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International Telecommunication Union
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Recommendation

ITU-T L.1061 (03/2023)

SERIES L: Environment and ICTs, climate change, e-waste, energy efficiency; construction, installation and protection of cables and other elements of outside plant

E-waste and circular economy

Circular public procurement of information and communication technologies

ITU-T L-SERIES RECOMMENDATIONS

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

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Recommendation ITU-T L.1061

Circular public procurement of information and communication technologies

Summary

Green procurement policies, which focus on purchasing durable information and communication technology (ICT) equipment and recycling e-waste, can help reduce emissions and resource extractions and influence the market by increasing demand and stimulating research and product development.

Recommendation ITU-T L.1061 provides technical guidance to public sector organizations on improving their procurement practices to purchase more circular ICT goods and services. The Recommendation covers the purchase of ICT equipment such as personal computers, terminals, network equipment and servers, and imaging equipment, and recommends specific requirements in procurement to (1) minimize the generation of e-waste and its adverse effects; (2) maximize the use of energy-efficient equipment; (3) maximize the useful life of equipment; and (4) maximize recyclability. It also covers design for e-waste prevention and procurement recommendations which are relevant for the management choices of the e-waste hierarchy, as well as specific requirements and guidance on procurement to enhance the energy efficiency, reduce greenhouse gas (GHG) emissions to mitigate climate change and reduce the emissions of hazardous substances in e-waste.

History

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FOREWORD

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Introduction

Communities worldwide face the consequences of climate change, depletion of natural resources, loss of biodiversity, environmental degradation and increasing poverty [b-UNDP]. To address these issues, all levels of society (public and private) realize that change is required to develop a more sustainable society and planet. Sustainable development [b-UN-1] has three pillars: economic, social and environmental.

Over their lifespan, ICT products follow pre-use, use and post-use processes. Raw material and part production, design and ICT goods manufacturing are pre-use processes that result in an ICT product. Procurement is the first process in an expected long use phase of that product, followed by post-use end-of-life treatment that starts with collecting ICT products declared as e-waste. Each decision in a given process affects the following decision. Pre-use decisions determine the durability of a product in the use phase. In the end, the amount of resulting e-waste, its effects and recyclability are also affected by pre-use decisions, but procurement is the first and key use decision.

Purchasing durable ICT equipment and recycling e-waste helps reduce emissions and resource extraction. Furthermore, green procurement policies can influence the market by increasing demand and stimulating research and product development, thus leading to increased availability and better prices for these ICT products.

This Recommendation focuses on the environmental pillar of sustainability in the public procurement of ICT products. Therefore, it aims to provide a set of circular procurement principles to contribute to achieving environmental goals for organizations in [ITU-T L.1420], the Connect 2030 in [ITU-T L.1031] for the ICT sector, and the planetary goals of the UNFCCC starting with the Paris Agreement.

Sustainable public procurement aims at achieving the best value for money on a whole-life basis in terms of generating benefits not only to the organization but also to society and the economy while minimizing environmental damage [b-DEFRA]. Cost, environmental and social aspects are the main components.

This Recommendation is structured as follows:

- The framework of environmental and circularity considerations in the public procurement of ICT products and services is in clause 6.
- The e-waste hierarchy ranks environmentally sound e-waste management strategies in clause 7.
- How procuring ICT equipment can contribute to minimizing the amount of e-waste produced at the top of the waste hierarchy, preventing its adverse effects on human health and the environment in clause 8.
- Extension of a product's lifetime in clause 9.
- Increasing recyclability contributes to the circular economy in clause 10.
- A summary of recommendations grouped by broad ICT product categories in clause 11.

To facilitate the implementation of the Recommendation, The Circular and Sustainable Public Procurement Guide [b-ITU23] provides practical guidance and help to ICT procurement planners and professionals to improve the circular and sustainable outcomes of their organization's ICT buying decisions and to avoid adverse impacts on social and environmental systems. The guide was developed in parallel with this Recommendation. Three levels of circular and sustainable ICT procurement for getting started or improving the level of circular and sustainable ICT procurement are covered in the guide:

1) Policy and strategy, including setting the guiding principles and goals and planning for circular and sustainable ICT procurement.
2) Creating the conditions, covering the practical steps for capacity building, target setting and enabling circular and sustainable ICT procurement.

3) Procurement processes, providing methods, approaches and cases of application for circular and sustainable procurement of ICT on the ground.

While predominately aimed at national governments, the guide is equally applicable to other public buyers. The guide has been developed by the GovStack initiative in collaboration with the Circular Electronics Partnership.

Recommendation ITU-T L.1061

Circular public procurement of information and communication technologies

1 Scope

This Recommendation provides a set of principles that provides a basis for circular public procurement of ICT equipment to:

– Maximize usable life,

– Maximize the use of energy-efficient equipment,

– Minimize any resulting amount of e-waste produced, and the adverse effects of e-waste, and

– Increase recyclability, thereby contributing to circular economy realization.

This set of recommendations defines standards to help the public sector in deciding the ICT products to be procured that will not only be cost-effective but also to minimize e-waste during and after a product's end of use. It means purchase preference shall be given to those products that are environmentally sustainable and that already contain sustainability as a criterion. The decisions of the public sector shall reward the manufacturers of ICT products to move towards more environmentally sustainable ICT products in the medium to long term.

This Recommendation covers the purchase of ICT equipment and including:

– Personal computer (PC) products including desktops, laptops, servers, displays, docks and other accessories.

– Terminals, such as smartphones, tablets and video-conferencing devices.

– Network equipment and servers including network switches, routers, Wi-Fi access points and network adapters.

– Imaging equipment, such as scanners and printers.

In general, any ICT equipment acquired through public procurement is at the procurer organization's disposal for use.

2 References

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

[ITU-T L.1000] Recommendation ITU-T L.1000 (2019), *Universal power adapter and charger solution for mobile terminals and other hand-held ICT devices*.

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

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

[ITU-T L.1005] Recommendation ITU-T L.1005 (2014), *Test suites for assessment of the universal charger solution*.

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

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

[ITU-T L.1022] Recommendation ITU-T L.1022 (2019), *Circular economy: Definitions and concepts for material efficiency for information and communication technology*.

[ITU-T L.1023] Recommendation ITU-T L.1023 (2020), *Assessment method for circular scoring*.

[ITU-T L.1024] Recommendation ITU-T L.1024 (2021), *The potential impact of selling services instead of equipment on waste creation and the environment – Effects on global information and communication technology*.

[ITU-T L.1031] Recommendation ITU-T L.1031 (2020), *Guideline for achieving the e-waste targets of the Connect 2030 Agenda*.

[ITU-T L.1033] Recommendation ITU-T L.1033 (2021), *Guidance for institutions of higher learning to contribute in the effective life cycle management of e-equipment and e-waste*.

[ITU-T L.1035] Recommendation ITU-T L.1035 (2022), *Sustainable management of batteries*.

[ITU-T L.1220] Recommendation ITU-T L.1220 (2017), *Innovative energy storage technology for stationary use – Part 1: Overview of energy storage*.

[ITU-T L.1221] Recommendation ITU-T L.1221 (2018), *Innovative energy storage technology for stationary use - Part 2: Battery*.

[ITU-T L.1300] Recommendation ITU-T L.1300 (2014), *Best practices for green data centres*.

[ITU-T L.1301] Recommendation ITU-T L.1301 (2015), *Minimum data set and communication interface requirements for data centre energy management*.

[ITU-T L.1304] Recommendation ITU-T L.1304 (2020), *Procurement criteria for sustainable data centres.*

[ITU-T L.1310] Recommendation ITU-T L.1310 (2020), *Energy efficiency metrics and measurement methods for telecommunication equipment*.

[ITU-T L.1320] Recommendation ITU-T L.1320 (2014), *Energy efficiency metrics and measurement for power and cooling equipment for telecommunications and data centres*.

[ITU-T L.1321] Recommendation ITU-T L.1321 (2015), *Reference operational model and interface for improving energy efficiency of ICT network hosts*.

