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*Technical Report*

**O-RAN Focus Group (Sustainability Focus Group) Circular economy guidelines on network equipment**

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# Foreword

This Technical Report (TR) has been produced by O-RAN Alliance.

# Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the O-RAN Drafting Rules (Verbal forms for the expression of provisions).

"**must**" and "**must not**" are **NOT** allowed in O-RAN deliverables except when used in direct citation.

# Executive summary

The implementation of circular economy transformative model on the telecommunications industry and its network equipment promotes the move to more sustainable business models. It favours both the manufacture of products with eco-design criteria, and the reuse and recycling of these at the end of their useful life. It also contributes to reducing the risk of resource depletion, provides continuity to the supply chain (components, critical raw materials, etc.) and helps reduce GHG emissions.

This document defines circular economy criteria aspects and indicators applicable on network equipment based on the recommendation ITU-T L.1023 (08/2023) “Assessment method for circularity performance scoring”, with the intention to reduce environmental impact through the homogenization and prioritization of said criteria based on the network equipment and its impact on the contribution to the circular economy model.

# Introduction

Circular economy model reduces environmental impact supporting the reduction of material use, recycling, and recovering of product, product parts, components, and materials to circulate them in the value chain for as long as possible.

The present document identifies circular economy aspects and indicators applicable on network equipment such as: O-CU, O-DU and O-RU including their respective description, contribution and non-contribution cases to circular economy and priority level according to the effect (for customer, environment etc.) of the indicator at hand.

The objective of this information is to homogenize circularity criteria applicable to network equipment with the aim of reducing its environmental impact during the different phases involved in its life cycle, through improvements that allow achieving the greatest positive effect that contributes to the circular economy in aspects such as: product durability, ability to recycle, repair, reuse, upgrade at equipment level, and finally ability to recycle, repair, reuse, upgrade at manufacturer level. This goal will involve cooperation with stakeholders along the whole of the value chain.

These guidelines are based on the latest recommendation ITU-T L.1023 (08/2023) “Assessment method for

circularity performance scoring”. Scoring methodology is out of scope on this document.

# Scope

The contents of the present document are subject to continuing work within O-RAN and may change following formal O-RAN approval. Should the O-RAN Alliance modify the contents of the present document, it will be re-released by O-RAN with an identifying change of version date and an increase in version number as follows:

version xx.yy.zz where:

xx: the first digit-group is incremented for all changes of substance, i.e., technical enhancements, corrections, updates, etc. (the initial approved document will have xx=01). Always 2 digits with leading zero if needed.

yy: the second digit-group is incremented when editorial only changes have been incorporated in the document. Always 2 digits with leading zero if needed.

zz: the third digit-group included only in working versions of the document indicating incremental changes during the editing process. External versions never include the third digit-group. Always 2 digits with leading zero if needed.

The present document specifies circular economy criterias guidelines involved from the design & manufacturing to end of the equipment lifecycle applicable in OPEN RAN network equipment, such as: O-CU, O-DU and O-RU, with the intention of creating common aspects and indicators that are necessary to analyze the degree of maturity of the circular economy by network equipment.

# References

## Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, O-RAN cannot guarantee their long-term validity.

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] ITU-T L.1023 2.0/August 2023: "Assessment method for circularity performance scoring". [i.2] GSMA /March 2022: "Strategy Paper for Circular Economy: Network equipment".

[i.3] NGMN 1.0/July 2021: " Green Future Networks. Network Equipment Eco-Design and End to End Service Footprint".

# Definition of terms, symbols and abbreviations

## Terms

For the purposes of the present document, the following terms apply:

**Circular economy** [ITU-T L.1020]: A circular economy is restorative and regenerative by design, and aims to keep products, components, and materials at their highest utility and value at all times while reducing waste streams. A concept that distinguishes between technical and biological cycles, the circular economy is a continuous, positive development cycle. It preserves and enhances natural capital, optimises resource yields, and minimises system risks by managing finite stocks and renewable flows, while reducing waste streams.

**ICT goods** [b-ITU-T L.1410]: Tangible goods deriving from or making use of technologies devoted to or concerned with:

* the acquisition, storage, manipulation (including transformation), management, movement, control, display, switching, interchange, transmission or reception of a diversity of data;
* the development and use of the hardware, software, and procedures associated with this delivery; and
* the representation, transfer, interpretation, and processing of data among persons, places, and machine

**O-CU:** O-RAN Central Unit [O-RAN.WG1.Use-Cases-Detailed-Specification-R003-v11.00]: a logical node hosting O-CU-CP and O-CU-UPO-DU: O-RAN Distributed Unit: a logical node hosting RLC/MAC/High-PHY layers based on a lower layer functional split.

