



PEPecopassport® PROGRAM

PSR

SPECIFIC RULES FOR Wires, Cables and Accessories

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1. Introduction

This reference document complements and explains the Product Environmental Profile (PEP) Drafting Rules defined by the PEPecopassport® program (PEP-PCR ed.4-EN-2021 09 06), available at www.pep-ecopassport.org.

It sets out the additional requirements applicable to “Wires, Cables and Accessories”. Compliance with these requirements is necessary to:

- Qualify the environmental performance of these products on an objective and consistent basis,
- Publish PEPs compliant with the PEP ecopassport® program and international reference standards.¹

This reference document was drawn up in compliance with the open, transparent rules of the PEP ecopassport® program and with the support of stakeholders and professionals in the wires, cables and accessories market.

	www.pep-ecopassport.org
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Critical review	The third-party Critical review was carried out by [EVEA] The declaration of conformity published on 2022/06/10 can be found in the Appendices.
Availability	The Critical review report is available on request from the P.E.P. Association contact@pep-ecopassport.org
Scope of validity	The critical review report and the declaration of conformity remain valid within 5 years or until the PEP Drafting Rules, or the normative reference texts to which they refer, are modified.

¹ ISO 14025, ISO 14040 and ISO 14044 standards

2. Scope

In accordance with the general instructions of the PEPECopassport® program (PEP-General instructions- ed4.1-EN-2017 10 17) and additional to the PCR, "PRODUCT CATEGORY RULES", (PEP-PCR ed.4-EN-2021 09 06) of the PEPECopassport® environmental product declaration program, this document sets out the specific rules for "Wires, Cables and Accessories" and defines the product specifications to be adopted by manufacturers in the development of their PRODUCT ENVIRONMENTAL PROFILES (PEPs) particularly with regard to:

- the technology and its type of application,
- the reference service lifetime taken into account for the product' Life Cycle Assessment (LCA),
- the conventional use scenarios to be adopted during the product use phase.

It covers the manufacturing, distribution, use, installation, end of life and benefits and impacts outside system boundary (if calculated) stages.

2.1. Description of the product family(ies) covered

In the "Wires, Cables and Accessories" category, there are four types of products:

2.1.1. Power transmission wires and cables

A power transmission cable is an electrical cable, an assembly of one or more electrical conductors, conductors are usually protected by insulation layers and usually held together with an overall sheath.

The assembly is used for transmission of electrical power. Power cables may be installed as permanent wiring within buildings, buried in the ground, run overhead, subsea, exposed, etc.

2.1.2. Communication and data wires and cables, which may have metal or optical fiber conductors

Communication and data cables are used to transmit data, they are classified mostly into optical fiber cables or copper cables. They allow communicating systems to be connected to each other via the ethernet protocol.

Optical fiber cables are used mostly for long distance communication, they transmit light signals. Whereas Copper cables are mostly used for LAN over shorter distances, they transmit electrical signals.

2.1.3. Control and command wires and cables, which can have metal or fiber optical conductors

Control cables are multi-conductor cables used in automation and instrumentation applications, they send signals to control the functioning of equipment, measure and regulate transmissions of automated processes.

2.1.4. Power and telecom accessories

2.1.4.1. Power accessories

A power accessory is an electrical device used to either join two electrical conductors or join electrical conductors to an equipment.

Power accessories that are included in this PSR are:

- Low voltage (<6kV):
 - Cable lug and connectors
- Medium voltage (12kV to 42kV):
 - Cable lug and connectors
 - Heat shrinkable and cold shrinkable cable terminations,
 - Separable connectors and plug-in bushings,
 - Surge arrestors
 - Taped, injected, heat shrinkable junctions and cold shrinkable junctions
 - Prefabricated junctions for insulated dry cables.
- High and very high voltage (>42 kV):
 - Cable terminations, junctions.
- Smart grid accessories.

Note: There exists a PSR-0005 for “Electrical switchgear and control gear solutions” for low voltage accessories. It should be noted that PSR-0005 does not cover the accessories listed above.

2.1.4.2. Optical telecom accessories

This section concerns all equipments and accessories for passive telecom connections used in optical telecommunication networks, such as described below.

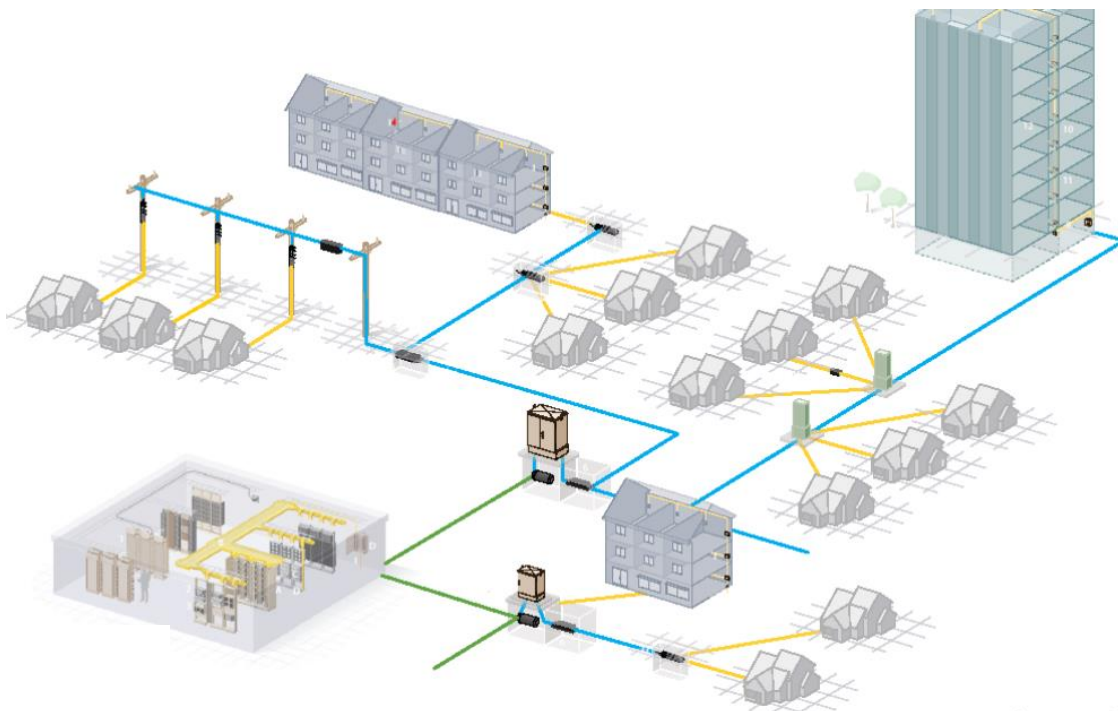


Figure 1 : Representation of an optical fiber network

Telecom accessory families considered are:

- Equipped bay and server farm
- Equipped cable heads and optical drawers
- Equipped cabinets

- Indoor optical boxes (OTO, ENTI, MDU, MMDB, OLT, FDU, ...)
- Outdoor optical boxes (BP, OLT, ...)
- Passive optical components (connectors, plugs, couplings, cords, pigtails, etc.)