[ITU-T L.1330] Recommendation ITU-T L.1330 (2015), *Energy efficiency measurement and metrics for telecommunication networks*.

[ITU-T L.1340] Recommendation ITU-T L.1340 (2014), *Informative values on the energy efficiency of telecommunication equipment*.

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

[ITU-T L.1420] Recommendation ITU-T L.1420 (2012), *Methodology for energy consumption and greenhouse gas emissions impact assessment of information and communication technologies in organizations*.

[ITU-T L.1470] Recommendation ITU-T L.1470 (2020), *Greenhouse gas emissions trajectories for the information and communication technology sector compatible with the UNFCCC Paris Agreement.*

[IEC 62623] IEC 62623:2022 (2022), *Desktop and notebook computers – Measurement of energy consumption*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 environmental life cycle assessment [ITU-T L.1410]: An environmental life cycle assessment (LCA) is a systematic analytical method by which the potential environmental effects related to ICT goods, networks and services …. can be estimated. LCAs have a cradle-to-grave scope where all the life cycle stages (raw material acquisition, production, use, and end-of-life treatment) are included. Moreover, transport and energy supplies are included at each stage of the life cycle assessment.

3.1.2 green public procurement [b-EU-1]: A process whereby public authorities seek to procure goods, services and works with a reduced environmental impact throughout their life cycle when compared to goods, services and works with the same primary function that would otherwise be procured.

3.1.3 life cycle [b-ISO 14040]: Consecutive and interlinked stages of a product system, from raw material acquisition or generation from natural resources to final disposal.

3.1.4 life cycle costing [b-ICLEI]: A method for assessing the total costs of the product group or service under study. It takes into account all costs related to the purchase and use of and maintenance operations for this product group or service and the disposal of any waste generated by it.

3.1.5 needs assessment [b-EC-2]: The first stage in the procurement cycle for green public procurement, prior to launching a tender, to ensure that a true demand exists for the goods, services or works being purchased, and to identify the most environmentally efficient way of meeting that need.

3.1.6 public procurement for innovation [b-OECD17]: This happens when the public sector uses its purchasing power to act as early adopter of innovative solutions which are not yet available on large scale commercial basis.

3.1.7 recyclability [ITU-T L.1022]: Ability of a product to be recycled at end-of-life.

3.1.8 refurbishing [b-IEV-904-04-09]: Functional or aesthetical maintenance or repair of an item to restore to original, upgraded, or other predetermined form and functionality.

3.1.9 remanufacturing [b-EN 4553]: Industrial process which produces a product from used products or used parts where at least one change is made which influences the safety, original performance, purpose or type of the product.

3.1.10 supply chain [b-ITU-2]: The group of planning, manufacturing and producing operations required to bring a product/service to the market. It covers activities that range from sourcing of raw materials to the delivery of a completed product.

3.1.11 supply chain due diligence [b-EC-3]: The obligations of the economic operator which places a [product] on the market, in relation to its management system, risk management, third party verifications by notified bodies and disclosure of information with a view to identifying and addressing actual and potential risks linked to the sourcing, processing and trading of the raw materials required for [product] manufacturing.

3.1.12 sustainable public procurement [b-DEFRA]: A process whereby organizations meet their needs for goods, services, works and utilities in a way that achieves value for money on a whole-life basis in terms of generating benefits not only to the organization, but also to society and the economy, whilst minimizing damage to the environment.

3.1.13 total cost of ownership [b-Mieritz]: A financial estimate intended to help buyers and owners determine the direct and indirect costs of a product or system. It is a management accounting concept that can be used in cost accounting, strategic planning and budgeting.

3.1.14 tracing [b-Dorp]: The ability to follow the supply chain upward and determine the source of a product.

3.1.15 tracking [b-Dorp]: The ability of keeping track of the flows of products transporting from upstream to downstream in a supply chain.

3.1.16 waste hierarchy [ITU-T L.1031]: Preference for actions in managing waste, including e-waste in five tiers of decreasing preference: waste prevention, preparation for re-use, recycling, other recovery and disposal.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 public sector: All levels of government and government-controlled or funded agencies, enterprises and other organizations that deliver public programmes, goods or services.

3.2.2 circular and sustainable procurement: The purchase of goods, services, works and utilities that meets user needs while generating positive environmental and societal impacts and stimulating the circular economy through purposeful design, production, sale, use, re-use and recycling processes throughout the lifecycle.

3.2.3 state of health: Current full charge battery capacity (in mAh) expressed as a percentage of the design capacity (rated capacity).

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AC Award Criteria

AMC Annual Maintenance Contract

BBP Butyl Benzyl Phthalate

CFC Chlorofluorocarbon

CPE Customer Premises Equipment

CPC Contract Performance Clause

CPU Central Processing Unit

DBP Dibutyl Phthalate

DEHP Bis(2-ethylhexyl) Phthalates

DIBP Diisobutyl Phthalate

EPD Environmental Product Declaration

EPR Extended Producer Responsibility

GHG Greenhouse Gas

GPP Green Public Procurement

GWP Global Warming Potential

HCFC Hydrochlorofluorocarbon

HFC Hydrofluorocarbon

IMA Imaging

LCA Lifecycle Assessment

LCC Lifecycle Cost Analysis

MON Monitors

MOB Mobile/Battery-Powered Computers

NIE Network Infrastructure Equipment

OEM Original Equipment Manufacturer

PBB Polybrominated Biphenyl

PBDE Polybrominated Biphenyl Ether

PCC Post-Consumer Recycled Content

RAM Random Access Memory

REACH Registration, Evaluation, Authorization and Restriction of Chemicals

ROHS Restriction of Hazardous Substances

RSC Restricted Substance Controls

SC Selection Criteria

STD Standard

STA Stationary Computers, Terminals, Network Devices

TCO Total Cost of Ownership

TS Technical Specification

WEEE Waste Electrical and Electronic Equipment

5 Conventions

None.

6 Environmental and circular aspects of public procurement of ICTs

6.1 General principles and considerations for green public procurement

- Buying responsibly and sustainably: Public administrations/public sector can have an impact in addressing these issues through the implementation of eco-friendly procurement practices without undermining cost-efficiency. The good news is that procurement costs can be reduced by purchasing products that are less harmful to the environment.
- Environmental impacts: that stem from their manufacturing, use and disposal.
- Manufacturing activities include acquiring, assembling and transporting raw materials and components. The supply chain in the ICT industry is highly complex, as ICT products can be made of several thousands of components made up of a large variety of materials and substances.

- Energy consumption and carbon emissions: ICT equipment requires electricity to run, including power used directly and indirectly power use such as for cooling in data centres or maintenance operations.
- Water is used to manufacture ICT products and for data centre cooling operations.
- Noise is generated by motors and spinning components, such as hard drive, CPU fan, case cooling fan and power supply fan [b-EU-2].
- Hazardous materials: Electrical and electronic equipment can contain various substances harmful to health and the environment if not manufactured, used and disposed of carefully.
- End-of-life disposal, recycling and durability. Though some components cannot be reused, much of what is used to make ICT equipment can be recycled, even though electronics recycling can be challenging because discarded electronic products are complex devices, and the amount of resources recovered may be small.
- Packaging materials are generated at various stages of the ICT lifecycle to transport, protect and distribute products.
- Fostering compliance with open standards and interoperable systems compatible with as many equipment manufacturers as possible.

6.2 Methods for calculating cost in public procurement

Public procurement is usually driven by the concept of the best value for money [b-UNOPS], considering only the purchase cost, ignoring the life cycle cost or non-financial impacts from a life cycle assessment:

- Life cycle cost (LCC) is the name of the technique used to establish the actual cost of ownership of a product or service, from purchase, through usage and maintenance costs, to disposal. That is the cost to consider as it incorporates other costs, otherwise hidden, beyond the purchase cost. The reduction of environmental impacts usually leads to economic savings in short to medium-term term [b-UNOPS]. From a procurement perspective, total cost of ownership (TCO) refers to the overall sum of all costs. LCC is one method available to calculate this TCO.
- Life cycle assessment (LCA) applies the life cycle concept to environmental impacts, such as carbon emissions, water usage, air pollution, energy consumption, hazardous and toxic substances and waste amounts [b-UNOPS]. This is standardized in [ISO 14040] and applied to evaluate the environmental impact of ICT goods, networks and services in [ITU-T L.1410].