**O-DU:** O-RAN Distributed Unit [O-RAN.WG1.Use-Cases-Detailed-Specification-R003-v11.00]: a Logical node hosting RLC/MAC/High-PHY layers based on a lower layer functional split.

**O-RU:** O-RAN Radio Unit [O-RAN.WG1.Use-Cases-Detailed-Specification-R003-v11.00]: a logical node hosting Low-PHY layer and RF processing based on a lower layer functional split. This is similar to 3GPP´s “TRP” or “RRH” but more specific in includign the Low-PHY layr (FFT/iFFT, PRACH extraction)

**RAN** [O-RAN.WG1.Use-Cases-Detailed-Specification-R003-v11.00]**:** Generally referred as Radio Access Network. In terms of this document, any component below near-RT RIC per O-RAN architecture, including O- CU/O-DU/O-RU

## Symbols

Void

## Abbreviations

For the purposes of the present document, the [following] abbreviations [given in i.1 and the following] apply:

CE Circular Economy

ICT Information and communication technology

NE Network equipment

O-CU O-RAN Central Unit

O-DU O-RAN Distributed Unit

O-RU O-RAN Radio Unit

PD Product durability

RAN Radio Access Network

3Rue Ability to Recycle, Repair, Reuse, and Upgrade, Equipment level 3Rum Ability to Recycle, Repair, Reuse, and Upgrade, Manufacturer level

# Circular economy on network equipment

Based on ITU-T L.1023 recommendation, there is a three-step methodology to identify an information and communication technology (ICT) good´s circularity in three dimensions via three circularity aspects: first, the ICT good durability, second, the ICT good ability to be recycled, repaired, reused and upgraded; and third, the manufacturers ability to recycle, repair, reuse and upgrade the ICT good put into the market. The three asppects are then divided into indicators for circular product design.

In this document the circularity indicators are then assessed at three levels, applicability identification on network equipment (O-CU, O-DU and O-RU), how well circularity has been achieved and priority level according to the effect (for customer, environment etc) of the indicator at hand.

Table 1 – Circularity Aspects – contains a list of circular principles that put all the indicators into different aspects. The description of each aspect is as follows:

1. **Product durability (PD):** It included indicators related to promoting the life span and durability of products by adapting their design and upgrading software to a new version and service support by ensuring the product can be used for as long as possible by the first user or subsequent users.
2. **Ability to recycle, repair, reuse, upgrade (3Rue) – equipment level:** It includes indicators related to the product´s structure and access to its priority parts for repair, connecting, systems to facilitate disassembly and reassembly, spare parts, diagnostic and information availability. It relates to:
   1. Possibilities to refurbish the ICT good;
   2. Possibilities to reuse product parts and components within the ICT good (after first use) in refurbishment of similar or other ICT goods;
   3. Facilite the identification, separation and recycling of materials. Addresses separate collection of products for better recycling and development of designated recycling technologies.
3. **Ability to recycle, repair, reuse, upgrade (3Rum) – manufacturer level:** It includes indicators related to the manufacturer ability (on company level) to facilitate recycling, repair, reuse, and upgrade. These requirements are not directly connected to the equipment, but to the infrastructure and support to be developed or supported by the manufacturer. It relates to:
   1. Availability of service support in terms of information, infrastructure, and spare parts.

**Table 4-1 Circularity aspects and indicators applicable on network equipment**



* Software and data support
* Scratch resistance
* Maintenance support
* Robustness

**Product Durability**



* Fasteners and connectors
* Diagnostic support
* Material recycling compatibility - Plastic parts
* Material recycling compatibility - Metal parts
* Recycled/renewable plastics
* Recycled metals
* Material identification
* Hazardous substances (Bromine and Chlorine)
* Critical raw materials
* Packaging recycling
* Technical performance product mass-based material efficiency

**Recycle, repair, reuse, upgrade (Equipment level)**



* Service offered by manufacturer
* Spare parts distribution
* Spare parts availability
* Disassembly information
* Collection and recycling programmes
* Environmental footprint assessment knwoledge publically available

**Recycle, repair, reuse, upgrade (Manufacturer level)**

In terms of network equipment circularity aspects and indicators and based on the latest publication of ITU- T L.1023 recommendation, two indicators such as: Battery for portable ICT goods and Data security have been excluded on the table above as they are not applicable on network equipment.

