are removed to dust, aluminium (Al), silicon (Si), vanadium (V), zirconium (Zr), titanium (Ti), boron (B) and niobium (Nb) to slag, but copper (Cu), nickel (Ni), molybdenum (Mo) and tin (Sn) will move to steel in steel manufacturing process.

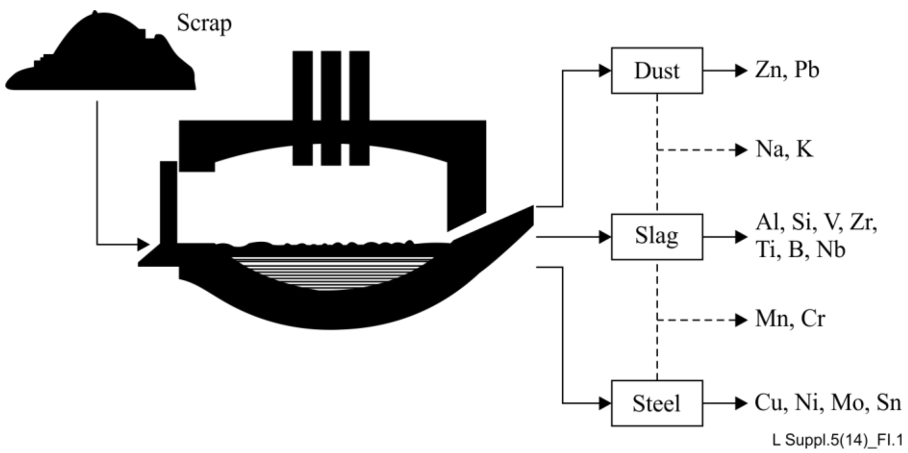


Figure I.1 – Removing impurities from scrap to slag, dust and steel

Recycled material content in stainless steel alloys

In any stainless steel item we buy these days, up to 60% of its weight is recycled materials. However, most of the recycled content isn't from end-of-use items, but from scrap materials from production and manufacturing.

Figure I.2 [b-ISSF]. illustrates how recycling fractions are divided and the difference within the fractions. In the new material production the percentage of material returned from end-of-life products is 25%, the percentage of material returned from production and manufacturing is 35% and the percentage of primary raw material is 40%.

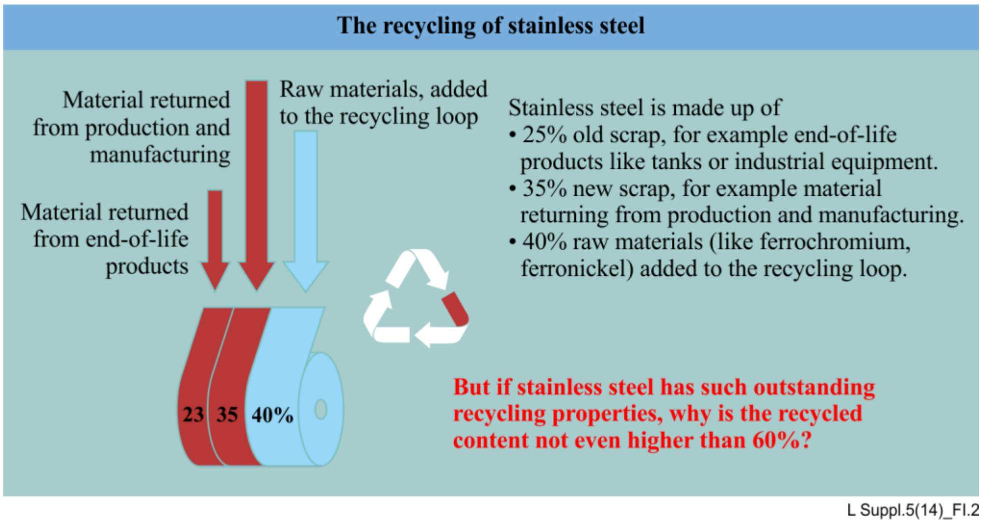


Figure I.2 – The recycling of stainless steel

The percentages in the Figure I.2 mean:

A) 25% means old scrap for example from metal parts end of life products means that the material has been used in other applications and the melted second time to raw for our product.

B) 35% means reutilization of materials such as rework, regrind or scrap generated in a process and capable of being reclaimed within the same process that generated it.

C) 40% means primary raw materials (not used before).