In environmental or green public procurement (GPP), the preferred procurement choice must be products and services with a positive environmental impact.

These products may include, according to [b-UNDP], green features at the expense of additional cost or resource consumption, such as products that are energy-efficient, with reduced environmental impact of the production phase, that contain less toxic materials, have a longer life cycle, that can be recycled, that minimize or eliminate packaging, minimize the use of natural resources, that are made from recycled materials, that can be easily repaired, maintained or upgraded, and whose firmware and software can be updated for a long period. These types of products are designed with the goal of reducing their environmental impact throughout their entire life cycle, from production to disposal. These features are described in detail in [b-ITU-T L.Suppl 20].

6.3 Phases of the tendering process

All that relates to the vision of the Circular and Fair ICT Pact [b-One Planet Network] to accelerate the transition to a sustainable ICT sector by taking a strategic approach to procurement, considering the three phases of the tendering process:

– The **pre-tender** phase of **buying less** involves setting ambitions, identifying needs and market collaboration.
– The **tender** phase of **buying better** by designing specifications and tender, followed by evaluation and award.
– The **post-tender** phase of **using better and longer** by managing supply, contract management and asset disposal.

The pre-tender relates to the first aim, the tender phase relates to all aims and the post-tender refers to the first two aims.

Four main types of GPP criteria [b-Kaps] apply in the previous three phases:

- **Selection criteria (SC)**: Assess the suitability of an economic operator, a tenderer, to carry out a contract (such as capacity to pursue activity, economic and financial standing, technical and professional ability).
- **Technical specifications (TS)**: The required characteristics of a product or a service, including requirements relevant to the product at any stage of the life cycle of the supply or service and conformity assessment procedures.
- **Award criteria (AC)**: Qualitative criteria with a weighted scoring are chosen to determine the most economically advantageous tender. Specifically, environmental performance characteristics to take into account.
- **Contract performance clauses (CPC)**: Special conditions laid down that relate to the performance of a contract and how it must be carried out and monitored, provided that they are linked to the subject matter of the contract (such as reporting on environmental performance, impact during product usage, lifespan or recycling).

There is a choice between two ambition levels for the criteria:

- **Core** criteria for easy application of GPP, focussing on key areas of the environmental performance of a product and aimed at keeping administrative costs for companies to a minimum.
- **Comprehensive** criteria, considering more aspects or higher levels of environmental performance, to go further in supporting environmental and innovation goals. This can be more challenging and costly to implement, as it requires a more thorough evaluation of the environmental impacts of the products being procured. However, it can also bring long-term benefits. By setting higher standards for environmental performance, comprehensive criteria can encourage the development and use of more environmentally friendly products, which can lead to reduced environmental impacts and costs over the product's lifecycle. In addition, it can help to drive innovation and support the development of new technologies that can contribute to the transition to a more sustainable and circular economy.

The pre-tender phase can benefit from assessing the existing fleet and procurement needs related to a CPC. Choices in the tender phase affect the post-tender phase, particularly CPC, regarding servicing, consumables and reporting.

Environmentally conscious design, or design-for-environment (DfE) [b-ITU-1], *namely the systematic integration of environmental considerations into product and process design* is relevant here. [ITU-T L.1031] highlights the four-key lifecycle phases of network infrastructure equipment (NIE) and customer premises equipment (CPE) and how each stage can be more sustainable. The four phases are:

– environmentally conscious product development,
– eco-efficient manufacturing,
– smart usage,
– end-of-life treatment.

The first phase relates to all aims, and the remaining phases match each of the three aims.

6.4 Models of ownership

There are alternative models to ownership, as organizations need ICT devices for the services they provide, not for the sake of ownership. Therefore, innovative service-oriented circular models focused on usage may allow more efficient management of devices and less e-waste generation than those oriented to ownership [ITU-T L.1024]. Decoupling ownership from use and maintenance involves other schemes such as **servitization** (use as a service provided by a third-party) or **pooling** and leasing devices across larger user groups (shared ownership).

Other circular business models are:

- Buy refurbished or remanufactured (use longer).
- Buy service: servitization or leasing, including external maintenance and support (use longer).
- Buy less: analyse concrete demand.
- Disposal of used products: Ensure products are adequately collected and with accessories [b-CFIP] and recycled properly (less waste).

6.5 Verification

The means of compliance **verification** for a product with a necessary or desirable green or circular characteristic can come from a declaration of the tenderer documenting the claim or holding a relevant Type I Ecolabel fulfilling the specified characteristic.

As a general compliance verification criterion, [b-Alfieri] proposes that products holding a relevant Type I Ecolabel [b-ISO 14024] or a label from another labelling scheme fulfilling the specified requirements will be deemed to comply. Alternative test results obtained by test bodies accredited in line with [b-ISO 17025] according to specific product categories, such as [b-ISO 14006] considering ecodesign in general, [b-IEC 62474] for electronic products and [b-IEEE 1680.1] for assessing the environmental performance of PC products, may be accepted as proof of compliance.

The complexity introduced by GPP can be tamed by coordination such as:

– Buyers' groups;
– International networks;
– Common criteria and guidance;

That coordination facilitates that procurers can:

– Procure circularly and fairly;
– Have the capacity to dialogue with the market (joint with international suppliers);
– Benefit from knowledge sharing with other similar organizations.

7 The e-waste hierarchy

As defined and standardized by [ITU-T L.1031], the best strategies for the environmentally sound management of e-waste are ranked in the waste management hierarchy, from waste prevention and minimization, and waste recycling to the final disposal. A visual representation is shown in Figure 1.

Figure 1 – The waste hierarchy [ITU-T L.1031]

According to the Basel Convention, guidance on strategies for preventing and minimizing hazardous and other wastes, prevention may include strict avoidance, source reduction and direct reuse [b-UNEP-2]. The following clauses recommend, in light of the e-waste hierarchy, the principles to be taken into consideration in the public procurement processes including: minimization of e-waste; optimization of use; and maximization of recyclability.

8 Minimization of the generation of e-waste and its adverse effects

On top of the waste hierarchy, minimizing the amount of e-waste generated and its hazardousness (toxicity) is the most effective strategy. E-waste prevention is the first pillar of e-waste minimization. This is related to the e-waste prevention targets of the Connect 2030 Agenda [ITU-T L.1031]. Targeting the reduction of e-waste generation has several implications:

- Reduction by the design of the **quantity of material** used in the manufacturing of products;
- Designing products with lower **toxicity in materials and compounds**;
- Consider procuring products that are not only new but also refurbished or remanufactured (developed in the next clauses);
- Consider using or consuming products for longer, encouraging the extension of a product's lifetime, ensuring any preventive maintenance, repair when faulty, and seeking reuse when no longer used (developed in the next clause);
- Keeping track of products to keep them accountable (traceable) and facilitate recycling (last clause).

8.1 Policy

Governments need to define organizational, governmental or national targets for circular public procurement.

It is necessary to incorporate in GPP processes organizational, governmental or national targets for e-waste reduction policy or objectives set according to [ITU-T L.1470] on GHG emissions for ICT compatible with the UNFCCC Paris Agreement or according to [ITU-T L.1031] on Guideline for achieving the e-waste targets of the Connect 2030 in [ITU-T L.1031] or as an input to an organizational impact assessment according to [ITU-T L.1420].

It is necessary to assess the environmental impacts of the procurement of ICT devices and ask for waste neutrality or waste compensation in specifications or award criteria. The expected outcome will be that suppliers make sure an equivalent amount of e-waste is collected and recycled.

As **SC** and **CPCs** collect environmental impact indicators from procured goods and services over the four-key lifecycle phases [ITU-T L.1031], it is necessary to facilitate the accounting of organizational environmental/sustainability impacts.