The pre-terminated optical cables shall be handled by the integrator of solutions as a set of discrete components.

3. Product Life Cycle Assessment

3.1. Functional unit and reference flow description

These specific rules are additional to section 2.1 "Functional unit and reference flow description" of the PCR (PEP-PCR ed.4-EN-2021 09 06), in order to provide a more precise definition of the functional unit for this product category.

As a reminder, there are 2 options for declaring the environmental impact indicators of a system declared in a PEP, each of them meeting different needs:

- The functional unit, to be used systematically when the comparison between systems (products, solutions...) is required (MANDATORY)
- The declared unit, which allows the direct integration of environmental impact indicators of products at the product or system level. (OPTIONAL)

3.1.1. Energy wires and cables

a. Functional Unit

In order to define the functional unit for energy wires and cables, the manufacturers shall use the following sentence:

« To transmit energy expressed for 1A over a distance of 1km during X years and a Y% use rate, in accordance with the relevant standards (mention the relevant standards or refer the product technical data sheet).

Lifetime and use rate correspond to the application Z as defined in the table given in Appendix 6.1. of the specific rules for wire, cables and accessories. »

The determination of the numbers X of years depends on the application and is explained in the section 3.5.4. "Use stage".

According to the functional unit definition, the different life cycle stages are not proportional to the same input parameters:

- The manufacturing, distribution, installation, end of life and benefits and impacts outside system boundary (if calculated) stages are proportional to the studied cable length (1 km),
- The use stage is proportional to the cable length studied (1 km) as well as the intensity carried. As detailed in paragraph 3.5.4.1., on account of the wide possible range of these products use for a given application, and to ensure the PEP comparability, the impact of the use stage shall be calculated for 1A.

Therefore, in the table with the environmental impacts, the column "Total" represents the environmental impact of the reference flow fulfilling the functional unit. The total cable impact installed shall be calculated by the PEP user according to his own use scenario. Moreover, the insert below shall be completed and included in the PEP, to ensure clarity and transparency for the user.

This PEP has been drawn up considering the following parameters:

- 1 km for manufacturing, installation, distribution and end of life stages in system boundaries
- 1 km for benefits and impacts outside system boundaries (if calculated)
- 1 km and 1A for the use stage.

The potential impact of use stage shall be calculated by the PEP user considering the real amperage through the product during the use by multiplying the impact by the square of the intensity. This PEP is valid in the intensity range taking into account the maximum allowable intensity.

If the intensity range is related to the installation conditions of the product, they shall be specified in the insert.

b. Declared unit

The declared unit could be:

A cable capable of transmitting "N" A over a distance of 1km during X years and a Y% use rate, in accordance with the relevant standards (mention the relevant standards or refer the product technical data sheet).

Lifetime and use rate correspond to the application Z as defined in the table given in Appendix 6.1. of the specific rules for wire, cables and accessories. »

N is the real current intensity used in the cable.

Conversion of environmental impacts from function unit to declared unit:

- Multiply Use phase impacts by square of N (N^2)

3.1.2. Communication and data wires and cables

a. Functional Unit

In order to define the functional unit for the communication and data wires and cables, the manufacturers shall use the following sentence:

« To transmit 1 communication signal on 1m, at a frequency of α Hz (or respectively a wavelength of β nm for a mono- or multi-mode optical fiber), during X years and a Y% use rate in accordance with the standards in force (mention the relevant standards or refer the product technical data sheet).

Lifetime and use rate correspond to the application Z as defined in the table given in Appendix 6.1. of the specific rules for wire, cables and accessories. »

If the protocol used and the cable (or respectively optical fiber) category are known, the manufacturer shall use the following sentence:

« To transmit one communication signal on 1m according to XX protocol, YY category, during X years and a Y% use rate in accordance with the standards in force (mention the relevant standards or refer the product technical data sheet).

Lifetime and use rate correspond to the application Z as defined in the table given in Appendix 6.1. of the specific rules for wire, cables and accessories. »

The determination of the numbers X of years depends on the application and is explained in the section "Use stage" in paragraph "3.5.4.2. Communication and data wires and cables".

Moreover, on account of the wide variability in the number of communication units that a cable can contain for a given application, and to ensure the comparability of the PEP, the impacts must be calculated for 1 communication signal.

Consequently, the manufacturer must carry out the life cycle analysis for the maximum capacity of the reference product and must present the results corresponding to the functional unit, ie 1 communication signal.

For optical cables, the impacts will be presented for 1 optical fiber. For copper cables, the impacts will be presented according to the protocol used, namely 2 pairs for the 100M Ethernet protocol and 4 pairs for the other protocols (1G or 10G Ethernet).

The impact results will be calculated by the PEP user by multiplying the impacts by the number of communications signals and by the number of meters of cables laid in order to obtain the impacts at the scale of the equipment.

b. Declared Unit

The declared unit could be:

“ A cable consisting of “N” (optical fibers or copper pairs) used to transmit communication signals on 1m at the frequency of α Hz (or respectively at a wavelength of β nm for an optical fiber mono or multimode), for X years and at a rate of use of Y%, in accordance with the standards in force (mention the standards in force or refer to the technical sheet of the product).

Lifetime and use rate correspond to the application Z as defined in the table given in Appendix 6.1. of the specific rules for wire, cables and accessories.”

N is the number of communication signals.

If the protocol used and the cable (or respectively optical fiber) category are known, the manufacturer shall use the following sentence:

A cable composed of X (optical fibers or copper pairs) used to transmit one communication signal on 1 m according to XX protocol, YY category, during X years and a Y% use rate in accordance with the standards in force (mention the relevant standards or refer the product technical data sheet).

Lifetime and use rate correspond to the application Z as defined in the table given in Appendix 6.1. of the specific rules for wire, cables and accessories. »

Conversion of environmental impacts from function unit to declared unit:

- Multiply production, distribution, installation, use & end of life stages impacts by N
- Multiply module D (if calculated) by N

3.1.3. Control and command Wires and cables

a. Functional unit

In order to define the functional unit for the control and command wires and cables, the manufacturers shall use the following sentence:

« To transmit data and signals on a distance of 1 meter during X years and a Y% use rate to control, measure and regulate equipments, in accordance with the standards in force. (mention the relevant standards or refer the product technical data sheet).