In summary, each group contains a set of indicators that directly address the group's topic. The proposed table is in principle unlimited regarding the number of groups and indicators. For example, new indicators for scratch resistance for example for metals, glass, etc. can be added with their respective circularity contribution scenarios. Also new groups can be added accordingly.

Following the second level of assessment of this document, below is described definition and contribution cases to circular economy of each indicator per aspect:

1. **Product durability**
   1. **Software and data support:** Availability of software and firmware updates & upgrades (according to EN 45554).
      * The most contributing variable to the circularity of the equipment: Software and firmware updates & upgrades availability can be categorized as long-term (class A, i.e., for a duration of time that reflects the expected maximum useful life of the product, cf. EN 45554).
      * Does not contribute to the circular economy of the equipment: No information on duration of availability (class D, cf. EN 45554) is provided on software and firmware updates & upgrades availability.
   2. **Scratch resistance:** Resistance of housing parts subject to be scratched (resistance regarding ASTM D3363 – 05 (2011) e2 standard.)
      * The most contributing variable to the circularity of the equipment: Plastic scratch resistance equal or greater than 2H.
      * Does not contribute to the circular economy of the equipment: Plastic scratch resistance lower or equal to B.
   3. **Maintenance support:** Availability of consumables, wear-out parts expected to be replaced periodically and availability of maintenance infrastructure (according to EN 45554).
      * The most contributing variable to the circularity of the equipment: Consumables and wear- out parts expected to be replaced periodically can be categorized as publicly available (class A in EN 45554) or as available to independent maintenance service providers (class B in EN 45554).
      * Does not contribute to the circular economy of the equipment: Consumables and wear-out parts expected to be replaced periodically can be categorized as not available (class E in EN 45554). No maintenance infrastructure are offered by manufacturer.
   4. **Robustness:** Refers to the ability of the equipment to tolerate or resist perturbations that may affect its functional body. If the equipment is robust, it has greater durability and is therefore better from a circular economy point of view.
      * The most contributing variable to the circularity of the equipment: The product's design features have better characteristics than the minimum requirements for the environmental class in which the product is intended to be used and comply to the enhanced requirements (Example: a product intended to be used in non-weather protected location and satisfies the requirements of class 4.1E (extended severity level) of [b-EN 300 019-1-4] instead of class 4.1 (minimum severity level) and complies to the enhanced requirements of ITU-T K.20/21/45).
      * Does not contribute to the circular economy of the equipment: The product's design features characteristics do not comply to several of the minimum requirements for the environmental class in which the product is intended to be used.
2. **Recycle, repair, reuse, upgrade – Equipment level**
   1. **Fasteners and connectors:** Fasteners, connectors and tools used to disassemble parts that are likely to need replacement during the expected lifetime of the product are reusable/removable per EN 45554.
      * The most contributing variable to the circularity of the equipment: Fasteners and connectors can be categorized as reusable (class A) and using no tools, basic tools or product specific tools (classes A-C as defined in EN 45554).
      * Does not contribute to the circular economy of the equipment: Fasteners and connectors can be categorized as neither removable nor reusable (class C).
   2. **Diagnostic support:** Facilitate the identification of problems or defects. Relates to the type of interface available and how intuitive it is for fault detection, parameter reset or default upgrade. An accessible diagnostic and reset interface facilitate further repair, reuse and upgrade. Diagnostic support classification by necessary interface.
      * The most contributing variable to the circularity of the equipment: Interface can be categorized as an intuitive interface (Class A) - cf. EN 45554.
      * Does not contribute to the circular economy of the equipment: Diagnostic is not possible with any type of interface (Class E) - cf. EN 45554.
   3. **Material recycling compatibility - Plastic parts:** Materials compatibility for joint recycling.
      * The most contributing variable to the circularity of the equipment: All of the following requirements shall be fulfilled;