8.2 Materials

It is needed to verify restrictions on hazardous substances in products and parts. That includes the following:

The European Directive on the "the restriction of the use of certain hazardous substances in electrical and electronic equipment" (ROHS) [b-EU-6] restricts the use of certain hazardous chemicals in products in the European Union. This policy is also implemented in other states. In particular, ROHS refers to the guidelines regulating the use of hazardous chemicals in electrical and electronic equipment (EEE). As a result, a list of hazardous chemicals is forbidden above a threshold due to their toxicity or environmental hazard. Currently, 10 substances are restricted due to their toxicity or environmental hazard:

- Lead
- Mercury
- Cadmium
- Hexavalent chromium
- PBDEs (polybrominated biphenyl ethers)
- PBBs (polybrominated biphenyls)
- DBP (Dibutyl phthalate)
- DIBP (Diisobutyl phthalate)
- BBPs (Butyl benzyl phthalates)
- DEHPs (Bis(2-ethylhexyl) phthalates)

The use above the thresholds is still allowed for some applications where no alternatives are available. The exemptions are reviewed by the EU Commission regularly.

The EU Regulation on the Registration, Evaluation, Authorization and Restriction of Chemicals (REACH) is the main legislation of the European Union to regulate the production and use of chemicals [b-EU-5]. It restricts the use of many substances in the European Union and is implemented in a similar way in many other countries.

Regrettable substitution refers to replacing a hazardous substance with another substance that may be less hazardous in the short term. Still, it ultimately has negative consequences for human health or the environment. This can occur when a hazardous substance is phased out or banned and a less hazardous substitute is chosen without considering the potential long-term impacts. For example, a hazardous chemical may be replaced with a less toxic substance but more persistent in the environment and therefore has a longer-lasting effect. Regrettable substitution can also occur when a hazardous substance is replaced with a substance that has unknown or untested long-term effects. To avoid regrettable substitution, as an **SC**, the tenderer must provide evidence that methods or tools have assessed the selected alternative(s) for comparative hazard assessment indicated by the OECD Substitution and Alternatives Assessment Toolbox [b-OECD] or the European Chemicals Agency [b-ECHA].

As an **SC**, a tenderer must demonstrate the use of a framework for restricted substance controls (RSC), considering restricted substances under RoHS and REACH along the supply chain for the products to be supplied. Product evaluations, according to the RSC, should, at minimum, cover the areas of product planning/design; supplier conformity; and analytical testing [b-Alfieri].

As **TS**:

- Restriction of chlorinate and brominate substances in plastic parts, except printed circuit boards, electronic components, cables and wiring insulation, and fans;
- Restriction of low-halogen substances in plastic parts;

- Post-consumer recycled content (PCC): percentage of presence of recycled plastic content in products or packaging. However, verification of the claim based on a mass balance is complex, and may be only an estimation that could vary over time. Given that, it is not required in [b-Alfieri].

As **AC**, points must be awarded when no substances on the REACH Candidate List are intentionally added above 0.1% (weight by weight) in each of the following sub-assemblies:

- Populated motherboard (including CPU, RAM and graphics units);
- Display unit (including backlighting);
- Casings and bezels;
- External keyboard, mouse and trackpad;
- External alternating and direct current power cords (including adapters and power packs).

As **CPC**, consumables in imaging equipment bring additional technical specifications regarding hazardous substances content in colourants [b-Kaps].

8.3 Product design

Product scoring [ITU-T L.1023] provides criteria to describe to what extent an ICT product is circular. It proposes a methodology to identify circularity via three circular design guideline groups: first, the ICT product's **durability**; second, the ICT product's ability to be recycled, repaired, reused and upgraded; and third the manufacturers' ability to **recycle**, **repair**, **reuse and upgrade** the ICT product put into the market.

As an **SC**, a tenderer must demonstrate assessment of product scoring and, regarding e-waste minimization, show the degree products were **designed to minimize e-waste** in their:

- "Ability to recycle, repair, reuse, upgrade – equipment level", particularly considering product-related information about material recycling compatibility, disassembly depth, recycled/renewable plastics, material identification, presence of hazardous substances, presence of critical raw materials and packaging recycling.
- "Ability to recycle, repair, reuse, upgrade – manufacturer level", particularly considering manufacturer provided disassembly information, collection and recycling programmes, environmental footprint assessment knowledge available to improve the equipment material efficiency.

Relevant indicators for a product constitute **TS** for minimum criteria and **AC** for additional improvements. In L.1023 terms, that translates into high or very high relevance ($R > 2$) indicators, where the margin of improvement must be low or very low ($MI < 3$).

8.4 Needs assessment

The guideline for achieving the e-waste targets of the Connect 2030 Agenda in [ITU-T L.1031] begins by identifying the need for a resource to achieve a production goal.

As **CPC**, a preliminary assessment of the **needs** is a preliminary procedure to evaluate the current fleet of equipment and decide to:

- Retain: for continued use in the same or new function (internal reuse);
- Return: to past supplier, if applicable;
- Reuse: externally as a sale or donation;
- Refurbish, remanufacture, reconfiguration: making a functional product;
- Recycle: sent for end-of-life processing.

That results in a report about the number and characteristics of the additional new products to procure.

In that need assessment, the digitalization of ICT services and capacity planning of computing resource needs can result in a reduction of physical device needs into a smaller number of physical machines through hardware virtualization, clustering and consolidating (virtual) devices into a lower number of servers, keeping the minimum number of running instances needed to save energy. Moreover, virtualization can take advantage of physical infrastructure, onsite or remotely, as in cloud-based models of machines or applications as-a-service.

8.5 Interoperability and reusability of components

As **TS**, examples of desirable accessories available to be procured separately are: adapters for backward compatibility, detachable cables, standardized external power supplies as defined by [ITU-T L.1000], [ITU-T L.1001], [ITU-T L.1002)] and [ITU-T L.1005], chargers and docks. Furthermore, using one standardized interface and ports for charging and data transfer can contribute further to these reductions with USB Type-C cable and connector [b-IEC 62680-1-3] as **AC**.

As **AC**, equipment with minimal or no accessory components: Decoupling the purchase of accessories from the purchase of new devices, avoiding duplication, results in a possible saving of resources and reduced generation of e-waste.

8.6 Transparency, reporting

Environmental product declarations (EPD) or LCA can help demonstrate production transparency, as described in [ITU-T L.1031].

As **SC**, the ability to provide digitalized product information and documentation, describing product design and manufacturing of each instance, in the form of **product data sheets** or **digital product passports** [b-Navarro], results in the corresponding reduction of paper, reduced manual handling of product information prone to errors, avoidance printed details in packaging, and reduction in packaging. Access to digitalized information allows for more informed, automated and less costly decisions.

As **CPC**, reporting on reuse and recycling activities helps assess and reduce environmental impacts.

8.7 Procurement process

Buy digital: the use of digital buying tools, such as a procurement platform or portal, that incorporate sustainability requirements for ICT goods and services, requiring suppliers to provide digitalized product-related information and documentation as **SC**. Electronic procurement enables transactions to be made quicker and in a more energy-efficient way as reported in [ITU-T L.1031].

Due diligence effectively can address the social and environmental risks related to raw material extraction, processing and trading of certain raw materials, and therefore waste prevention, even though it is only related to e-waste. This involves the supply chain and, consequently, an **SC** requirement.

According to [b-EC-4], there are internationally recognized references to take into account:

- The ten principles of the United Nations Global Compact [b-UN-2];
- The Guidelines for Social Life Cycle Assessment of Products [b-UNEP-1];
- The ILO Tripartite Declaration of Principles concerning Multinational Enterprises and Social Policy [b-ILO];
- The OECD Due Diligence Guidance for Responsible Business Conduct (RBC) [b-OECD-4];
- The OECD Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas [b-OECD-2];
- The risks in the battery supply chain in relation to the protection of the natural environment and of biological diversity in line with the Convention on Biological Diversity [b-CBD],

which also includes the consideration of local communities and the protection and development of those communities.