Lifetime and use rate correspond to the application Z as defined in the table given in Appendix 6.1. of the specific rules for wire, cables and accessories. »

The determination of the numbers X of years depends on the application and is explained in the section “Use stage” in paragraph “3.5.4.3. Control and command Wires and cables”.

b. Declared unit

The declared unit is the same as the functional unit mentioned above. Thus the conversion factor to recalculate environmental impacts from functional unit to declared unit is "1".

3.1.4. Power connection accessories

a. Functional unit

In order to define the functional unit for the power connection accessories, the manufacturer shall use the standard formulation indicated below:

« To connect together the power transmission cables, or connect them to equipments, for one unit and its packaging, under operating conditions identical to those of the cable, namely: 1 A during X years, with a use rate of Y%, according to the standards in force. (mention the relevant standards or refer the product technical data sheet).

Lifetime and use rate correspond to the application Z as defined in the table given in Appendix 6.1. of the specific rules for Wire, Cables and Accessories. »

The determination of X number of years depends on the application and is explained in section "Use stage" in paragraph "3.5.4.4. Power connection accessories".

Because of the wide variety of possible uses of these products for a given application, and to ensure comparability of the PEPs, the impact of the use stage shall be calculated for 1A. In the table of environmental impacts, the "Total" column therefore represents the environmental impact of the functional unit, namely the connection of power transmission cables expressed for one packaging unit and for 1A. The total impact of the power connection accessories installed shall therefore be calculated by the user of the PEP based on his own scenario of use.

Moreover, the insert below shall be presented in the PEP to guarantee clarity and transparency for the user.

The PEP submitted was prepared taking into consideration the following parameters:

- 1 packaging unit for the production, distribution, installation and end of life stages in system boundaries
- 1 packaging unit for benefits and impacts outside system boundaries (if calculated)
- 1 packaging unit and 1A for the use stage

The potential impact of the use stage, estimated as Joule losses, shall be calculated by the user of the PEP as a function of the actual amperage during the use of the product by multiplying the impact considered by the square of the intensity. The PEP is valid within an intensity range taking into account of the maximum permissible intensity.

b. Declared unit

The declared unit could be:

“Energy connection equipment and accessories made up of "M" connection points used to connect energy transport cables to each other or to equipment, under conditions of use identical to those of the cable, namely: "N" A for X years and at a utilization rate of Y%, according to the standards in force. (mention the relevant standards or refer the product technical data sheet).

The duration and rate of use correspond to application Z as defined in the table presented in appendix 6.1. rules specific to wires, cables and accessories.”

N is the real intensity of the current used for the whole of the equipment. M is the number of connection points.

Conversion of environmental impacts from the functional unit to the declared unit:

- Multiply the impacts of the production, distribution, installation and end of life stages by M
- Multiply the module D (if calculated) by M
- Multiply the impacts of the use stage by the square of N (N²).

3.1.5. Optical telecom accessories

a. Functional unit

In order to define the functional unit for optical telecom accessories, the manufacturer shall use the standard formulation indicated below:

« To protect and link, splice or connect

- 1 connection point,
- during X years (reference lifetime)
- with a Y% use rate

Lifetime and use rate correspond to the Z application as defined in the table given in Appendix 6.1. of the specific rules for wire, cables and accessories. »

According to the functional unit definition, production, distribution, installation, use and end of life stages depend on the maximum capacity of the reference flow fulfilling the functional unit.

The number N of connection points depends on the reference product used in the reference flow. The reference product belongs to a family of products listed in the introduction.

Consequently, the manufacturer shall realize the life cycle assessment for the maximal capacity of the reference product and shall present the results reduced to one connection point.

Note:

- A connection point is available in various ways: fusion splices, mechanical splicing, connectors. The nature of these connection points shall be specified in the PEP.
- Storing, Mixing and Deriving are secondary functions of equipments and accessories for Optical Telecom connections which are not included in the calculation of environmental impacts. Nevertheless, if necessary, these functions should be specified in the PEP.

Example of formulation of the functional unit:

« To protect and link a connection point for 30 years with a 70% use rate for optical telecommunication application in residential building ».

b. Declared unit

The declared unit could be:

“An optical telecom accessory comprised of the “N” connection points used to protect and link, splice or connect during X years (reference lifetime) with a Y% use rate.

Lifetime and use rate correspond to the Z application as defined in the table given in Appendix 6.1. of the specific rules for wire, cables and accessories. »

The environmental impacts from functional unit to declared unit can be recalculated by multiplying each environmental impact by number N of connection points

3.2. System boundaries

As described in the “Product Category Rules”, the following life cycle stages shall be included:

- The manufacturing stage as described in paragraph 2.2.3 of the “Product Category Rules”,
- The distribution stage as described in paragraph 2.2.4 of the “Product Category Rules”,
- The installation stage as described in paragraph 2.2.5 of the “Product Category Rules”,
- The use stage as described in paragraph 2.2.6 of the “Product Category Rules”,

If breakdown of modules B (B1 to B7) is done according to paragraph 2.2.6 of the PCRed.4, the environmental impacts of the use phase must be broken down done as given below:

B1: Use or application of the product installed	Not Applicable. Module equal to 0
B2: Maintenance	Not Applicable. Module equal to 0
B3: Repair	Not Applicable. Module equal to 0
B4: Replacement	Not Applicable. Module equal to 0
B5: Restoration	Not Applicable. Module equal to 0
B6: Energy requirements during the use stage	Energy losses must be considered as given in paragraph 3.5.4 of this document
B7: Water requirements during the use stage	Not Applicable. Module equal to 0

- The end-of-life stage as described in paragraph 2.2.7 of the “Product Category Rules”.

Benefits & impacts outside system boundaries, also called as "module D" as described in 2.2.8 of the "Product Category Rules". This step as mentioned in the "Product Category Rules" is outside system boundaries and is optional.

The following sections complete for manufacturing, installation, use, end life and module D stages, the respective sections 2.2.3, 2.2.5, 2.2.6 , 2.2.7 & 2.2.8 of the “Product Category Rules” (PEP-PCR-ed4-EN-2021 09 06).

3.3. Cut-off criteria

The rules set out in the “Cut-off rules” paragraph of the applicable PCR (PEP-PCR-ed4-EN-2021-09 06) shall apply.