        1. Plastic parts >25g do not contain metal inlets or fasteners that are molded, heat or ultrasonically inserted or glued-in and cannot be separated by breaking off from the plastic part or with commonly available tools.
        2. Plastic parts >100g do not have an adhesive, coating, paint or finish that is not compatible with recycled. NOTE: Plastic parts with >25% post-consumer recycled content and printed-circuit boards are exempt. Requirement does not apply to parts where such measures are required for safety, legal or technical requirements.
        3. Plastic parts >25g are comprised of a single resin or combination of resins compatible for recycling and are separable by hand or with commonly available tools from other plastic parts >25g and not compatible for joint recycling. NOTE: Printed circuit boards, wires and cables, connectors, electronic, optical, acoustic, ESD and EMI components are excluded.
      * Does not contribute to the circular economy of the equipment: None of the requirements specified is fulfilled.
   4. **Material recycling compatibility - Metal parts:** Materials compatibility for joint recycling.
      * The most contributing variable to the circularity of the equipment: All of the following requirements shall be fulfilled.
        1. In metal parts with weight > 25 g, metals are kept separable for easy recycling, particularly the materials intended for different end-of-life treatment.
        2. Data on used alloys is available.
        3. Metal parts with weight > 25 g do not have such adhesive, coating, paint, or finish that is not compatible with recycling.
      * Does not contribute to the circular economy of the equipment: None of the requirements specified is fulfilled.
   5. **Recycled/renewable plastics:** Use of pre- or post-consumer recycled plastics. NOTE: Refers to plastics used in the ICT good itself.
      * The most contributing variable to the circularity of the equipment: Total content of recycled and biobased plastics 75-100%.
      * The less contributing variable to the circularity of the equipment: Total content of recycled and biobased plastics 0-25%.
   6. **Recycled metals:** Use of recycled metals.
      * The most contributing variable to the circularity of the equipment: Combined total recycled metals content in at least two predominant metals by mass is 75-100%.
      * Does not contribute to the circular economy of the equipment: Combined total recycled metals content in at least two predominant metals by mass is 0-25%.
   7. **Material identification:** Identification and marking of the materials contained in the equipment. The identification and marking of materials facilitate the subsequent recycling of the equipment. Materials identification according to ISO 11469.
      * The most contributing variable to the circularity of the equipment: Markings to identify base materials as per ISO 11469, ISO 1043-1 (plastics), ISO 1629 (rubbers) ISO 18064 (thermoplastic elastomers), as well as fillers and reinforcing materials (ISO 1043-2), plasticizers (ISO 1043-3) and flame retardants (ISO 1043-4)
      * Does not contribute to the circular economy of the equipment: No markings to identify materials on any part.
   8. **Hazardous substances (Bromine and Chlorine):** Reduction of bromine and chlorine in plastic parts (The flame retardant used in plastic parts may contain these hazardous substances).
      * The most contributing variable to the circularity of the equipment: Each plastic part in the product exceeding 0.5 g shall not contain greater than 1000 ppm chlorine or greater than 1000 ppm bromine at the homogeneous level [b-IEEE1680]. Test methods such as IEC 62321-3-1 and 62321-3-2 are recommended. [b-IEEE1680]. NOTE: Parts which exceed 25% post-consumer recycled content may contain a maximum of 5000 ppm chlorine and a maximum of 5000 ppm bromine [b-IEEE1680]. Power cords - in jurisdictions where PVC- free power cords have not been approved by safety agencies for use in the product - are exempted. [b-IEEE1680].
      * Does not contribute to the circular economy of the equipment: The bromine and chlorine based substances content is unknown.
   9. **Critical Raw Materials:** Declaration of Critical Raw Materials Content. NOTE: CRMs are different for each region. Examples of defined CRM include L.1100 and the list of CRM for the EU [b-EU-CRM]. Each product has to choose the appropriate CRM list.
      * The most contributing variable to the circularity of the equipment: Based on the CRM content assessment, the location of the CRM in the ICT good is available to improve recyclability.
      * Does not contribute to the circular economy of the equipment: The CRM content is unknown.
   10. **Packaging recycling:** Material recycling aspects included in the primary packaging.
       * The most contributing variable to the circularity of the equipment: All the aspects of material efficiency are considered for the packaging, by fulfilling all of the following five requirements:
         1. Elimination of elemental chlorine as a bleaching agent used to bleach virgin or recovered fibers subsequently used in product packaging.