To enhance the recyclability rate of steel following specific guideline has to be taken into account:

- Contamination of stainless steel alloys with copper (Cu) weakens the recyclability of stainless steel alloys.
- Austenic stainless steel with molybdenum must be kept separate from other stainless steel grades, because it has a high molybdenum (Mo 2%) concentration.

Technology metals and plastics

High-technology products and green technology solutions are dependent on a large number of technology metals even if used in only very small quantities. Technology metals includes rare earth elements like Sc, Y, La, Ce, Pr, Nd, Pm, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, precious metals like Ru, Rh, Pd, Ag, Os, Ir, Pt, in semiconductor used substances Ge, Se, Sb, Te and other technology metals like Li, Be, Co, Ga, Zr, Nb, Mo, Cd, In, Hf, Ta, W, Re and Bi. Many of these are used in electronics mainly in printed circuit boards and its components like semiconductors, soldering processes and surface treatments. Especially interested are of following metals – Ta, Ag, Au, W, Ru.

Recycled material content in polymers

There are various alternatives to the recovery of value from plastic waste:

- Polymers can be mechanically recycled which means re-melting and transformation of plastics into new recycled products. However only around 22% of post-consumer plastics waste is suitable for mechanical recycling, namely those which are available from clean and sorted waste streams, e.g., PET drinking bottles, large films or window frames. Also, it is important with plastics to know which plastics grades can be recycled together and which must be separated before recycling. In Table I.1 is presents guidelines from VDI on which plastics can be recycled together [b-VDI 2243].

Table I.1 – Plastics recycling's compatibility in mechanical recycling.

		Additive											
Matrix material	**Important plastics**	**PE**	**PVC**	**PS**	**PC**	**PP**	**PA**	**POM**	**SAN**	**ABS**	**PBTP**	**PETP**	**PMMA**
	PE	1	4	4	4	1	4	4	4	4	4	4	4
	PVC	4	1	4	4	4	4	4	1	2	4	4	1
	PS	4	4	1	4	4	4	4	4	4	4	4	4
	PC	4	3	4	1	4	4	4	1	1	1	1	1
	PP	3	4	4	4	1	4	4	4	4	4	4	4
	PA	4	4	3	4	4	1	4	4	4	3	3	4
	POM	4	4	4	4	4	4	1	4	4	3	4	4
	SAN	4	1	4	1	4	4	4	1	1	4	4	1
	ABS	4	2	4	1	4	4	3	4	1	3	3	1
	PBTP	4	4	4	1	4	3	4	4	3	1	4	4
	PETP	4	4	3	1	4	3	4	4	3	4	1	4
	PMMA	4	1	3	1	4	4	3	1	1	4	4	1

1 – Compatible
2 – Compatible with limitations
3 – Compatible only in small amounts
4 – Not compatible

- The second is energy recovery after incineration which is currently much less valued in the public because the benefits are not yet well understood. Through energy recovery, plastic waste can be used in order to generate heat, steam or electricity. One kilogram of plastic waste has the same heating value as one litre of fuel oil. Energy recovery is suitable for mixed and soiled plastic waste which would otherwise be technically or economically difficult to recycle.
- The third is feedstock recycling processes such as the gasification of plastic waste into synthesis gas, to be used in blast furnaces as a reducing agent, is a good option in combination with the other recycling options.

Some examples of substances that can cause harmful effects to the recycling process of plastics are fire retardants and colour agents.

Technology metals recycling in electronics

At the end of their life electronics go to multi material separation. Before multi material separation, product goes to disassembly process in which e.g., printed circuit boards (PCBs), external electric cables and batteries are disassembled from the product. Separated components PCBs, batteries and cables go to their own recycling processes. Multi material separation means that the metallic materials are prepared to recycling and contaminated plastics, which contain flame retardant, filler or reinforcement and plasticizer, to landfill.

For populated PCBs generally recycling routes include component recycling via disassembly and material recycling via mechanical processing, pyrometallurgy, hydrometallurgy or a combination of these processes.

Even the technology of robotics offer us a more cost effective way to identify and separate valuable components from PCBs. One of the limiting challenges for component recycling as such is the new high technology and many times also the lower cost of new components.

Pyrolytic treatment involves melting of the ground feedstock in a furnace in a high temperature. The organic parts are burned and toxic emissions are addressed with a afterburner. Process produced black metal is copper rich and can be treated by electro refining. The precious metals are recovered from the anodic sludge with leaching melting and precipitate route. Currently the majority of PCBs with higher precious metal content will be handled first with a primary mechanical treatment before the smelting process. In the pyrolytic treatment the polymers are used as fuel in the burning process however there exists pure mechanical treatment approaches where polymers have found a second life in plastic products. A commercial pure mechanical recycling system includes, eddy current, electrostatic and magnetic separation, classification and secondary treatments to generate non conductive, ferrous and metallic fractions from scrap PCBs.