Rules for allocation between co-products

The rules set out in the "Rules for allocation between co-products" paragraph of the applicable PCR (PEP-PCR-ed4-EN-2021-09 06) shall apply

3.4. Development of scenarios (default scenarios)

These specific rules are additional to section 2.5 "Development of scenarios (default scenarios)" of the PCR (PEP-PCR ed.4-EN-2021 09 06).

The default scenarios provided for all phases of the life cycle are applicable for all countries.

3.4.1. Manufacturing stage

3.4.1.1. Energy wires and cables

This section specifies the section 2.2.3 "Manufacturing stage" of the "Product Category Rules".

The default scenario to be considered in this stage are:

- Recycled content: 0% recycled content or 100% virgin materials in raw materials
- Production loss rate: 20% of total weight of raw materials used for manufacturing the final product.

The default end of life treatment scenario for manufacturing losses to be considered:

- Transportation, assuming a local transport as described in "Product Category Rules".
- Refer annex D of PCR for recycling of metals end-of-life treatment of different materials
- Landfilling of other materials that are not provided in annex D of PCR.

Accepted document of proof to modify default scenarios

If the declarant wants to use specific data instead of default data given in this PSR, this data must be justified in the LCA report. This data provided by industries do not have to be certified but based on traceable proof. These supporting documents are documents engaging the responsibility of the registrant or supplier or a third party (example of third party: independent certification body). These supporting documents must be available if claimed.

The recycled content of raw materials may, for example, be justified by supplier data (data sheet or supplier's declaration) but cannot be justified by generic data (e.g. sector, trade unions, ADEME).

The production losses rates of raw materials may, for example, be justified by an internal document from the production plant (example: annual report mentioning the quantity of material entering and leaving the process).

The end-of-life treatment of waste may, for example, be justified by a certificate from the company in charge of the plant's waste treatment.

3.4.1.2. Communication and data wires and cables

Refer paragraph 3.5.1.1

3.4.1.3. Control and command Wires and cables

Refer paragraph 3.5.1.1

3.4.1.4. Power connection accessories

This section specifies the section 2.2.3 “Manufacturing stage” of the “Product Category Rules” for the power connection accessories category.

The default scenario to be considered in this stage are:

- Recycled content: 0% recycled content or 100% virgin materials in raw materials
- Production loss rate: 50% of total weight of raw materials used for manufacturing the final product.

The default end of life treatment scenario for manufacturing losses to be considered:

- Transportation, assuming a local transport as described in "Product Category Rules".
- Refer annex D of PCR for end-of-life treatment of different materials
- Landfilling of other materials that are not provided in annex D of PCR.

3.4.1.5. Optical telecom accessories

Refer paragraph 3.5.1.4

3.4.2. Distribution stage

The rules set out in the 2.5.3 “Transport scenarios” paragraph of the applicable PCR (PEP-PCR-ed4-EN- 2021 09 06) shall apply.

3.4.3. Installation stage

This section specifies the section 2.2.5 “Installation stage” of the “Product Category Rules”.

3.4.3.1. Energy wires and cables

Considering the wide range of possible installation of these products, installation processes are excluded from the system boundaries. This extended cut-off rule does not exclude the respect of the other requirements from the “Product Category Rules” (PEP-PCR-ed4-EN-2021 09 06), such as considering the end of life of packaging treatment and waste from the installation stage (manufacturing, transportation, and end of life of waste).

The default value of 5% of product is to be considered as product waste in installation stage.

The default end of life treatment scenario for end of life of packaging or waste from installation stage to be considered:

- Transportation, assuming a local transport as described in "Product Category Rules",
- Refer annex D of PCR for end-of-life treatment of different materials
- Landfilling of other materials that are not provided in annex D of PCR.

Below the environmental impact table, it shall be mentioned that the impact concerning the product installation processes should be completed by the PEP user.

3.4.3.2. Communication and data wires and cables

Refer paragraph 3.5.3.1

3.4.3.3. Control and command Wires and cables

Refer paragraph 3.5.3.1

3.4.3.4. Power connection accessories

Considering the wide variety of possible methods of installation for power connection accessories, the determination of the installation impact shall be carried out on the basis of the hypotheses below to ensure comparability of the PEPs:

- The manual installation operations not requiring a power supply are not included within the scope of the study,
- The screwing or crimping processes are excluded, because of their low impact, as described in Section 2.2.8 of the “Product Category Rules” (PEP-PCR-ed4-EN-2021 09 06),
- For the installation processes requiring a thermal power supply (heat shrinkable accessories, for example), the impact of the installation shall be calculated as follow, taking into consideration the use of a gas torch:
 - Gas consumption of the torch:

The consensual generic dataset to be taken into account is a consumption of 250 g of propane gas, taking into consideration the following hypotheses:

- A nozzle characteristic (NC), expressed in g/l, of 1000 g/h
- A length of use of the torch (Δt) expressed in hours, of 0.25h (15 minutes) per conductor, i.e.:

Gas consumption (C), expressed in grams, and calculated according to the following formula:

$$C = NC \times \Delta t$$

- Gas combustion emissions:

In agreement, the emissions associated with the complete combustion of the 250g of propane gas in the air to be considered are 749g of CO₂ and 408g of H₂O.

The methods of installation described above correspond to the currently used technologies. In the case of future further developments, and to ensure the comparability of the PEPs, a request for updating the specific rules for “Wires, Cables and Accessories” shall then be made to the technical committee of the PEP Association.

Moreover, the treatment of waste from the packaging used to transport the product up to the installation place shall be considered in the installation stage, by applying the modularity principle mentioned in the “Product Category Rules”. Similarly, for products generating waste during installation, the manufacturing of those waste, as well as their transportation to the installation place and their end of life shall be taken into account at installation stage.

The default end of life treatment scenario for end of life of packaging to be considered:

- Transportation, assuming a local transport as described in "Product Category Rules".
- Refer annex D of PCR for end-of-life treatment of different materials
- Landfilling of other materials that are not provided in annex D of PCR.

3.4.3.5. Optical telecom accessories

Refer paragraph 3.5.3.1

3.4.4. Use stage

This section specifies the section 2.2.6 “Use stage” of the “Product Category Rules” by setting the assumptions for the calculation of the use stage impact.

3.4.4.1. Energy wires and cables

Concerning energy wires and cables, the impact due to energy losses in use stage is important even sometimes predominant over the product total life cycle. Therefore, the product life cycle impact depends strongly on the assumptions made at use stage.

The impact due to energy losses in use stage depends on choices regarding:

- The product reference lifetime,

- The product use rate,
- The linear conductor resistivity,
- The current intensity through the conductor.