Therefore, public procurement must perform due diligence to achieve informed procurement decisions facilitated by collective arrangements in procurement consortia, such as those proposed by CFIT [b-One Planet Network] and supported by digital data, such as digital product passports.

Furthermore, **CPC** for reporting on e-waste generation and impacts at end-of-life management contributes to assessing compliance with the goal of this clause, connected to traceability.

8.8 Traceability

Circularity requires the ability to **track and trace** product flows (e.g., devices, parts, materials, e-waste) for their impacts across the forward and reverse supply chain.

Tracing allows for verifying an item's history, location or components using documented recorded identification, finding out about origin, composition and actors involved and deducting from that repair or end-of-life handling possibilities.

Tracking allows to find out what happened to a product in its past and future, which is helpful for impact assessment and reporting. As **CPC**, tracking enables the reporting on the end-destination of ICT equipment.

Therefore, the **traceability**, as **SC**, and **trackability**, as **CPC**, of products, provenance (suppliers, manufacturers, designers, extended to parts and raw materials) and end-destination is required to be able to identify a product precisely, by product model, batch or even individually (serialized): tracking and tracing are essential for a responsible circular economy, following individual products and flows across the manufacturing and reverse supply chain. Digital linked data and ledgers can facilitate that throughout the life cycle, as considered in digital product passports.

However, as **AC**, the information provided by suppliers shall be **verifiable** to allow the confirmation of the veracity of assertions about sustainability and circularity. This can be implemented through self/third-party declaration or certification schemes and digitally through digital signatures in data sheets and documents.

8.9 Consumables

Consumables are replaceable products that are essential to the functioning of the main product. They are typical for imaging equipment products. They can be replaced or replenished by either the end-user or service provider during the normal usage and life span of the imaging equipment product. This is the case for containers and cartridges that hold toner or ink, and that fit onto or into or are emptied into an imaging equipment product.

Cartridges and consumables in imaging products are responsible for a large part of a product's environmental impacts and, therefore, should be included in the life cycle costing.

Procurement can include, as **CPC,** a contract for the effective supply of consumables or, as **TS,** a guaranteed supply of consumables during the planned usage period, and that can include, as **CPC,** reporting on supplied consumables, remanufactured cartridges and containers, page-yield declaration, consumable mass resource efficiency (images produced per gram of consumable material).

At the organization level, contracting leasing agreements, as **CPC**, may promote the use of products with higher durability, extend the real usage time and reduce the amount of waste by encouraging take-back systems and managed printing services. This is becauase the imaging equipment fleet may be better managed when outsourced [b-Kaps].

GPP and the technical specification of printing paper supplies, as **SC**, **TS**, **AC** or **CPC**, including recycled fibre and sustainable sourced paper, is beyond the scope of this Recommendation[1].

8.10 Batteries

Public procurement of ICTs shall take into consideration [ITU-T L.1010] green battery solutions for mobile phones (when applicable) and hand-held information and communication technology solutions and [ITU-T L.1035] sustainable management of batteries and EU relevant guidelines and given the different types of batteries found in ICT equipment per [ITU-T L.1035].

The purchase of ICT equipment should consider the battery component view of the impact of batteries on the environment, end-of-life impact as e-waste and its reporting, which necessitates the inclusion, as **CPC**, of specific clauses in procurement tenders. Information on batteries and their evaluation for equipment that is not mobile are in [ITU-T L.1220] and [ITU-T L.1221].

9 Maximizing useful life

After prevention, the second strategy to achieve e-waste minimization in the waste hierarchy is optimizing the use phase, including preparation for re-use, mentioned in [ITU-T L.1031] related to "smart usage". It has to do with ensuring that a device, once it has incurred a very high environmental impact from being manufactured, has the longest possible lifespan. This means:

– Looking carefully at product durability.

– Keeping a product or its parts in the highest value status by ensuring preventive hardware and software maintenance, repair, recondition, refurbishment or remanufacture over its entire usable lifespan.

– Choosing a product considering the environmental usage conditions, such as mobility and expected stresses during usage, such as in mobile and outdoor environments.

– Finding the correct usage of the product in each phase of its lifespan, which translates into finding a purpose/function and user. Changing function may require an upgrade or recondition. Changing user requires reallocation, data wipe and reset to the initial or factory state.

– Using better and longer brings the possibility of buying **refurbished** or **remanufactured** instead of only new.

– Keeping track of products over their lifespan, making those decisions, and knowing about the actions and results.

– Ensuring that after the end-of-use phase in an organization, still usable devices can have a second life as products or ensure their parts are recovered, or the product is recycled correctly.

– Adopting circular business models, not just ownership, such as servitization (device as-a-service), where the service provider can take care of and reallocate devices to maximize useful life.

9.1 Stress during usage

Mobile devices such as laptops, tablets and smartphones may be subject to drops and other **physical stresses** such as water contact, dust and extreme temperatures that affect durability. However, according to [b-Alfieri], resistance to these stresses improves durability, with higher stress levels expected for **rugged products** used in an outdoor environment. Therefore, it is necessary that

[1] EU GPP criteria for different product categories: https://ec.europa.eu/environment/gpp/eu_gpp_criteria_en.htm.

procurers consider evidence from standardized testing methods [2] [b-IEC 60068], [b-ETSI EE EN 019-x] series for environmental conditions and environmental tests for telecommunications equipment, [b-US DoD] (G or H) of the following aspects as part of their procurement process to ensure that they are purchasing durable and reliable products:

- **Drop testing**: To determine how well a product can withstand accidental drops, impacts or other shock events that may occur during normal use or handling. Robustness of a product affect durability. In a drop test, the product is typically dropped from a predetermined height onto a hard surface, and the resulting damage or functional failure is assessed. Both [b-US Dod] and [b-IEC 60068] provide detailed guidelines and procedures for conducting drop testing, including the specific heights, surfaces and angles that should be used and the criteria for evaluating the results.
- **Ingress protection**: For rugged equipment used for outdoor working activities and other harsh usage environments and conditions, it is desirable to have a rating on ingress protection from solid objects, dust and water, and temperature stress testing.
- **Temperature range**: Resistance to temperature changes and its performance at extreme temperatures to ensure that devices and materials can function reliably in a wide range of temperature conditions.
- **Mechanical stress and shock**: Vibration refers to the rapid oscillation or movement of a device, while shock refers to a sudden impact or force applied to it. Specifically, screen resilience refers to the ability of a device's screen to withstand impact, scratches or other forms of damage.

These aspects can be **TS** for mobile or rugged products subject to stress or **AC** for stationary and indoor products.

9.2 Management

Management services, including maintenance, repair, upgrade and disposal, can come from different sources depending on the purchase model or routes:

– Device only: the public organization should have a dedicated team for these services;

– Device and services, which are outsourced;

– Device as-a-service (DaaS), all is outsourced, under a subscription fee to be tendered in exchange for hardware lease and management services.

[2] Reported detailed choices in [b-JRC21]: IEC 60068 Part 2-31: Ec (Freefall, procedure 1), MIL-STD-810G, or MIL-STD-810H – Method 516.8 – Shock (Procedure IV) with a drop height of 45 cm.