A number of different hydrometallurgical approaches has been developed to pilot plant stage.

The main characteristics which are used to determine if the PCB scrap should be handled mechanical or hydro mechanical way are response to magnetic field, electro positivity, chemical reactivity, polyformic, electrical conductivity, liberation size and material density. The major benefits for hydrometallurgical approach are more efficient recovery of metals, the high quality of recovered plastics like exposits including the capability to extract both brominated hydrocarbon and halogen derivatives.

The basic mechanical techniques deployed in mechanical processing are inherited from the raw material processing techniques and that is the reason why separation yields especially for precious metals are far behind the results reached for example with pyrolytic process. The situation has been enhanced by using different pulverisation techniques in combination with different stages of mechanical separation techniques like ferromagnetic removal, permanent magnets, eddy current techniques, air tables with a pyrolytic process where some output fractions of the mechanical treatment will be destined to the pyrolytic process.

A typical pyrolytic process is described in Figure 6, where the e-scrap undergoes pre-processing in the form of dismantling and crushing. Glass, a certain amount of plastic, and iron and aluminium are separated out, because copper and other precious metals bring the value for the smelter (see Figure 7). The kaldo furnace needs no input energy into the furnace, because plastic in the input raw material provides sufficient energy for the smelting process. The energy released are recycled and converted to electricity or district heating. The smelted electronic scrap, known as black copper, is integrated with the smelter's main copper flow for further refining and the extraction of copper and precious metals. The glass fibre in epoxy resin smelts and mixes with the slag. Precious group metals and copper are recovered in the process. Process slag is a by-product, which is reused e.g., filling material in land construction work and there substitutes primary materials. The silica in the slag compensates silica sand, which is needed to maintain the quality of slag.

Appendix II

Used mobile phones collection in Korea

Many people want to use new mobile phones. For example, people in Korea use their phones 26.9 months in average and then change their phones to new ones. Most of them change their phones not because the phones are out of order but because they want to have new models.

Table II.1 shows the recycling rates of three Korean telecommunication companies. In Table II.1, the amount of recycling mobile phones include usage of rental phones, exportation of used phones, recycling of partial components in mobile phones, and resale of mobile phones. According to Table II.1, about 10 % of mobile phones have been recycled.

Table II.1 – Recycling rates of Korean telecommunication companies (unit: 1,000 ea.)

Year	Korean telecommunications company	Amount of sales	Amount of recycling	Rate of recycling (= Amount of recycling / amount of sales)
2010	KT	8.725	1.008	11.6%
	SKT	12.791	1.606	12.6%
	LG U+	4.341	382	8.8%
	Total	**25.857**	**2.996**	**11.6%**
2011	KT	9.362	249	2.7%
	SKT	12.775	1.127	8.9%
	LG U+	4.596	181	3.9%
	Total	**26.733**	**1.557**	**5.8%**
January ~ July, 2012	KT	3.854	445	11.5%
	SKT	5.528	997	18%
	LG U+	3.064	258	8.4%
	Total	**12.446**	**1.700**	**13.7%**
(Source: Parliamentary inspection of the administration of KCC, June 2012)				

Many used phones are not used anymore but are just kept in house or discarded. These mobilephones and their batteries contain hazardous materials that might cause eco-environmental damage [b-MPPI]. Hence, reusing and recycling mobile phones is helpful for the eco-environmental protection aspect, and useful from the economical perspective.

There is a cost related to collecting, shipping and reuse or recycling of mobile phones.

There has been collaboration between the public and private sectors to face the many challenges that represent collecting used mobile phones [b-E0LICT].

The ***compensation system*** for exchanging mobile phones of telecommunication companies is one of example of used phones collection. The compensation system gives a discount when purchasing a new phone when the previously used phone is returned.

The ***EcoAS*** (Electrical and electronic equipment and vehicle eco-assurance system) is one of Korea's environmental systems. It restricts hazardous materials to be used for electronic and electrical products and vehicles. It also requires that products be easily recycled. Moreover, it manages all the eco system from design and production, to discard products in order to reduce eco-environmental effects. The EcoAS combines RoHS (Restriction of hazardous substances, restriction of the use of hazardous substances in EEE (Electrical and electronic equipment)), WEEE (Waste electrical and electronic equipment) and ELV (End of life vehicle) of EU environmental systems together. The EcoAS is applied to manufacturers, importers and sellers. The EcoAS imposes recycling taxes when it is not applied properly [b-EcoAS].