To ensure PEP comparability, different assumptions were set for these four parameters.

c. Reference lifetime and use rate

Refer paragraph 3.5.4.6

d. Linear resistivity and intensity

For energy transmission products, energy consumption results in losses by Joule effect, over the use time:

$$E = Z \times I^2 \times \Delta t$$

Where:

Z: linear resistivity of the cable in Ω/km

I: current in A

Δt : use time in s

Concerning energy wires and cables, because of the wide and various possible uses of these products for a given application, and to ensure the PEP comparability, the functional unit is expressed for a current of 1 A.

The determination of the exact use impact shall be carried out by the PEP users, depending on the product use context and using the impact calculated for 1A.

Concerning the linear resistivity of the conductor, it shall be, in order of preference, corresponding to an increasing resistivity:

- Either be measured according to the protocol of Appendix A of the standard IEC 60228 (“Conductors of insulated cables”),
- Either refer to the resistivity specified in the standard quoted in the functional unit,
- Either refer to the maximum value of the conductors at 20° C in IEC 60228 standard “Conductors of insulated cables”.

This rule allows expressing the losses by Joule effect in the cable during use stage regardless of the use scenario knowledge of end charge specific to each PEP user and thus ensures PEP comparability.

Energy consumption during use stage is then expressed in $\text{J} \cdot \text{km}^{-1} \cdot \text{A}^{-2}$ or equivalent unit, considering that the functional unit is given for 1A and for a length of 1 km of cable.

$$[1] E [\text{J} \cdot \text{km}^{-1} \cdot \text{A}^{-2}] = Z [\Omega \cdot \text{km}^{-1}] \times I [\text{A}^2] \times \Delta t [\text{s}]$$

Thus, by multiplying by the square of the intensity and the actual length of the circuit, the PEP user gets the consumption by Joule effect over the considered use time.

Example: length= 10 km and average current I= 15A, the loss is then $225 \times R \times \Delta t$

Protection conductors are not taken into account in the calculation of the Joule effect losses.

For multi-conductors cables and assuming a balanced system, a current intensity of 1A shall be considered in every conductor except in the protection conductor.

The following assumptions shall be specified in the PEP and justified in the LCA report:

- Conductor resistivity determination method,
- Conductor resistivity value ($\Omega \cdot \text{km}^{-1}$),
- Reference lifetime and use rate.

3.4.4.2. Communication and data wires and cables

There are three types of communication and data transmission cables:

- Twisted pair cables,
- Coaxial cables,
- Optical fiber cables.

In the case of communication wires and cables, the impact of the product use stage over the product total life cycle is low. The energy consumed during use stage by communication and data cables is related to the attenuation of the transmitted signals. This attenuation is due to the signal energy loss through the conductors.

Note:

- *On metal conductors, resistive losses and electromagnetic emission occurring at high frequency induce attenuation. Attenuation increases with conductors' length and frequency of emitted signal.*
- *On optical fiber cables, attenuation depends on the type of fibers, the used wavelength and on the optical fiber length. The attenuation measurement (in dB) expresses the ratio between the emitted energy and the received energy: the smaller the measured value is, the better the link is.*

The energy consumption during use stage shall correspond, in order of preference, to growing energy consumption:

- Either be measured. The paragraphs "Use stage losses determined by measurement" describe the loss measurement methods,
- Or shall refer to the loss maximum values as specified in the respective standards. The paragraphs "Use stage losses determined by standards" describe how to calculate the losses.

In all cases, the determination of loss method used shall be specified in the PEP and justified in the LCA report.

a. Reference lifetime and use rate

Refer paragraph 3.5.4.6

b. Twisted pair cables

Twisted pair cables are mainly used for computer networking and telephony. Networks are defined in the standards, such as being links of length up to 100 meters maximum, consisting in 90 meters of horizontal cables and 2 times 5 meters of patchcords. In business, installed horizontal cables may vary from 10 to 90 meters. The average length usually found in a set of connections is 40 meters.

This average length of 40 meters is used to calculate the energy loss at the frequency of considered protocol because attenuation is not proportional to the length but has an exponential behavior. Indeed, we know that more than 50% of the energy is consumed in the first 20 meters of cable.

The energy loss is calculated using a 40m cable length, and the consumed power is then reduced to the functional unit (1 meter of cable).

Use stage losses determined by measurement

For the use stage loss measurement, the following formula from Physics of transmission shall be used:

$$P_{\text{lost}} = (P_e - P_s) \times N_{\text{pair}} / L_{\text{average}}$$

Where:

P_{lost} = consumed power in Watt / meter of cable

P_e = power input in Watt and $P_e = U^2/Z = Z \cdot I^2 = U \cdot I$

Z = resistance of the cable in ohm

U = voltage in volt

I = intensity in ampere

P_s = output power in watt and $P_s = P_e \times 10^{(-ATT/10)}$

ATT = linear attenuation in dB of the cable at the frequency of the maximum amplitude of the spectrum used in the communication protocol for an average length (L average) used in meters. The frequencies to be used are mentioned in the chart below. The measurement method of linear attenuation is described by the standard IEC 61156-1.

Nbpair = the number of pairs used in the communication protocol.

L average = average length in meters of an installed cable

In all cases, the obtained value in watt shall be multiplied by the reference lifetime and use rate of the corresponding application to obtain the energy consumed in Wh or Joule (see Appendix 6.1.).

Generally, choices shall be identified in the PEP and justified in the LCA report.

Use stage losses determined by standards

Used network protocols set the frequency range of transmitted signals. For the loss calculation, the frequency value at the maximum spectral amplitude in the communication protocol is used. The frequencies to be used are mentioned in the table below.

To meet the requirements of these protocols, the cables are divided into categories. For each category is assigned an attenuation value according to the central frequency of the relevant protocol. This maximum attenuation by category is defined in the standard IEC 61156 corresponding to the cable category.