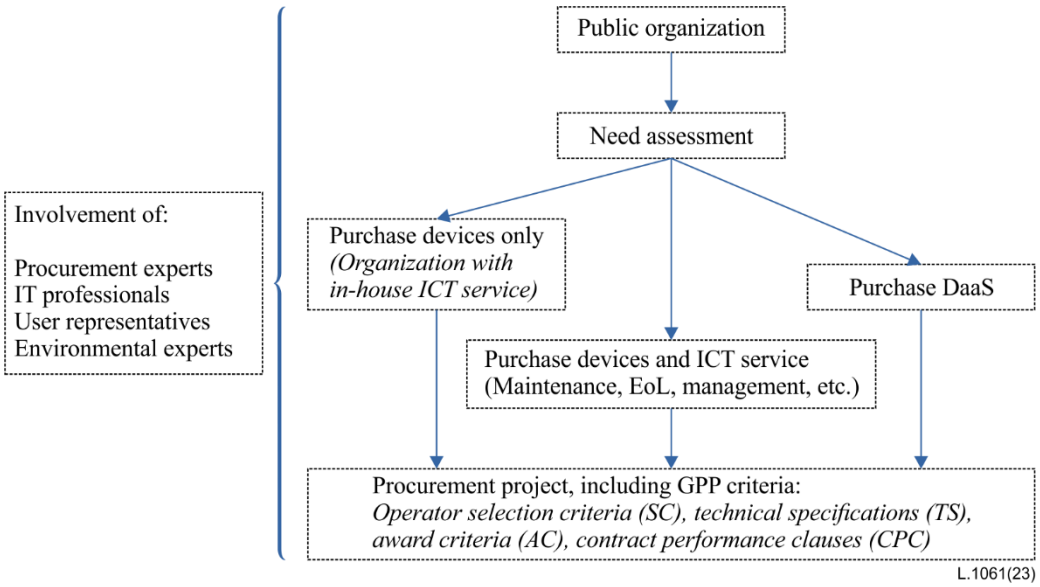

Figure 2 – Possible procurement routes identified for public organizations

Figure 2 illustrates examples of routes defined in terms of the procurement needs and capabilities of the public organization and the market.

The aim is to extend the product lifetime, which can provide both environmental and life cycle cost benefits. Although the procurement of refurbished (also called reconditioned) and remanufactured products is currently not common, it is an effective way to contribute to maximizing the useful life of products, which can have the same performance and warranty as new products.

9.3 Maintenance and repair

For all procurement routes, the duration and conditions of the manufacturer's warranty, as **TS** and the provision of an extended service agreement, as **CPC**, have to be defined in the tender and analysed in the bids.

In terms of design for repairability options [b-Alfieri], the following are aspects to consider:

– Hardware design for maintenance: design for maintenance and repairability, as **TS**.

– Hardware maintenance and repair: considering the continued availability period of consumables and spare parts that need a replacement for the maximum usage period planned as part of durability as a **TS**.

– Software maintenance with updates available for the longest period, depending on the product. The ability to update obsolete software, specifically security updates as **TS**, reduces software obsolescence, as firmware and operating system support, particularly security maintenance, is required to keep the device usable, safe for the most prolonged expected usage period.

– Instructions on how to replace the parts must be provided with a service or repair manual as **TS**. The manual must include security measures to ensure safe repair, an exploded diagram of the device illustrating the parts that can be accessed and replaced, which could also be provided in the form of a tutorial video, and the tools required. The service/repair manual must be available online, free of charge.

Manufacturer's warranty: as **TS**, the tenderer must provide written evidence of the manufacturer's warranty, with conditions to invoke the warranty, pick-up and return, incident management, access to diagnostic and repair tools, battery coverage and replacement, and preventive maintenance.

Extended services agreement: as **CPC**, a service-level agreement with conditions to invoke the service, pick-up and return, incident management, access to diagnostic and repair tools, battery coverage and replacement, and preventive maintenance. As part of that, the provider must provide periodical *[monthly/annual]* reporting on its compliance with all the metrics, key performance indicators and other indicators defined by the service-level agreement as **CPC**.

ICT products are often discarded even before their average first usage life span in cases of malfunction or fault. Even though the fault may be repaired, the product is discarded due to various reasons such as non-availability of spare parts, time for new purchase being less than time for repair or ignorance. One of the solutions to such a problem is to have an OEM AMC regime in which OEM may replace the faulty part with an original one at a reasonable cost and within a reasonable time. This will result in cost savings, extend the useful life of ICT products, reduce the total e-waste generated over a period of time and reduce the exploitation of natural resources.

The warranty and service agreement criterion is focused on service agreements associated with either procuring equipment or device as-a-service (DaaS) business models.

The sustainability and SC of the Government of the Netherlands [b-Netherlands] provide many examples of related clauses.

Repair: The repairs should be handled only by certified repair centres during the warranty period to avoid voiding the manufacturer's warranty [b-Alfieri].

Outside the warranty period the supplier or a manufacturer authorized repairer should either provide a repair service during the specified contract period or provide critical parts and repair instructions to the purchaser.

As a basic **TS** criterion, ensure that joining or sealing techniques for the products supplied do not prevent the repair and replacement of the parts (critical components).

Alternatively, as a comprehensive **TS** criterion, ensure that critical components are easily accessible, repairable and replaceable by using commercially available tools.

NOTE – This is in line with [b-EN 45554], excluding on-board soldered CPUs.

Critical parts can vary based on the product category and manufacturer. The manufacturer shall ensure repair or availability of parts that fail most often.

Longevity and replacement of batteries: part of the design for repairability, as **TS**, ensures that batteries can be easily changed, at least by a maintenance service operator.

For the cost estimation, as the TCO and the LCC, an estimate of parts to replace (batteries, mechanical parts) must be included. Therefore, the tenderer must provide the details to estimate these as **SC** since these cost estimates can determine the choice.

9.4 Usage

Extending the life of ICT equipment results in reducing environmental impacts and makes products accessible to a greater number of users, helping reduce pressure on manufacturing new products.

The management and control of purchased products, as [ITU-T L.1031] proposes, translates into the need to **continuously evaluate and periodically report on the usage performance** of what has been procured with regards to environmental performance and functionality, to assess the efficiency and effectiveness of green procurement processes.

That performance evaluation can come as a **CPC** on a performance report under an extended services agreement, a **TS** or **AC** over products that can record and provide that information, as usage meters.

Accessible **usage meters**, built into the product itself or added as an external device, allow usage monitoring and improve information and data about product lifetimes. Usage meters can allow for usage monitoring in several ways. For example, they can track the number of hours the product has

been used, the number of times it has been turned on or off, or the amount of data that has been processed.

Knowing the usage history of a product can improve the availability of products by informing maintenance decisions to replace wear-affected components before they are likely to cause failure [b-Botzler]. Furthermore, usage meters can provide reliable information that helps in repair, disposal, sale, donation or recycling decisions. In general, these contribute to minimizing the lack of trust in the quality of second-hand products and the development of second-hand markets. Support for standard remote monitoring functionality from network telemetry or network management protocols of these usage meters or event records helps having this information reflected in an organizational digital inventory system to assist and automate maintenance decisions.

Digitalization, digital twinning: providing supporting information about each product item regarding maintenance, upgrade, repair, reuse, and refurbishment, in a digital and standardized format and associated with a unique product instance identifier (digital twinning, as a digital product passport) enables:

- Automating product data processing for device management, considering environmental and other criteria.
- Inventory and tracking of assets across the usage phase and beyond, contributing to preventing generating uncontrolled e-waste.
- Facilitating maintenance tasks with more precise information and support for automation.

Being something new, it can be considered **AC**.

9.5 Secondary usage (reuse)

Once equipment becomes unsuitable for its primary purpose, it may be upgraded through several strategies, including refurbishment, repair and upgrading. These upgrades may be part of a maintenance and servicing contract that results in a new reuse phase:

- **Internal reuse** of ICT products refers to the organizational policy and practice of re-using ICT products within the same organization in different functions, rather than disposing of them and replacing them with new ones [ITU-T L.1033].
- **External reuse**: External reuse is still an option when internal reuse is not possible. This is the practice of donating for social use or selling these products after the initial procurement period.

There are also **financial considerations**. One of these is **depreciation**, the decrease in the value of an asset over time. By re-using ICT products, organizations can extend the period over which the products depreciate, resulting in a lower overall depreciation cost. Another is **residual value**, the estimated value of an asset at the end of its useful life.