The Ministry of Environment of Korea provides the disposal direction for recyclable wastes of small home appliances such as mobile phone, camera, MP3, mixer, etc., and provides separated disposal boxes.

Many campaigns are conducted nation-wide every year by the public sector, the private sector, and through collaboration between the public and private sectors. Example are the Seoul recycling centre, GyungGi province's campaign, the save phone campaign, etc. Some companies, churches and schools have also campaigned to collect used mobile phones.

In Korea, sometimes door-to-door buyers with carry-on handcarts collect used mobile phones as part of a bulk collection of other larger and heavier home appliances. Then, it is likely to be damaged in handling and storage. The door-to-door buyers may pay small amounts of money to collect used mobile phones and may sell them to recycling centres.

Appendix III

Good practice case studies of donation, refurbishment and reuse of used ICT equipment

Ateliers Sans Frontieres (ASF) case study: ASF is a small not-for-profit NGO operating in France that refurbishes and recycles used computing equipment. ASF established a programme to help rehabilitate people who find it difficult to hold onto regular jobs because of drug addictions and other problems by employing them to disassemble used computing equipment. Companies pay ASF to handle the cost of collecting and disassembling used computing equipment, which helps fund ASF refurbishment activities. A film illustrating the project may be viewed at www.digitalpipeline.org .

Close the Gap international case study: Close the Gap is an European not-for-profit organization that helps bridge the digital divide by offering projects in the developing world for access to cost-efficient ICT equipment. Close the Gap collects computers from its donors and has a partnership with an external private partner called Flection for refurbishing these donated assets. By doing so, Close the Gap offers a quality service towards its donors in terms of data wipe, recycling and reporting. Quality is also assured to the project partners in the developing world who can obtain a cost-effective IT tool that is configured according to the requirements of the end-users. See www.close-the-gap.org for further information.

Computer Aid International: See Computer Aid International's website (www.computeraid.org) which notes that Computer Aid International exists to tackle the causes and effects of poverty through practical ICT solutions. They work with not-for-profit organizations in developing countries to provide equipment and support where it is most needed by poor communities in areas such as agriculture, health and education. Computer Aid International is the world's largest and most experienced provider of high-quality, professionally refurbished PCs to developing countries and works with partners to deliver training and technical support to endrecipients.

RDC Case Study: RDC is a British company that manages computing equipment for a number of large organizations. It began operations in 1991, and is now a leader in the eco-environmentally responsible handling of used computer equipment. RDC operates a comprehensive system for managing and tracking the used equipment it collects. Companies that send RDC their used computing equipment receive most of the revenue from the resale of the refurbished equipment, with RDC taking a commission. See www.rdc.co.uk for more information.

UNIDO case study: This shows how commercial refurbishers can operate in developing countries. Donors such as business and government organisations who are considering donating used IT to donation schemes need to be reassured that their confidential data is being eradicated. Donors risk multi-million pound costs of remedying any data breaches. In the EU, the creator of a data record is responsible to ensure it is not released to unauthorized persons and to pay for the costs of remedying any breaches that do occur. A US insurance industry review of 2009 calculated the average total per-incident costs in 2009 were $ 6.75 million (say £4.5 million).

Appendix IV

Future work on energy consumption

To support new generation ICT network infrastructures and related ICT services, telecoms and ICT service providers will need an ever larger number of devices, with sophisticated architectures able to perform more and more complex operations in a scalable way. Hence, in order to continuously offer the maximum performance and reliability levels, today's networks, links and devices are designed with highly specialized hardware and software, which is provisioned for busy load and sometimes lacks power management capabilities. As a consequence, while peak load is reached rarely and for short time periods, the overall power consumption remains more or less constant with respect to different traffic utilization levels.