         2. Elimination of the use of expanded polystyrene in product packaging.
         3. Packaging is designed in a way that it allows reuse, recycling or recovery.
         4. Sum of the concentrations of intentionally added lead, cadmium, mercury and hexavalent chromium present in primary packaging shall not exceed 100 ppm by weight.
         5. Minimum used 30% recycled content by mass of plastic and fibre-based materials.
       * Does not contribute to the circular economy of the equipment: None of the requirements for packaging material recycling are fulfilled.
   11. **Technical performance product mass-based materials efficiency:** Technical performance per product mass.
       * The most contributing variable to the circularity of the equipment: Technical performance per product mass used improved > 15% in between product at hand and previous corresponding product model.
       * Does not contribute to the circular economy of the equipment: Technical performance per product mass not improved in between product at hand and previous corresponding product model.
3. **Ability to Recycle, Repair, Reuse, upgrade - Manufacturer level**
   1. **Service offered by manufacturer:** Duration of Repair, Reuse, upgrade services (according to EN 45554).
      * The most contributing variable to the circularity of the equipment: Repair, Reuse and upgrade service availability can be categorized as long-term (class A). NOTE: Expected durability is the time a customer (the user of the ICT good) can expect the product to last.
      * Does not contribute to the circular economy of the equipment: No Repair, Reuse and upgrade service availability is offered.
   2. **Spare parts distribution:** Availability of spare parts to different categories of persons/ organisations to facilitate equipment repairability (according to EN 45554).
      * The most contributing variable to the circularity of the equipment: Spare parts are publicly available or available to independent repair service providers (Class A and Class B, as defined in EN 45554).
      * Does not contribute to the circular economy of the equipment: Spare parts are not available (Class E, as defined in EN 45554).
   3. **Spare parts availability:** Duration of spare parts availability (according to EN 45554). The longer the availability of spare parts, the greater the circularity.
      * The most contributing variable to the circularity of the equipment: Spare parts availability can be categorized as long-term (class A, i.e., a repair, re-use or upgrade process, for which the required spare part(s) is/are available for a duration of time that reflects the expected durability of the product category, cf. EN 45554)
      * Does not contribute to the circular economy of the equipment: No information on duration of availability is provided for spare parts (class D, i.e., repair, re-use or upgrade process, for which the required spare part(s) is/are available at the time of sale, but for which the duration of availability cannot be determined, cf. EN 45554).
   4. **Disassembly information:** Classification of information availability by comprehensiveness (according to EN 45554).
      * The most contributing variable to the circularity of the equipment: Information is publicly available (class A, i.e., repair, re-use or upgrade process, for which the relevant information is available to all interested parties, cf. EN 45554).
      * Does not contribute to the circular economy of the equipment: Information is available to the manufacturer only (class D, i.e., repair, re-use or upgrade process, for which the relevant information is available to the product manufacturer, cf. EN 45554).
   5. **Collection and recycling programmes:** Designated collection and recycling programs.
      * The most contributing variable to the circularity of the equipment: A designated collection program for refurbish, remanufacturing, repair and a designated selective, recycling program for specific parts of ICT goods (e.g., specific recycling process able to recover Germanium from optical fiber, Tantalum from Tantalum capacitors or Indium from LCD/OLED displays, etc.) is available.
      * Does not contribute to the circular economy of the equipment: Neither designated collection nor designated recycling program is available.
   6. **Environmental footprint assessment knowledge publically available:** Knowledge on the equipment environmental footprint.
      * The most contributing variable to the circularity of the equipment: An [b-ISO 14040] / [b- ISO 14044] or [b-ITU-T L.1410] compliant life cycle assessment (LCA) has been carried out on the ICT good and the results are made available on demand.
      * Does not contribute to the circular economy of the equipment: Neither an environmental footprint assessment have been done on the ICT good, nor an environmental footprint assessment on a similar type of equipment are made available on demand.

