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Environmental Engineering (EE);
Example of a Life Cycle Assessment (LCA)
of a mobile phone

Reference
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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Environmental Engineering (EE).

Modal verbs terminology

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

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Executive summary

The objective of the present document is to show how a Life Cycle Assessment (LCA) of an ICT good, a mobile phone, is performed by an ICT manufacturer, based on ETSI ES 203 199 [i.1].

For compliance with ETSI ES 203 199 [i.1] all body text and annexes need to be considered when performing an LCA, i.e. this example is fully compliant with ETSI ES 203 199 [i.1] as described in clause 4.2 except for a few deviations listed in the 'Reporting' clause 4.12.

Introduction

The present document has been developed to demonstrate the application of ETSI ES 203 199 [i.1] for the environmental assessment of the life cycle impact of a mobile phone.

ETSI ES 203 199 [i.1] defines a set of requirements to reflect the quality that practitioners should strive for. To foster results of LCAs becoming more transparent and, for the quality of data and LCA tools to improve over time, the present document is applying the requirements outlined in ETSI ES 203 199 [i.1] in the following pages. ETSI ES 203 199 [i.1] requires that deviation(s) from the requirements are clearly motivated and reported. For further details regarding compliance refer to clause 5.2 in ETSI ES 203 199 [i.1].

The present document is intended for LCA practitioners wanting to assess mobile phones environmental impacts and it will help them to perform and report their LCAs of mobile phones in a uniform and transparent manner.

The following uses of mobile phone LCA applications are the most frequently used ones, but others may be identified and used as well:

- Evaluation of product system environmental impact, such as climate change.
- Assessment of primary energy consumption.
- Identification of life cycle stages and activities with high significance.
- Comparisons of specific mobile phones under the conditions described in clause 5.3 in ETSI ES 203 199 [i.1].
- Comparative analysis between an ICT product system featuring mobile phones and reference product system.

The present document was developed jointly by ETSI TC EE and ITU-T Study Group 5. It will be published respectively by ITU and ETSI as ITU-T L.Supp60 [i.7] and ETSI TR 104 080 (the present document), which are technically-equivalent.

1 Scope

The present document aims to present an example of an objective and transparent Life Cycle Assessment (LCA) of a mobile phone.

The present document will provide an example of an LCA of a mobile phone fully compliant with ETSI ES 203 199 [i.1]. The present document will be technically aligned with ITU-T L.Suppl.60.

The present document can be read by anyone aiming for a better understanding of LCA of mobile phones. However, the present document is especially intended for LCA practitioners with a prior knowledge of ETSI ES 203 199 [i.1].

The purpose of the present document is to:

- provide an example of an LCA of a mobile phone, aligned with the requirements of ETSI ES 203 199 [i.1] to ensure a sufficient quality of LCA studies of mobile phones;
- harmonize the LCAs of mobile phones;
- increase the credibility of LCAs of mobile phones;
- increase the transparency and facilitate the interpretation of LCA studies of mobile phones;
- facilitate the communication of LCA studies of mobile phones.

Recognizing ETSI ES 203 199 [i.1] as reference, the present document will apply it for the LCA of a mobile phone. The present document is valid for all types of mobile phones.

While ETSI ES 203 199 [i.1] defines a set of requirements which reflect the quality that practitioners should strive for, the present document does not contain any requirements.

Comparisons of results from environmental assessments of mobile phones which have been performed by different organizations and with different tools, are beyond the scope of ETSI ES 203 199 [i.1], as such comparisons would require that the assumptions and context of each study are exactly equivalent.

2 References

2.1 Normative references

Normative references are not applicable in the present document.

2.2 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, ETSI 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] ETSI ES 203 199 (V1.4.1): "Environmental Engineering (EE); Methodology for environmental Life Cycle Assessment (LCA) of Information and Communication Technology (ICT) goods, networks and services".