Motivated by these considerations, some innovative solutions and device prototypes are nowadays being performed for wired and wireless network devices. The energy efficiency for network devices need to exploit dynamic adaptive technologies that allow saving energy when a device (or part of it) is not used. In particular, it is possible to distinguish two main kinds of network-specific energy-saving capabilities exploitable: (i) Dynamic power scaling, which allows network devices tuning dynamically the trade-off between energy profile and processing capacity of internal processing blocks/engines, while meeting the actual traffic load and quality of service (QoS) constraints; and (ii) smart standby, which allows putting currently unused parts of network devices (such as redundant network interfaces, unused network terminations, etc.) into very low energy consumption modes, where only some basic functionalities are performed (e.g., heart-beating message reply). Moreover, some studies and demonstrations have been performed on a network connection proxy (NCP) architecture that covers devices for network-related tasks whenever they fall in a low-power state. Running an NCP enables devices to take full advantage of low-power states without losing their network presence nor dropping their connections and without relying on any peer's capability; this approach provides effective frameworks that fit the current Internet infrastructure, boosting the use of low-power states and yielding to great energy savings in the short term.

Energy-aware capabilities can have very different implementations depending on the specific network elements. To make the implementation of the energy-aware optimization hardware-independent, a novel standard interface, the green abstraction layer (GAL), has been designed. The GAL permits an easy intercommunication between heterogeneous energy-aware hardware (HW) and software (SW) at the data-plane, and operations, administration and management (OAM)/control applications at the control plane. The work item for GAL standardization has been approved by ETSI (European Telecommunications Standards Institute) [b-ETSI DES/EE-0030], Technical Committee "Environmental Engineering" [b-ETSI Env]. In particular, the specific goal of the GAL is to extend and re-engineer the advanced configuration and power interface (ACPI) standard [b-ETSI Env] for general purpose computing systems, and adapt it to architectures, functionalities and paradigms of network devices, and especially of their data-plane components. In other words, the GAL is designed to allow control processes acquiring information on the green capabilities available at the data-plane, configuring them, and carrying measurements on the energy consumption. The GAL can be used as standard interface by three main sets of processes: (i) Local Control Policies (LCPs), which optimize the configuration at the device level, in order to achieve the desired trade-off between energy consumption and network performance, according to the incoming traffic load; (ii) network–wide control policies (NCPs), to autonomously control and optimize the behaviour of a network (a set of devices) – typical examples of these kinds of processes are traffic engineering, routing and signalling algorithms/protocols (e.g., OSPF-TE/RSVP-TE) with "green" extensions; (iii) Monitoring and OAM, for the operator to control and optimize the behaviour of a network (as in Network Management systems with "green capabilities").

The GAL interface has been used in practical experiments and demonstration tests in order to verify its actual effectiveness for energy efficiency improvement. The results obtained show not only the effectiveness of all the proposed approaches with respect to the reduction of the energy consumption and corresponding costs and CO_2 emission, but also their technical need in an Internet evolution prospective. Most of the future approaches/technologies might be not scalable with respect to the traffic increase in terms of energy consumption without an intensive and deep use of advanced power management mechanisms like those proposed in the ECONET project.

Appendix V

Recommendations for battery testing

A simpler approach to determining a battery's appropriateness for reuse is ensuring that it is still capable of holding a minimum charge of one hour. The actual remaining capacity of a used laptop battery, rather than the percentage of the original capacity, will vary depending on a number of factors:

First, there are four-cell, six-cell and nine-cell batteries in used in laptops as of the writing of this document. For example, a used nine-cell battery at 50% capacity may contain more charge than a brand new four-cell battery at 100%.

Second, there are different original battery ratings within the same battery category. For example, a new four-cell battery may be rated for five amp-hours, while another brand-new four-cell battery may only be designed to carry three amp-hours.

Third, the rate at which a battery is discharged, which affects how many times it needs to be recharged and therefore the remaining battery life is also largely dependent on the device that contains it.

For instance, newer laptops often contain power-saving features such as low-power processors, lowpower memory, energy-saving disk drives and screens. Older devices may not include these features and will thus draw down the same battery at a faster rate under similar conditions. Similarly, netbooks, which run very basic applications, will typically be able to run longer on the same battery capacity.

Finally, identical laptops under different use conditions will draw power at different rates. For example, a laptop running in standby mode will draw significantly less power than a laptop running multiple applications and devices.

The cost of a new laptop battery may equal or even exceed the value of the used laptop that contains it, so there is an added incentive amongst users and refurbishers not to discard batteries which are able to complete a circuit and hold a charge for a minimum of one hour. In other cases, users in countries where the electrical grid is unreliable may need a battery that can hold charge for longer in order to continue working when no electricity is otherwise available. In many cases, however, users discard fully functional laptop batteries prematurely, when many could be retained in use or for re-use.