Table 1 below includes all the data to use for horizontal cables complying with the reference standards (performance standard cable IEC 61156 and Ethernet IEEE standard 802.3)

Table 1 : Data for Copper cables

Twisted pair copper cables			
Protocol	Frequency	Category	Power consumption
Ethernet 100M BP (*) = 100 MHz	31,25 MHz	Cat. 5e According to IEC 61156-5	4,7 dB/40m at 31,25 MHz Power injected / pair = 14 mW Leading to 0,462 mW/m of cable on 2 pairs
Ethernet 1G BP (*) = 250 MHz	83 MHz	Cat. 6 According to IEC 61156-5	7,2 dB/40m at 83 MHz Power injected / pair = 14 mW Leading to 1,134 mW/m of cable on 4 pairs
Ethernet 10G BP (*) = 500 MHz	400 MHz	Cat. 6a according to IEC 61156-5 ed.2	16,0 dB/40m at 400 MHz Power injected / pair = 14 mW Leading to 1,365 mW/m of cable on 4 pairs
Ethernet 10G BP (*) = 600 MHz	400 MHz	Cat. 7 according to IEC 61156-5	16,0 dB/40 m at 400 MHz Power injected / pair = 14 mW Leading to 1,365 mW/m of cable on 4 pairs
Ethernet 10G BP (*) = 1000 MHz	400 MHz	Cat. 7a according to IEC 61156-5 ed.2	15,2 dB/40 m at 400 MHz Power injected / pair = 14 mW Leading to 1,358 mW/m of cable on 4 pairs
Ethernet 10G BP (*) = 1200 MHz	400 MHz	Cat. 7+ (intermédiaire) Cat. 7a according to IEC 61156-7	14,8 dB/40 m at 400 MHz Power injected / pair = 14 mW Leading to 1,353 mW/m of cable on 4 pairs
Ethernet 40G BP (*) = 2000 MHz	1600 MHz	Cat. 8.1 according to IEC 61156-9	16,0 dB/20 m at 1600 MHz Power injected / pair = 14 mW Leading to 2,730 mW/m of cable on 4 pairs
Ethernet 40G BP (*) = 2000 MHz	1600 MHz	Cat 8.2 according to IEC 61156-9	16,0 dB/20 m at 1600 MHz Power injected / pair = 14 mW Leading to 2,730 mW/m of cable on 4 pairs

(*) BP: cable bandwidth

c. Coaxial cables

For television modulated from 47 to 2500 MHz, the used power doesn't exceed 85 dBμV, meaning 18 mV on 75 Ohms. Lost power is around 0.26 μW. This lost power is considered negligible by comparison with the impacts of the manufacturing, distribution and end of life product stages.

For mobile telephony networks, the 50-Ohm coaxial cables inside transmitter equipping aerials are powered by a maximum electric power of 10 to 40W. The emission frequency varies from 1.8 MHz to 3 GHz.

With different diameters of coaxial cables and attenuations depending on the size of coaxial cables, it is difficult to establish a general rule. The determination of losses such as defined for twisted pair cables shall be used with the value 1 for the Nbpair parameter.

In all cases, the value obtained in Watt is multiplied by the reference lifetime and use rate of the corresponding application to get the energy consumed in Wh or Joule (see Appendix 6.1.).

Moreover, the choices and assumptions used for loss calculation shall be identified in the PEP and justified in the LCA report.

d. Optical Fiber cables

Optical fiber cables are mainly used for computers networking from medium-sized to large distances. Used network protocols establish optical fiber type: either the multimode fiber, or the single-mode fiber. In optics, attenuation depends on the wavelength.

Distances of multimode fiber optical local networks are from 300 to maximum 2000 meters. A 150-meter length is used, consensually, to calculate the optical signal attenuation at the wavelength of the considered protocol as a conservative approach.

Distances in single-mode fiber optical local networks are less than 10 km. A 500-meter length is used, consensually, to calculate the optical signal attenuation in the wavelength of the considered protocol as a conservative approach.

Attenuation is not proportional to the length but is exponentially related. This value is then reduced to the functional unit (1 meter of cable).

For the optical signal loss calculation, the most impacting wavelength shall be used for attenuation for both types of optical fibers (as we don't know which one will be used by the final customer), that is to say $\lambda=850$ nm for multimode fibers (OM) and $\lambda = 1310$ nm for the single-mode fibers (OS).

Average lengths to estimate line losses are identified in Table 2 below.

Use stage losses determined by measurement

For the use stage losses determined by measurement, the formula issued from Physics of transmission will be used:

$$P \text{ lost} = (P_e - P_s) \times N_{bFO} / L \text{ average}$$

Conversion mW in dBm : $P[\text{mW}] = 10^{(P[\text{dBm}]/10)}$

Where:

$P \text{ lost}$ = loss of optical signal in Watt / meter of cable

P_e : Input power in Watt

P_s : output power in Watt and $P_s = P_e \times 10^{(-ATT/10)}$

ATT: cable attenuation in dB at a used wavelength for an average length (L average) in meters. Wavelengths and installation average length are specified in the chart below. The measurement method of linear attenuation is described by IEC 60794 standard

N_{bFO} = number of optical fibers in the cable

L average = average length of installed cables in meters

In all cases, the value obtained in Watt shall be multiplied by the reference lifetime of the corresponding application to have the power in Wh or Joule (see Appendix 6.1.).

Generally, choices and hypotheses used for loss calculation shall be identified in the PEP and justified in the LCA report.

Use stage losses determined by standards

The maximum attenuation values at the reference wavelength are 3.5 dB/km (IEC 60793-2-10) for multimode fibers and 0.4dB/km for single-mode fibers.

The table below includes all the data to use for the optical cables from reference standards (cable performance standard IEC 60793, IEC 60794 and Ethernet IEEE standard 802.3).

Table 2 : Data for optical fibers

Optical Fiber Cables					
Protocol	Optical fiber type	Wavelength	Maximum distance	Average length	Power consumption
10GBASE-SR	Multimode	@850nm	< 300m	150 m	Attenuation at $\lambda=850\text{nm}$: 3.5dB/km Injected power=0 dBm leading to 1mW Leading to 0.76 mW/km or 0.76$\mu\text{W}/\text{m}$ of 1FO
1000BASE-SX			500m		
10BASE-FL			2 km		
100BASE-LX	Single mode	@1310nm	2 to 3 km	500 m	Attenuation at $\lambda=1310\text{nm}$: 0.4dB/km Injected power=0 dBm leading to 1mW Leading to 0.09mW/km or 0.09$\mu\text{W}/\text{m}$ of 1FO
1000BASE-LX			2 km		
10GBASE-LR			10km		

3.4.4.3. Control and command Wires and cables

For control and command wire and cable category, the impact of the stage is negligible compared to the impact of the total product life cycle.

The environmental impacts of Joule effect energy losses for control and command wires and cables are negligible compared to other stages impacts (manufacturing, distribution and end of life). Indeed, these cables are using currents with an intensity around a few tens of mA, either because the transported currents are low in intensity (measure cables), or because the voltage and current are applied in a sporadic way (control cables).

Therefore, in the environmental impact table, the “Use” column shall include the reference “Negligible”, indicating that the impact assessment of this stage is negligible by comparison with the other life cycles stages of these products.