[i.2] Recommendation ITU-T L.1015 (01/2019): "Criteria for evaluation of the environmental impact of mobile phones".

[i.3] ETSI TR 103 679 (V1.1.1): "Environmental Engineering (EE); Explore the challenges of developing product group-specific Product Environmental Footprint Category Rules (PEFCRs) for smartphones".

[i.4] Galen, J. V. (2023): "The environmental impact of reusing iPhones: a case study looking into the environmental benefits of reusing iPhones through Twig" (Master's thesis) (Accessed 28 May 2024).

[i.5] ISO 14040:2006: "Environmental management -- Life cycle assessment -- Principles and framework".

[i.6] ISO 14044:2006: "Environmental management -- Life cycle assessment -- Requirements and guidelines".

[i.7] ITU-T L.Supp60: "Example of a Life Cycle Assessment (LCA) of a mobile phone".

3 Definition of terms, symbols and abbreviations

3.1 Terms

For the purposes of the present document, the terms given in ETSI ES 203 199 [i.1] apply.

3.2 Symbols

Void.

3.3 Abbreviations

For the purposes of the present document, the abbreviations given in ETSI ES 203 199 [i.1] apply.

4 Example of an LCA of a mobile phone fully compliant with ETSI ES 203 199

4.1 Introduction

The purpose of the present document is to show how an LCA of a mobile phone is performed by an ICT manufacturer based on ETSI ES 203 199 [i.1].

NOTE: The data presented in this example are not real data but rather examples.

For compliance with [i.1] all body text and annexes need to be considered when performing an LCA, i.e. this example as such is fully compliant with [i.1] as described in clause 5.2 in ETSI ES 203 199 [i.1] except for a few deviations listed in the Reporting clause below.

4.2 Goal definition

The goal of this example LCA study is to clarify and understand the environmental impact of a mobile phone, during all stages of the lifecycle, with respect to the mid-point impact categories Climate Change (CC) and Resource Use, Mineral, Resources (RDMR).

NOTE 1: The Environmental Footprint (EF) Life Cycle impact Assessment method consists of 14 further impact categories (such as Ozone Depletion and Respiratory Inorganics) beyond CC and RDMR which are not considered for the present example. It is encouraged to analyse the results for each impact category to further explore the environmental impacts.

The purpose of the LCA study is for internal use in order to develop the product and processes to be more environmentally sound. Based on previous experience [i.3], data availability and a screening, it is judged that beyond the mandatory CC, RDMR is enough to exemplify the application of [i.1].

NOTE 2: Many more impact categories exist and a two are selected for this example just to highlight that it is important to assess different categories to avoid burden shifting. The purposes of performing an LCA may vary e.g. from internal use cases to understanding the potential impact and identifying of opportunities to improve environmental performance of a good to external use cases to gain information about typical environmental performance of a good to assist in policy choices.

4.3 Scope definition

The studied product system is one mobile phone for Business-to-Consumer (B2C) with typical functionality such as voice, SMS and internet browsing. Except the operating system software program, it physically consists of general building blocks such as: display, battery, mechanics, electromechanics and electronic components. These building blocks can in turn be categorized according to Parts defined in Table E.1 in ETSI ES 203 199 [i.1]. Table E.1 also includes Software as a Part. In this case of an entry-level mobile phone the main software component is the general operating system which according to clause 6.1.3 in ETSI ES 203 199 [i.1] can be considered optional due to allocation difficulties. Moreover, applications that users may install themselves are excluded as the preferences and choices of users vary remarkably.

In the studied product system, the sales package is out of the scope such as sales package materials, user guide and accessories such as the charger, cable and headset.

NOTE 1: The limited scope for the present example is allowed in [i.1] however the sales package materials are commonly included in mobile phone LCAs. Including or excluding e.g. packaging materials and chargers could have significant effect for several impact categories.

NOTE 2: Depending on the goal and scope of the study sales package may or may not be included and the package content may vary.