Bearing in mind this technical information, the following testing methods are proposed for laptop batteries:

1) Method 1: demonstration

This is the most commonly used and represents a simple test, able to be undertaken by all refurbishers. The system/battery combination is tested to ensure it can hold an appropriate charge and meet the minimum run time/charge of one hour. The laptop battery should be inserted into the laptop and then fully charged. The system should be started with the screensaver disabled, and allowed to run functions to demonstrate the capability of operating off the power grid. The time for the battery to fully drain is recorded, with at least one hour run time. In some situations the end user may request a longer lasting battery according to their needs.

2) Method 2: self-managing the smart battery

This test is more sophisticated and requires some expertise and knowledge and applies to newer batteries. All new laptop batteries now incorporate "smart" battery technology which enables the battery to be assessed using a battery check programme provided by the manufacturer. For a laptop powered by a "smart" battery, the calculated method may be used. The power used by the laptop should be determined in watts (W). The battery should be interrogated or tested to determine the full charge capacity in watt-hours (Wh). The runtime is determined by:

Run time in hours (h) = FCC(Wh)/Power used (W).

Appendix VI

Labeling and documentation of refurbished and repaired ICT equipment

For refurbished computing equipment or components, any information regarding the status of the equipment should conform to the labelling and/or documentation requirements as follows: the labelling or documentation should include the name, address, and complete contact information for the refurbisher, the unique identification number of each refurbished device (e.g., original serial number), the testing that was performed, and confirmation that the refurbished/repaired equipment is fully functional.

Other labelling elements can include the date testing was completed, the need for additional software, etc. Tested laptop batteries should be labelled with the result of the test.

In addition to the above, if the refurbishers are selling or donating shipments of repaired/refurbished computing equipment or components, they should provide detailed documentation of each device in the shipment (as described in the next paragraph), with such documentation accessible so that shipments do not have to be unpacked (e.g., by customs officials) in order to find the documentation. The refurbisher should fill out and sign a Declaration of Testing and Determination of Full Functionality and Reuse Destination of Exported Used Computing Equipment.

This declaration document requires the consignor (refurbisher selling or donating equipment or components) to provide contact information for the exporter, the consignee, and the user, as well as list each unit's type of equipment, model and serial numbers, year of manufacturing, testing information, and a signed declaration that all of the devices and components are fully functional and being exported/imported for the purpose of reuse, and not for recycling, further processing, or final disposal.

In addition, a refurbisher or other party who refurbishes and repairs computing equipment should ensure that their practices are consistent with applicable IT, data security and other legislation. In some countries an organization making certain changes to computing equipment would then be regarded as the new supplier to the market and hence responsible for demonstrating the same compliance provisions as the original manufacturer. This may not be the case in all countries and is likely to vary with the extent of product repair.

It is also the case that there may be specific labeling requirements via IT or other regulations for such refurbished or repaired computing equipment. These distinctions may be especially important where the device is intended for resale in another country. Where repair affects the original manufacturer's guarantee provisions, consumers should be aware of this fact. Such labeling may be on the equipment itself or documented in the product packaging as determined by applicable regulations.

Where possible, information on opportunities for subsequent users to recycle the refurbished and/or used computing equipment should also be provided through use of a label on the product, or on the product packaging, or invoice or through a product information insert.

Where possible, and where labelling is used, a standardized label should be applied to provide all the information listed above, to ensure that subsequent users have access to this information in a uniform manner. Additional information can be provided on the product packaging, or through a product information insert. Where individual product labelling is not used, documentation should provide this information.

Appendix VII

Example of product handling and refurbishment of mobile phones

1. Facilities that refurbish used mobile phones should take steps to identify and sort used mobile phones which are to be refurbished from those that should be recycled for material recovery due to damage, wear, age or performance.

2. Refurbishment facilities should take care not to release data stored on the used mobile phones that they receive and should seek to remove and destroy such data.

3. Care should be taken to ensure that prolonging the life of a mobile phone does not result in the product exceeding the expected life of some of the components in the product. This problem is not unique to mobile phones.

4. Used mobile phones should be evaluated and assessed to determine the extent to which they are suitable for re-use with or without repair or refurbishment. As a minimum, this assessment will include:

(a) An "air" or "ping" test: calling a test number (which will vary from country to country and from network to network), to generate a service response, and indication of whether or not the handset is functional;

(b) a "loop back" test: blowing or speaking into the handset while on a call, to determine whether or not the microphone and speaker are functional;

(c) a screen and keypad test: switching the handset on and pressing each of the keys, to indicate whether or not the LCD and keys are functional;

(d) a battery test: testing the battery with a volt meter to indicate whether or not the battery is functional.