3.4.4.4. Power connection accessories

The impact due to energy losses in use stage will depend on the selection regarding:

- The product reference lifetime;
- The product use rate;
- The linear resistance of the conducting part of the connection accessories;
- The intensity of the current going through it.

To ensure the comparability of the PEPs, different hypotheses have been established for these 4 parameters. These hypotheses shall be specified in the PEP and presented in the LCA report.

a. Reference lifetime and use rate

Refer 3.5.4.6.

b. Linear resistance and intensity

For power connection accessories, the environmental impacts of the use stage are considered negligible, with the exception of the power consumption, which is expressed by the Joule losses over the use time.

The power consumption during use stage is then expressed according to the following formula:

$$E = R \times I^2 \times \Delta t \quad \text{with} \quad R = Z \times L \times 10^{-3}$$

Where:

E: power consumption, expressed in J;

R: resistance of the conducting part of the reference product for the power connection accessory, expressed in Ω ;

Z: resistance per unit of length of the conducting part of the reference product for the power connection accessories, taking the maximum value of the resistance per unit of length of the cable in the standard IEC 60228 relating to the class of the cable, the nature of the core and for the smallest cross-section supported by the accessory, in Ω/km ;

L: overall length of the conducting part in the axis of the cable in m;

I : intensity in A;

Δt : time of use in s.

For connection accessories, because of the wide variety of possible uses of these products for a given application and to ensure the comparability of the PEPs, the functional unit is expressed for an intensity of 1A per active conductor.

This rule enables the Joule losses to be expressed in the use stage regardless of the specific scenario to each user of the PEP.

With the same objective, resistance R of the conducting part is calculated for the most unfavorable case to take into account of all possible situations and enable the user to do the calculation.

The exact impact of the use stage shall be determined by the users of the PEP according to the context of use of the product, based on the impact calculated for 1A.

- Where the conducting part forms part of the connection accessory (accessory and conducting part in the packaging unit), R is then given by the manufacturer, considering that the functional unit is given for 1A. Thus, by multiplying by the square of the intensity, the user of the PEP obtains the power consumption over the use time considered.
- Where the conducting part is supplied by the installer (accessory without the conducting part in the packaging unit), the impact of the use stage is given for a resistance R of 1Ω

The actual resistance R shall be taken into account by the installer according to the rules set out above. Thus by multiplying by the square of the intensity and by the actual resistance of the conducting part, the user of the PEP obtains the power consumption over the use time considered.

For multi-conductor cables, and assuming a balanced system, a current of 1A in each conductor shall be considered, except for the protective conductor. The protective conductor is not taken into account when calculating the Joule losses.

3.4.4.5. Optical telecom accessories

The environmental impacts due to energy losses in use stage are calculated from joules effect losses of the optical connections.

a. Reference lifetime and use rate

Refer paragraph 3.5.4.6

b. Use stage losses determined by measurement

For the use stage losses determined by measurement, the following formula shall be used:

$$P_{lost} = P_{input} - P_{output}$$

Conversion mW in dBm :

$$P[\text{mW}] = 10^{(P[\text{dBm}]/10)}$$

Where: P_{lost} = loss of optical signal in Watt

P_{input} = input power in Watt

P_{output} = output power in Watt

In all cases, the value obtained in Watt shall be multiplied by the reference lifetime and use rate of the corresponding application to obtain the energy consumed in Wh or Joule (see Appendix 6.1.).

c. Use stage losses determined by calculation

Depending on the connection technology used, the maximum losses (P_{cx}) specified by the manufacturers are given in the table below.

As in the paragraph 3.5.4.2 of this document, it is considered that the power injected into the connection is 0 dBm or 1 mW and assumed a close connection with the laser (the most unfavorable case).

The calculation of the maximum value of the connection loss is made as follow:

$$P_{\text{connection}} = 1 - 10^{(-P_{\text{cx}} / 10)}$$

Table 3 : Data for optical connections

Technology used	Loss expressed in dB (P_{cx})	Connection loss in mW
<i>Fusion splice</i>	<i>0.1 dB</i>	<i>0.023 mW</i>
<i>Mechanical splicing</i>	<i>0.25 dB</i>	<i>0.056 mW</i>
<i>Connector</i>	<i>0.5 dB</i>	<i>0.109 mW</i>

The energy consumed by **an optical connection** is then obtained by multiplying this value expressed in Watt by the reference lifetime, expressed in seconds, and the use rate.

In the case products in the reference flow support multiple types of connection technologies, the calculation shall be made by taking into account the most unfavorable technology.

For example, for a reference lifetime of 20 years and a 100% use rate, the total energy consumed in use is:

$$0.109 \times 10^{-3} \text{ [W]} \times 20 \text{ [years]} \times 365 \text{ [days]} \times 24 \text{ [hours]} \times 3600 \text{ [seconds]} = \mathbf{68\ 748 \text{ Joules}}$$

For illustration, 68,748 Joules is the energy consumption of a bulb of 70 watts during 16 minutes.

In general, the choices made and the underlying assumptions for the loss calculation shall be identified in the PEP and justified in the LCA report.

3.4.4.6. Reference lifetime and use rate

The reference lifetime and the use rate of wires, cables and accessories were consensually determined by all the technical experts of the profession for the different possible application areas. This hypothetical reference lifetime is always smaller than the product real lifetime.

Any wire or cable or their accessories, according to standards to which it corresponds to, belongs to a single application.

The table given in Appendix 6.1. includes the different fields of application covered for wires, cables and accessories, and specifies the product reference lifetime and use rate leading to the use time to take into account in the calculations.

In the exceptional case an application is not described in the table in the appendix, and to ensure the PEP comparability, a 5-year lifetime with a 100% use rate shall be considered by default.

Moreover, a request to update the Product Specific Rules for “Wires, Cables and Accessories” shall be made to the Technical Committee of the PEP Association for adding an application with a reference lifetime and use rate.

3.4.5. End of life stage

This section supplements the section 2.2.7 “End of life stage” of the “Product Category Rules”, by setting the processes to be considered in the study of the end of life stage.

A breakdown of module C (C1 to C4) can be done according to figure 4 of Appendix B of PCR,

If the breakdown of module is done, the content of each sub-module should be as follows:

C1: Not applicable

C2: Transportation from installation site to waste treatment (grinding & separation) site or final disposal

C3: Waste treatment process (grinding and separation), Recycling of materials (metals)

C4: Disposal (landfill) of other materials

Note: ECOSYSTEM public LCI datasets are not relevant for cables, wires and accessories as they are a part of other products or equipments. They are end of life datasets in which the percentage of product recycled, incinerated and landfilled is not known. They are not coherent with this PSR where end of life scenario (recycling, incinerated or landfilled) for each material is defined.