The **operating lifetime** is estimated to be 4 years by the first owner based on the studied type of mobile phone and on consumer surveys. No extended operating lifetime or other lifetimes are considered.

NOTE 3: 4 years operating lifetime is considered longer than the average. However, it is nevertheless chosen as some consumers fit the profile [i.4]. Shorter and longer lifetime are tested in the sensitivity analysis.

The **functions** of a mobile phone are many such as calling, web browsing, creating mobile hotspot, watching videos on the internet, enable video meeting, setting alarm, setting of timer, keeping time, navigation.

The **applicable functional unit** is "*3G/4G/5G access for 1 hour daily calling and enable use of a 1080×2340 pixels video player for 2 hours web browsing and 4 hours video watching daily for 4 years*".

This use case is just one specific scenario. The use pattern and therefore energy consumption of the device may vary a great deal, for example depending on which features are used and for how much time and on whether the charger is left plugged into the power socket. Other scenario-based sensitivity analyses may be conducted. The assessment scope is also focused on direct operations and therefore infrastructure capacity buildings (like factories, roads, vehicles and telecommunications) are excluded. Also, capital goods, like production machinery are excluded. Human resources, corporate overhead and travels are also excluded.

ICT Manufacturers facility data are included (energy, materials, waste, etc.).

NOTE 4: Manufactures have the possibility to use primary data and other practitioners can use external sources e.g. manufacturer external reports and LCI databases.

The assessed mobile phone is a globally sold and used product. As the geographical and temporal coordinates vary dynamically for the Raw Material Acquisition and Production of most mobile phones the presented results for Raw Material Acquisition and Production will therefore represent a global snapshot for the mobile phone.

4.4 System boundaries

Table 2 in ETSI ES 203 199 [i.1] specifies the mandatory, recommended and optional life cycle stages/unit processes for ICT goods. Listed below are the life cycle stages included in this LCA example for a mobile phone:

- A1 Raw material extraction.
- A2 Raw material processing.
- B1.1 Parts production.
- B1.2 Assembly.
- C1 ICT goods use.
- D2.1 Storage/Disassembly/Dismantling/ Shredding.
- D2.2 Recycling.
- D3 Other EoLT.

The recommended B1.3 is left out due to allocation problems and B3 (ICT specific site construction), is not applicable to the studied product system of one mobile phone.

Moreover, C2, C3 and C4 are not applicable to the studied product system.

In EoLT D2.1, D2.2. and D3 processes are included. D1 is not applicable to the studied product system.

Support activities are intentionally excluded for any unit processes.

Underlined Processes in Figure 1 are included in the studied product system.

Processes below in italic style are not included as they are optional or not part of the studied product system scope.