5. All refurbishers should adhere to the practice of selling or transporting only those mobile phones that have been tested for functionality, unless to a properly authorized recycling vendor or outsource repair centre.

6. All refurbishing companies should utilize a reusable, recyclable or biodegradable material as a storage and packaging medium for used mobile phones, and encourage such further use.

7. In general, only benign cleaning solutions should be used to clean used mobile phones. If they are not, refurbishers should use cleaning solutions in an eco-environmentally sound, efficient and safe manner. Where applicable, local laws and regulations should always be adhered to.

8. When disassembling mobile phones or components of such phones, the refurbishment facility should ensure that where necessary the appropriate tools are used in order to prevent damage.

9. Care should also be taken to preserve the value of the component or material where practicable and to protect workers and the environment.

10. Refurbishment facilities should ensure that any solder used during the refurbishment process is compatible with the original solder used within the mobile phone and is compatible with any substance restrictions in the destination market. Soldering joints should be of the same condition and quality as contained in the original product. All soldering activities should be undertaken in conformity with occupational health and safety requirements to minimize worker exposure to fumes and dust.

11. Only manufacturer-specified genuine or refurbished genuine parts should be used. In particular, non-genuine parts must not be used for safety or system critical functions. Parts should be sourced from suppliers with independent third party accredited quality management systems. Parts should be subject to a receiving inspection suitable to assure the quality and performance level of the

parts. Corrective action processes should be in place to ensure the effective management of quality issues.

12. Refurbishment facilities should ensure that parts used in the refurbishment of mobile phones, including electrical devices, cases and covers, are of a type and design that will allow the mobile phones to comply with the rated operational characteristics specified by the original equipment manufacturer.

13. Replacement antennas should have the same part number as the original equipment, and should not alter the mobile phone's operational characteristics (including SAR) as specified by the original equipment manufacturer.

14. Replacement batteries should include the same safety circuitry and insulation found with the original equipment. All replacement batteries must allow the mobile phone to conform to the rated operational characteristics (including SAR) specified by the original equipment manufacturer and be able to hold an appropriate charge.

15. In accordance with appropriate waste shipping regulations, any battery that fails the inspection process and is rejected should be placed in a specifically designated container for proper transport to a recycling facility.

16. End-of-life batteries and any associated circuit boards or electronic assemblies containing lead-based solders are to be managed in an eco-environmentally sound manner and in accordance with the Basel Convention when destined for transboundary movement.

17. Replacement battery chargers should include the same safety circuitry, insulation and filtering found with the original equipment.

18. The maximum power level for a particular model must not be exceeded as a result of refurbishment. Technical standards for mobile phones usually specify a maximum power level and an allowable tolerance above and below this nominal value.

19. Facilities should not add or update software for refurbished mobile phones that would change the rated operational characteristics specified by the original equipment manufacturer as this may affect compliance of the mobile phone with standards for interference or for human exposure to radio frequency (RF) transmissions.

20. When refurbishers are exporting refurbished mobile phones to other countries, care should be taken to ensure compliance with the Basel Convention; with the decisions of its Conference of the Parties (for Parties to the Basel Convention); and with all applicable legislation governing product imports, technical standards, labelling, and health and safety requirements.

21. Used mobile phones resold into foreign markets should be packaged and handled in a manner that is consistent with their planned reuse.

Management of components and materials removed from used mobile phones

22. Refurbishment facilities should ensure that components and other materials removed from mobile phones, which are destined for reuse, are handled in a suitable manner that preserves their value.

23. Used mobile phone components and materials, not suitable for reuse, should be managed on site in a manner that preserves their value for materials and energy recovery.

24. In the case of materials that can be used only for purposes of materials recovery and recycling, the facilities should handle the materials on site so as to protect workers and the environment.

25. Refurbishment facilities should be encouraged to minimize the landfilling of used mobile phone components and materials and arrange for appropriate material recovery and recycling where practicable.

26. Items removed from used mobile phones, which may include batteries, electronic components, circuit boards and other items removed during reassembly, should be managed in an eco-environmentally sound manner and in accordance with any applicable requirements of the Basel Convention when destined for transboundary movement.

27. Refurbishment facilities should be aware of the Basel Convention guidance documents on transboundary movements of hazardous wastes destined for recovery operations and on preparation of technical guidelines for the eco-environmentally sound management of wastes subject to the Basel Convention.