As a last step of assessment of this document, and part of the third level, below is described priority level definition and will be detailed in the following sub-chapter by each network equipment included in the scope of this document.

Table 2 – Priority level – consist of a level of relevance of each circularity indicator based on relevance characteristics

**Table 4-2 Priority level definition based on contribution effect to circular economy**

|  |  |  |
| --- | --- | --- |
| **Level** | **Priority Level** | **Description** |
| 1 | Very HIGH | Indicator with a very high positive effect to the contribution of the circular economy |
| 2 | HIGH | Indicator with a high positive effect to the contribution of the circular economy |
| 3 | LOW | Indicator with a low positive effect to the contribution of the circular economy |
| 4 | Very LOW | Indicator with a very low positive effect to the contribution of the circular economy |

## O-CU/O-DU

**Table 4.1-1 O-CU/O-DU priority definition based on circularity economy effect**

|  |  |  |
| --- | --- | --- |
| **Circularity aspects** | **Circularity indicator** | **Priority** |
| Product Durability | Software and data support | 1 |
| Scratch resistance | 4 |
| Maintenance support | 1 |
| Robustness | 3 |
| Recycle, repair, reuse, upgrade  – Equipment level | Fasteners and connectors | 1 |
| Diagnostic support | 2 |

|  |  |  |
| --- | --- | --- |
|  | Material recycling compatibility - Plastic parts | 2 |
| Material recycling compatibility - Metal parts | 1 |
| Recycled/renewable plastics | 2 |
| Recycled metals | 1 |
| Material identification | 1 |
| Hazardous substances (Bromine and Chlorine) | 1 |
| Critical Raw Materials | 1 |
| Packaging recycling | 2 |
| Technical performance product mass-based material efficiency | 1 |
| Recycle, repair, reuse, upgrade  – Manufacturer level | Service offered by manufacturer | 1 |
| Spare parts distribution | 2 |
| Spare parts availability | 1 |
| Disassembly information | 1 |
| Collection and recycling programmes | 2 |
| Environmental footprint assessment knowledge publically available | 1 |

## O-RU

**Table 4.2-1 O-RU priority definition based on circularity economy effect**

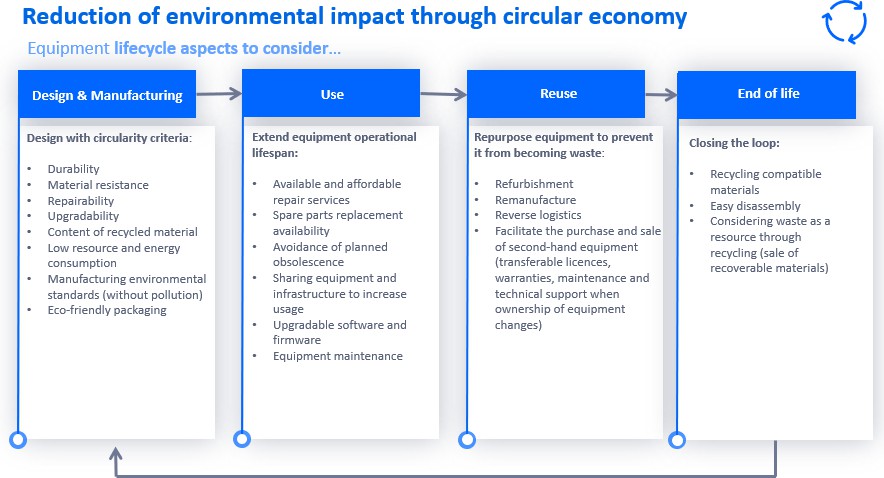
|  |  |  |
| --- | --- | --- |
| **Circularity aspects** | **Circularity indicator** | **Priority** |
| Product Durability | Software and data support | 1 |
| Scratch resistance | 4 |
| Maintenance support | 1 |
| Robustness | 1 |
| Recycle, repair, reuse, upgrade  – Equipment level | Fasteners and connectors | 1 |
| Diagnostic support | 2 |
| Material recycling compatibility - Plastic parts | 2 |
| Material recycling compatibility - Metal parts | 1 |

|  |  |  |
| --- | --- | --- |
|  | Recycled/renewable plastics | 2 |
| Recycled metals | 1 |
| Material identification | 1 |
| Hazardous substances (Bromine and Chlorine) | 1 |
| Critical Raw Materials | 1 |
| Packaging recycling | 2 |
| Technical performance product mass-based material efficiency | 1 |
| Recycle, repair, reuse, upgrade  – Manufacturer level | Service offered by manufacturer | 1 |
| Spare parts distribution | 2 |
| Spare parts availability | 1 |
| Disassembly information | 1 |
| Collection and recycling programmes | 2 |
| Environmental footprint assessment knowledge publically available | 1 |

# Annex A (informative):

Reduction of environmental impact through circular economy

## Equipment lifecycle aspects to consider



**Figure A.1-1: Reduction of environmental impact through circular economy**

# Revision history

|  |  |  |
| --- | --- | --- |
| **Date** | **Revision** | **Description** |
| 2023.12.11 | 01.00 | First version of circular economy guidelines on network equipment based on ITU-T  L.1023 (08/2023) |

# History

|  |  |  |
| --- | --- | --- |
| **Date** | **Revision** | **Description** |
|  |  |  |
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