Circular procurement models, such as leasing and service-oriented models, also contribute to the extension of product lifetimes and minimization of environmental impacts by allowing customers to pay for the use of a product rather than purchasing it outright. In leasing or the "as-a-service" contract model, the product is provided, respectively, for a set period or according to a service-level agreement. At the contract end, the product is returned to the provider for refurbishment and re-leased to another customer. This allows the product to be used multiple times rather than discarded after a single use. In addition, this model enables a specialized provider to retain ownership of the product, allowing for better maintenance and maintenance the procurer may perform, further extending its lifespan.

Reuse comes with the requirement for functionality for **secure data deletion**, as **TS**, for the deletion of user data contained in all data storage devices of the product[3]. Instructions on using this functionality, the techniques used and the supported secure data deletion standard(s) must be provided in the user manual or by a web link to the manufacturer's webpage. This requirement is established in EU Commission Regulation 2019/424 [b-EC19/424].

9.6 Energy consumption and energy efficiency in the use phase

Energy consumption in the use phase has an influence on environmental impact and affects end-of-use decisions based on the TCO.

The calculated annual Typical Energy Consumption (E_{TEC}) in kWh need be reported as the energy efficiency if defined depending on type of product.

As **TS**, minimum energy performance threshold: the E_{TEC} for each piece of equipment delivered as part of the contract must be less than or equal to a maximum E_{TEC} requirement; similar criteria need be established for the energy efficiency if defined.

As part of the **AC**, points must be awarded in proportion to the improvement in energy efficiency beyond the minimum.

Energy consumption and their efficiency need to be tested and based on the applicable standards. A list of applicable standards from ITU, ETSI and ATIS is available in [ITU-T L.1316].

Measurement of energy consumption of personal computing products needs to be based on testing and calculations according to [IEC 62623].

Alternatively, for some types of products, Energy Star levels from the United States of America or the EPREL labels in the European Union exist.

9.7 Procurement of refurbished and remanufactured products

The potential to extend a product's life beyond its first use has been addressed by increasing the potential for equipment to be repaired, re-used, and given a second life after its service life with a public authority [b-Alfieri].

Another suitable option for facilitating product lifetime extension is the procurement and use of refurbished or remanufactured equipment [b-Alfieri] (criteria area 5). A second use can be ensured through:

- Refurbishment or reconditioning process of a used product to return to satisfactory working conditions.
- Remanufacturing process of a used product, equivalent to a new product.
- Preparation for reuse: checking, cleaning or repairing. Preparation for reuse can be performed on a product or on a waste item (after recovery), depending on national legislation.

For that, the tenderer must implement quality assurance and control procedures to ensure the minimum quality of the equipment delivered as part of the contract. The required functionality tests performed on the refurbished or remanufactured equipment must be delivered as a certificate of the tests conducted with the equipment to be reused. The quality of the refurbishment or remanufacture process is therefore a **SC**.

Quality assurance and control procedures must cover, as a minimum, the following steps:

- Inspection;
- Reprocessing (e.g., repair, replace or upgrade) if needed;

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[3] According to IEEE 2883 – 22 (2022) "Standard for Sanitizing Storage" [b-IEEE 2883], at least for the level of "Clear".

- Cleaning;
- Testing;
- Storage;
- Packaging and transport.

Quality assurance levels: The procurer should establish minimum quality requirements as per the examples below:

- Aesthetic grade: No sign of aesthetic damage should be visible to more than 20 cm.
- Original factory settings: The products must be restored to their original factory settings and must be fully unlocked for use.
- Products must be upgradeable to the latest firmware supported by the OEM (where applicable and technically feasible).
- An instruction manual must be provided. In the absence of physical instruction manuals, a link or reference to the manufacturer's instruction manual should be included when possible.

Regarding the **bundling procurement of refurbished, remanufactured and new products in the same or different tender**: There are arguments for bundling or separating the procurement of a refurbished or remanufactured product in the same or separate call for tender from new products:

- Same: a minimum share of refurbished products should be maintained, as a **TS** or **CPC**, in tenders for new products for the following reasons: it is very unusual for a tenderer to issue a specific tender to buy only refurbished products; the demand for refurbished products must be increased to stimulate the offer.
- Separate: [b-Kaps] considers that separate tenders allow small companies that are specialized in refurbished products and do not have new products in their portfolio to participate in the procurement process.

9.8 Batteries

Following clause 8.10 on batteries, considering [ITU-T L.1010], [ITU-T L.1035], [ITU-T L.1220], [ITU-T L.1221] and the JRC studies and EU regulations [b-Alfieri], the following elements are taken into consideration: prolongation of battery lifetime, and replacement of batteries (see clause 9.3).

In addition, it is proposed to introduce a minimum technical specification and a more ambitious award criteria linking battery life and cycle endurance, as **TS**. Further battery endurance can be an **AC**.

In the core criteria of the new proposal of the EU on battery life and endurance, for the verification, the tenderer shall provide test reports showing the batteries' performance in the areas chosen: battery endurance shall be verified according to the test requirements laid down in, for example, [b-IEC 61960-3] or [b-IEC 61960-4].

If a comprehensive criterion is used, points shall be awarded for additional battery life and endurance cycles greater than a minimum of 500 cycles (with 80% capacity retention). The cycle performance may be achieved using software which partially charges the battery. In this case, the applicant shall pre-install the software as the default charging routine [b-Alfieri].

A pre-installed battery protection software is desirable for product types that can support that, as **TS**, to extend battery endurance (state of health) when the product is systematically in grid operation. The provision of state of health information about the battery is an important **TS**. A battery management system with software to adapt to stop charging before 100% or fully charge when needed, named intelligent charging, as comprehensive criteria **TS** or **AC** for basic criteria.

10 Maximizing recyclability

This is part of all design, purchase, use and reuse measures that lead to improved recycling and other recovery and minimizing disposal as proposed in [ITU-T L.1031]. Recyclability depends on decisions at the design phase, information to assist in the disassembly and processing, and end-of-life processing.

Design for recycling: with criteria mentioned in [ITU-T L.1023] and in [b-Alfieri]:

- Marking of plastic casings, enclosures and bezels for the correct indication of the chemistry, with exceptions when unfeasible, as comprehensive **TS**.
- Recyclability of plastic casings, enclosures and bezels – separable inserts and fasteners for computers and displays, where the presence of paints and coatings does not significantly impact the resilience of plastic recyclate produced from these components upon recycling, as comprehensive **AC**.
- Declaration of critical raw materials. This is considered in [ITU-T L.1023] 3RUe8, but was found difficult to provide and removed in [b-Alfieri]. Therefore, low MI can be an **AC** to score if provided.

Design for dismantling, mentioned in [ITU-T L.1031] in relation to enabling disassembly, separation and material purification, and in [ITU-T L.1023] in relation to material recycling compatibility. Therefore, low MI can be an **AC** to score if provided. However, this is not included in [b-Alfieri].

Information:

Disassembly instructions are considered in [ITU-T L.1023]. Therefore, a lower MI can be an **AC** to score if provided.

Material datasheets, digital product passports, and digitalization: providing supporting information regarding disassembly, separation and material purification, in a digital and standardized format is a promising future resource.

End-of-life management includes: [b-Alfieri]

1) Secure computer collection, sanitization, reuse and recycling, as **TS**.
2) Reporting of the end-destination of ICT equipment as **CPC**.

The first requires the procurement of end-of-life management services for all ICT devices. Tenderers must provide a service for the re-use and recycling of the whole product or of components requiring selective treatment for equipment that has reached the end of its service life. The service must comprise the following activities:

- Collection: take-back system, EPR and take-back schemes (in [ITU-T L.1021] and [ITU-T L.1031]) confidential handling and secure data deletion (unless carried out in-house), related to that TS met as mentioned in clause 9.5.
- Functional testing, servicing, repair and upgrading to prepare products for reuse.
- The remarketing of products for reuse.
- Dismantling for component reuse, recycling and/or disposal.