28. Refurbishment facilities should handle residual materials on site in a manner that protects against releases into the environment and ensures that they are safely transported to an appropriate facility.

29. Facilities should first characterize their process residuals using testing or by having knowledge of the materials and processes used at the facility.

30. If residuals are to be disposed of, the refurbishment facilities should ensure that the residuals are delivered to a landfill or incineration facility that is suitable for the specific residual, is properly authorized by relevant regulators, is well maintained and is well operated.

31. Refurbishment facilities should also be aware of the Basel Convention technical guidelines for the identification and eco-environmentally sound management of plastic wastes and for their disposal, technical guidelines on specially engineered landfill (D5), and the draft technical guidelines for the recycling/reclamation of metals and metal compounds (R4). These guidelines are available from the Secretariat of the Basel Convention.

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

33. In the case of transboundary movements, refurbishment facilities should ensure that all mobile phones, components (e.g., batteries) and residuals destined for materials recovery are prepared for shipment and transported in full compliance with the Basel Convention.

Administrative measures and personnel training

34. Refurbishment facilities should maintain records of all mobile phones received and their disposition.

35. Records should be kept for a period that is consistent with relevant national or local regulations and practice.

36. Refurbishment facilities should have systems in place for defining specific envirionmentally sound management objectives, develop plans to meet the objectives, implement such plans and monitor progress towards achievement of those objectives.

37. All certified refurbishers should be compliant with an envirionmentally sound management policy and have an [b-ISO14001], [b-EMAS] or similar certification, including those that are "tailor made" for individual circumstances, such as for specific industrial sectors or enterprises.

38. Refurbishment facilities should ensure that all their employees are thoroughly familiar with proper procedures for carrying out their responsibilities during normal facility operations and during emergencies.

39. Refurbishment facilities dealing with products that are potentially hazardous to the health and safety of their workers or the environment are required to have processes, documented or otherwise, in place to ensure that those products are regularly inspected and monitored as required by their country's regulatory authority.

40. Refurbishment facilities dealing with products and materials that are defined by their country as "waste" are required to hold all relevant waste management permits, licences or other authorizations required by their country's regulatory authority.

41. 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.

42. Refurbishment facilities should perform, at regular intervals, evaluations to identify applicable local authorizations and to determine how these requirements apply to the facility.

43. Where refurbishers or other parties are exporting refurbished mobile phones, care should be taken to ensure compliance with all applicable laws governing product trade.

44. Any organization that remarkets used mobile phones should ensure that those mobile phones continue to meet all applicable industry and government standards and requirements, including the original product's rated operational characteristics.

45. Refurbishers, and other parties which recondition and repair mobile phones, should ensure that their practices are consistent with applicable telecommunications and other legislation. Labelling may be a requirement and such labelling may be on the mobile phone itself or in the product packaging as determined by the aforementioned applicable regulations.

46. Any party refurbishing or remarketing a mobile device should inform the subsequent purchaser that the product is used and/or refurbished and provide contact information necessary in the case of faulty product. It should be noted that there may be specific labelling requirements under telecommunications or other regulations for such refurbished devices.

47. If any mobile phones that are not refurbished and require shipment across boundaries, such shipments should follow the Guideline for Transboundary Movement of Collected Mobile Phones.

Appendix VIII

Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal

The Basel Convention was adopted on 22 March 1989 by the Conference of Plenipotentiaries in Basel, Switzerland, in response to a public outcry following the discovery, in the 1980s, in Africa and other parts of the developing world of deposits of toxic wastes imported from abroad. The overarching objective of the Basel Convention is to protect human health and the environment against the adverse effects of hazardous wastes. Its scope of application covers a wide range of wastes defined as "hazardous wastes" based on their origin and/or composition and their characteristics.

Under the Basel Convention, e-wastes are characterized as hazardous wastes when they contain components such as accumulators and other batteries, mercury switches, glass from cathode-ray tubes and other activated glass, PCB-containing capacitors or when contaminated with cadmium, mercury, lead or PCBs. Also, precious-metal ash from the incineration of printed circuit boards, LCD panels and glass waste from cathode-ray tubes and other activated glasses are characterized as hazardous wastes. To address the eco-environmental issues related to the increasing transboundary movements of these wastes, and to ensure that their storage, transport, treatment, reuse, recycling, recovery and disposal is conducted in an environmentally sound manner, a proactive approach is essential. The plastics associated with e-waste may also be covered, under Annex II of the Basel Convention [b-BASEL].

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