3.4.5.1. Energy wires and cables

To ensure PEP comparability, end of life steps to be taken into account are:

- Transportation from installation site to waste treatment (grinding & separation) or final disposal site, assuming a local transport as described in the “Product Category Rules”,
- A stage of grinding / separation of metals and plastics,
- Refer annex D of PCR for end-of-life treatment of different materials
- Landfilling of other materials that are not provided in annex D of PCR.

As for the installation stage, considering the wide range of possible removal processes of these products, the removal processes and/or dismantling of cables are excluded from the PEP perimeter. The impact of removal shall be carried out by the PEP user, considering the product use features.

3.4.5.2. Communication and data wires and cables

Refer paragraph 3.5.5.1

3.4.5.3. Control and command Wires and cables

Refer paragraph 3.5.5.1

3.4.5.4. Power connection accessories

To ensure PEP comparability, end of life steps to be taken into account are:

- The separation between the accessory and the connected cable,
- Transportation, assuming a local transport as described in the “Product Category Rules”,
- Refer annex D of PCR for end-of-life treatment of different materials
- Landfilling of other materials that are not provided in annex D of PCR.

The processes of removal and/or dismantling of accessories are excluded from the system PEP perimeter. The impact of removal shall be carried out by the PEP user, considering the product use features.

3.4.5.5. Optical telecom accessories

Refer paragraph 3.5.5.4

3.4.6. Benefits and impacts outside system boundaries (module D) – optional

As mentioned in paragraph 2.2.8 of the “Product Category Rules”, the net benefits and impacts beyond the system boundaries also referred as "module D" may also be included in the PEP.

3.5. Rule(s) for extrapolation to a homogeneous environmental family

The rules set out in the “Rule(s) for extrapolation to a homogenous environmental family” paragraph of the applicable PCR (PEP-PCR-ed4-EN-2021-09 06) shall apply. No default extrapolation rule has been defined in the context of the development of this PSR.

3.6. Rule(s) applying to joint environmental declarations

The rules set out in the “Rules for drafting collective environmental declarations” paragraph of the applicable PCR (PEP-PCR-ed4-EN- 2021 09 06) shall apply.

3.7. Environmental data requirements

The rules set out in the “Environmental data requirements” paragraph of the applicable PCR (PEP-PCR-ed4-EN- 2021 09 06) shall apply.

3.8. Environmental impact calculation

The rules set out in the “Environmental impact calculation” section of the applicable PCR (PEP-PCR-ed4-EN- 2021 09 06) shall apply.

3.9. Information on carbon offset, carbon storage and delayed emissions

Carbon offset processes are not part of the product system under study. Carbon offset shall not be included in the calculation of the “Climate change” indicator.

NOTE A carbon offset is a reduction in emissions of carbon dioxide or other greenhouse gases made to compensate for an emission elsewhere.

The effect of temporary carbon storage and delayed emissions, i.e. the discounting of emissions and removals as in dynamic LCA, shall not be included in the calculation of the GWP. The effect of permanent biogenic carbon storage shall not be included in the calculation of the “Climate change” indicator. All biogenic carbon entering system must exit at the end of life.

4. Drawing up the Product Environmental Profile

The rules set out in the “Drawing up the Product Environmental Profile” section of the applicable PCR (PEP-PCR-ed4-EN- 2021 09 06) shall apply.

5. PEP update rules

The rules set out in the “PEP update rules” section of the applicable PCR (PEP-PCR-ed4-EN- 2021 09 06) shall apply.

6. Appendices

6.1. Hypothesis per application area

APPLICATION AREAS	Applications	Lifetime (years)	Use rate	Used time (years)
INFRASTRUCTURES	Energy distribution networks	40	100%	40
	Railway networks	30	100%	30
	Telecom networks (fixed and mobile phones)	20	100%	20
INDUSTRIAL APPLICATIONS	Oil, gas and petrochemicals	30	100%	30
	Handling	10	50%	5
	Automation	5	100%	5
	Nuclear	40	100%	40
	Wind turbines	20	30%	6
	Photovoltaic power plants	10	50%	5
	Airports	20	100%	20
ONBOARD SYSTEMS	Civil aeronautics	15	80%	12
	Shipbuilding and marine	30	80%	24
	Rolling stock	30	50%	15
	Automotives (Cars and trucks)	10	10%	1
BUILDING	Residential/tertiary/industrial except LAN	30	70%	21
	Data centers	10	100%	10
	LAN : residential	10	17%	1.7
	LAN: tertiary	10	25%	2.5
	LAN: industrial (factories, warehouses)	10	100%	10

6.2. Glossary

OTO: Optical Terminal Outlet

ENTI: External Network Testing Interface

MDU: Multi-Dwelling Unit

MMDB: Multi-operator MDU Distribution Box

OLT: Optical Line Termination

FDU: Fiber Distribution Unit

BP: Branching Point

LAN: Local Area Network

IP: Internet Protocol

6.3. Declaration of conformity



Programme PEP Ecopassport*

Attestation de revue critique des règles additionnelles sectorielles pour les fils, câbles et matériels de raccordement

Document revu : PSR0001 – Fils, câbles et matériels de raccordement, version du 10/06/2022

Etabli par : SYCABEL / NEXANS

SYCABEL a demandé à EVEA, en tant que cabinet conseil spécialisé en Analyse du Cycle de Vie, la revue critique des règles additionnelles sectorielles pour les fils, câbles et matériels de raccordement.

Référentiels :

L'objectif de cette revue critique est de vérifier la conformité de ce document avec les référentiels suivants :

- Le PCR référence PCR-ed4-FR-2021 09 06, disponible sur www.pep-ecopassport.org établi par le programme PEP Ecopassport*.
- Les normes NF EN ISO 14020 - 2002 et NF EN ISO 14025 - 2010.
- Les normes NF EN ISO 14040 et 14044 – 2006.

Conclusion :

L'inclusion des câbles hybrides a été enlevé à cause d'un manque de méthodologie claire sur la façon d'appliquer les règles pour ces produits. La plupart des modifications concernent l'application des nouvelles règles de fin de vie, pour lesquelles les règles du PCR ed4 ont été retenue.

Le document revu ne présente pas de non-conformité avec les référentiels précités. Par conséquent le PSR relatif aux fils, câbles et matériels de raccordement est conforme aux exigences de ces référentiels.

Tim Osmond

Vérificateur PEP Ecopassport* - EVEA