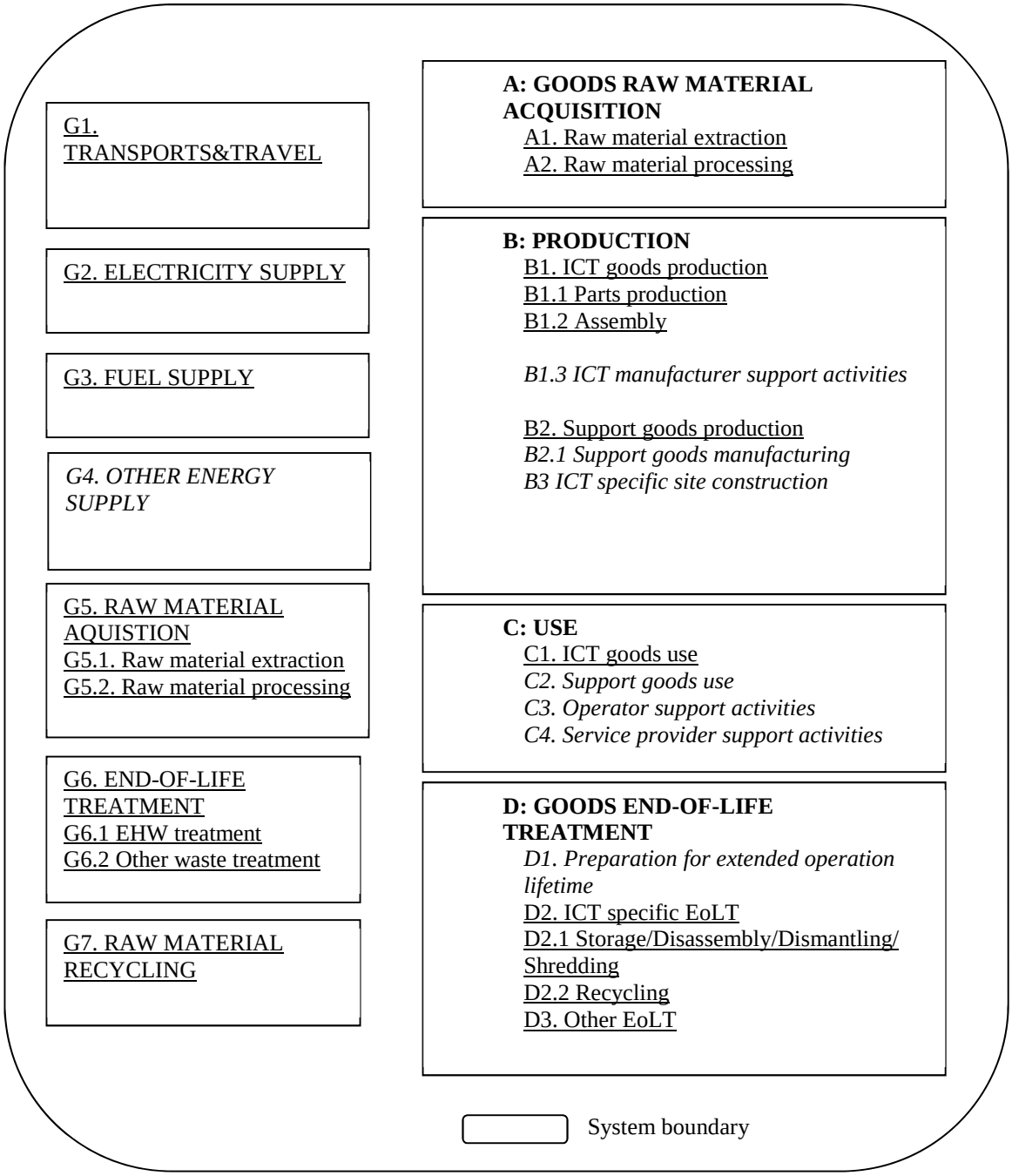


Figure 1: The system boundary of the product system for LCA of the mobile phone

4.5 Data collection

4.5.1 Goods Raw material acquisition (A)

Selected external databases are used for Raw Material Extraction (A1) and Raw Material Processing (A2) data.

ICT manufacturer Bill Of Materials (BOM) and primary material data are used to identify the Parts and Raw material contents of the mobile phone.

NOTE: There are also other ways of collecting material content and BOM data, e.g. teardown reports, manufacturers, external data sources. Data quality evaluation is always important and the chosen approach needs to be motivated.

4.5.2 Production (B)

Primary data (transportation mode, distance and masses) are collected for transports of Raw Materials (G5) and Parts (B1.1.1-10) to Final Product and from own production (Assembly, B1.2) operations. Primary data for consumption of Electricity, Fuel and Raw Materials in B1.2 are also collected. Part Production (B1.1.1-10) and Raw Materials Acquisition LCI data (G5) are collected from external databases and case by case, from suppliers based on BOMs and material content.