The following are components requiring selective treatment in accordance with Annex VII of the WEEE Directive [b-EU-3]:

- mercury-containing components;
- batteries;
- printed circuit boards greater than 10 cm^2 in size;
- plastic containing brominated flame retardants;

- chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs) or hydrofluorocarbons (HFCs), hydrocarbons;
- external electric cables;
- polychlorinated biphenyls containing capacitors;
- components containing refractory ceramic fibres;
- electrolyte capacitors containing substances of concern;
- equipment containing gases that are ozone-depleting or have a global warming potential (GWP) above 15;
- ozone-depleting gases must be treated following Regulation (EC) No 1005/2009 [b-EUfbahn].

The provider has to demonstrate the capacity and quality to provide end-of-life management services for ICT devices as a **SC**.

The second, **reporting on the end-destination of ICT equipment** (**CPC**): a report on the status of the equipment in the inventory once all items have been processed for re-use, recycling or disposal. The report must identify the proportion of items re-used or recycled, whether they remained within regulatory borders (e.g., in the EU) or were exported, with shipment and treatment information.

Recycling, despite commonly understood as making used products into new materials, it is about repeating a cycle. By prioritizing the most environmentally sound strategies and responsibly implementing them, it is possible to optimize higher-value recovery and minimize the negative environmental impacts of e-waste. Recycling to maximize preparation for product and component reuse, higher in the e-waste hierarchy, is more environmentally sound than dismantling to recover certain raw materials or energy. Therefore, any verifiable effort to support preparation for reuse must be encouraged. However, methodological developments are needed to be able to measure that in a standardized and manageable way.

11 Summary of requirements

The following table provides a brief summary of the requirements, see details in previous clauses, to achieve the main aims or circularity goals through sustainable procurement:

- Minimize any resulting amount of e-waste produced, and the adverse effects (W, clause 8).
- Maximize the use of energy-efficient equipment (W and L).
- Maximize usable life or lifespan (L, clause 9).
- Increase the recyclability, thereby contributing to the circular economy (R, clause 10).

They are organized by order of preference according to the e-waste hierarchy in [ITU-T L.1031] and into the context of [b-ITU-T L.Suppl 20].

As described in the overview of clause 6, procurement criteria are grouped into four main types: SC, technical specifications award criteria, and contract performance clause (CPC).

The table shows relevance by product groups, with their specific issues:

– Stationary computers, terminals, network devices (STA): cooling, energy efficiency in the office, server and data centre environments.

– Monitors (MON): energy efficiency, substances.

– Mobile/battery-powered computers, terminals, smartphones (MOB): batteries, mobility, outdoors.

– Imaging equipment (IMA): printing supplies and consumables such as ink and toner.

The relevance of criteria per product group is marked in the table according to ambition level by an "X" (core) or a "C" (comprehensive) criteria, while a blank " " means not relevant or not applicable.

Criteria	**Product group**				**Cat**
8 Minimization of the generation of e-waste and its adverse effects	**STA**	**MON**	**MOB**	**IMA**	
Collecting environmental impact indicators from procured goods and services	X	X	X	X	SC
Demonstrating use of a framework for RSC (e.g., compliance with RoHS directive)	X	X	X	X	
Demonstrating assessment of product scoring	X	X	X	X	
Degree to which products were designed to minimize e-waste	X	X	X	X	
Declaration of critical raw materials in product design	X	X	X	X	
Provide digitalized product information and documentation, describing product design and manufacturing	X	X	X	X	
Provide information about the supply chain required for due diligence	X	X	X	X	
Traceability of products and provenance	X	X	X	X	
Restriction of chlorinate and brominate substances in plastic parts	X	X	X	X	TS
Restriction of low-halogen substances in plastic parts	X	X			
Percentage of presence of recycled plastic content in products or packaging	X	X	X	X	
Accessories available to be procured separately	X	X	X	X	
Standardized interfaces and ports	X	X	X	X	
Information provided by suppliers should be verifiable	X	X	X	X	AC
Avoidance of regrettable substitution	X	X	X	X	
Equipment without accessories			X		
Separate charger			X		
Collecting environmental impact indicators from procured goods and services	X	X	X	X	CPC
Hazardous substances content in colourants				X	
Preliminary procedure to need assessment of the current fleet of equipment	X	X	X	X	
Reporting on reuse and recycling activities	X	X	X	X	
Reporting on e-waste generation and impacts at end-of-life management	X	X	X	X	
Tracking and reporting on the end-destination of ICT equipment	X	X	X	X	
Contract for the effective supply of consumables				X	
Guaranteed supply of consumables during the planned usage				X	
Reporting on supplied consumables, remanufactured cartridges and containers, page-yield declaration, consumable mass resource efficiency	X	X	X	X	
Contracting of leasing agreements	X	X	X	X	
Reporting on environmental impact of batteries, end-of-life impact as e-waste	X	X	X	X	

9 Maximizing useful life and energy efficiency	STA	MON	MOB	IMA	
Procuring durable and reliable products	X	X	X	X	SC
Procuring refurbished and remanufactured products to extend product lifetime	X	X	X	X	
Quality assurance/control procedures for refurbished/remanufactured products	X	X	X	X	
Provide the details to estimate TCO and LCC	X	X	X	X	
Durability testing under stress			X		TS
Drop testing and other standardized testing methods, for rugged products			C		
Ingress protection rating, for rugged equipment			C		
Resistance to temperature changes and performance at extreme temperatures, for rugged products			X		
Vibration and shock resistance, for rugged products			C		
Duration and conditions of manufacturer's warranty	X	X		X	
Design for maintenance and repairability	X	X		X	
Continued availability of consumables				X	
Continued availability of spare parts			X		
Software maintenance with updates available for the longest period	X	X		X	
Availability of service or repair manual	X	X		X	
Written evidence of the manufacturer's warranty	X	X		X	
Ensure that joining or sealing techniques for the products supplied do not prevent the repair and replacement of the critical parts (basic)	X	X		X	
Ensure that critical components are easily accessible, repairable and replaceable by the use of commercially available tools (comprehensive)	C	C		C	
Ensure that batteries can be easily changed, at least by a maintenance service operator			X		
Functionality of secure data deletion	X			X	
Minimum energy performance	X	X		X	
Minimum share of refurbished products in tenders for new products			X		
Information on battery state of health			X		
Battery life and cycle endurance			X		
Pre-installed battery protection software			X		
Stress resistance, for stationary and indoor products	X	X	X	X	AC
Drop testing and other standardized testing methods, for stationary and indoor products	X	X	X	X	
Ingress protection rating, for stationary and indoor products	X	X	X	X	
Resistance to temperature changes and performance at extreme temperatures, for stationary and indoor products	X	X	X	X	
Vibration and shock resistance, for stationary and indoor products	X	X	X	X	
Further battery endurance	X	X	X	X	
Availability of usage meters built into the product	X	X	X	X	
Providing information about each product item, in a digital and standardized form for automating management, inventory and maintenance	X	X	X	X	

Improvement in energy efficiency beyond the minimum	X	X	X	X	
Battery management system for intelligent charging (AC/TS)	X	X	X	X	
Provision of extended service agreement for maintenance and repair	X	X	X	X	CPC
Duration and conditions of extended service agreement with service-level	X	X	X	X	
Periodic reporting on service-level compliance of extended services	X	X	X	X	
Performance report under an extended services agreement	X	X	X	X	
Minimum share of refurbished products in tenders for new products	X	X	X	X	
Devices as-a-service	X	X	X	X	
10 Maximizing recyclability	**STA**	**MON**	**MOB**	**IMA**	
Demonstrate capacity to provide end-of-life management services	X	X	X	X	SC
Secure computer collection, sanitization, re-use and recycling	X	X	X	X	TS
Confidential handling and secure data deletion	X	X	X	X	
Dismantling for component re-use, recycling and/or disposal	X	X	X	X	
Marking of plastic casings, enclosures and bezels for the correct indication of the chemistry (comprehensive)	C	C			
Recyclability of plastic casings, enclosures and bezels (comprehensive)	C				AC
Design for dismantling, material recycling compatibility (comprehensive)	C				
Availability of disassembly instructions	X	X	X	X	
Declaration of critical raw materials	X	X	X	X	CPC
Reporting on end-destination of ICT equipment	X	X	X	X	

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