4.5.3 Use (C)

Energy consumption during mobile phone use stage in the described specific scenario is estimated based on the third alternative in clause 6.3.1.2.1 of ETSI ES 203 199 [i.1] (with certain user profile / product category) including typical use of all functionalities of multifunctional ICT goods. Phone charging energy efficiency is based on the ICT manufacturer's own charger relevant for the study. It is assumed that the charger is not unplugged and therefore no-load consumption has been considered (worst case scenario). Battery capacity is based on relevant battery for the study. World average energy mixes are used as the product is intended for global market.

4.5.4 Goods End of Life Treatment (D)

For EoLT data are based on average data from literature (e.g. regarding amount of electricity used per piece or mass of mobile phone for Storage/Disassembly/Dismantling/Shredding (D2.1) and Recycling (D2.2.1, D2.2.2, D2.2.4 and D2.2.5).

4.5.5 Generic processes (G1-G7)

For transports (G1) distances, transportation modes and own facilities consumption of electricity (G2), Fuels (G3), Raw Materials (G5) and Raw Material Recycling (G7) primary data are used. Relevant local and global energy mixes are collected from LCI databases.

4.5.6 Other information

For Raw Material Acquisition the LCI databases used are not transparently reporting data on transports (G1), thus impact from these transports between Raw Material Extraction (A1) and Raw Material Processing (A2) cannot be reported separately.

Furthermore, the amount and type of Transport of Raw Materials to Part Production are not transparent.

4.6 Data calculation

4.6.1 B1.1.1 Battery

Below follows some examples of data calculations.

The mass of the battery used in the mobile phone is measured. An LCI module for Lithium ion batteries expressing the impacts per mass is applied according to Figure B.1 in ETSI ES 203 199 [i.1].

NOTE: Depending on the LCI data available also other possibilities exist that are based on battery capacity and energy content.

4.6.2 B1.1.2 Cables

There are no cables in the studied product system.

4.6.3 B1.1.3 Electro-mechanics

The mass of electromechanics such as connectors, acoustic components (e.g. speaker, microphone) and antenna are identified and appropriate LCI datasets expressed per masses are applied.

4.6.4 B1.1.4 Integrated circuits, ICs

The mass and type (logic or memory) of each IC inside the mobile phone is identified, as well as used amount (pieces) of each IC.

The die area for each IC is identified where possible.

Where data for die areas are available the following approach is used for each such IC:

$$H \times I \times J + K \times L$$

Where:

- H = Die area of IC [cm^2]
- I = Environmental loadings/(cm^2×masklayer)
- J = 1/front-end yield × masklayers for technology node (Scope 1,2,3 front-end)
- K = Mass IC [kg]
- L = 1/back-end yield × environmental loading/kg IC (Scope 1,2,3 back-end)

To reduce the variance, Logic type ICs and Memory type ICs use different values for masklayers and for environmental loading/kg IC.

Where data for die areas are not available the following approach is used for each such IC:

$$M \times N$$

Where:

- M = Mass of IC [kg]
- N = environmental loadings/kg IC (Scope 1,2,3 front-end and back-end, considering front-end and back-end yields)

The individual footprints for all analysed ICs - times their respective used amounts (pieces) in the mobile phone - is the total result for ICs.

The masses of transistors and diodes are identified. LCI data set expressed per mass transistor and diode are applied.

NOTE: There are several other ways to find out the environmental loadings for ICs such as described in clause 5.2.1.1 of ETSI TR 103 679 [i.3].

4.6.5 B1.1.5 Mechanics/Materials

The mass of mechanical components and different materials are identified based on BOM and material data. Then appropriate LCI datasets are applied for materials and related manufacturing technologies.

4.6.6 B1.1.6 Display

The active area of the display is determined. Then an area based CO_2e model and a mass based LCI model for display unit are used. This approach is used to the derive other environmental loadings than those contributing to CC whenever such environmental loadings are not available per active area but instead available per mass.

The following approach is used:

- Mass (g) of display LCI module which corresponds to the active area in mobile phone:

$$Active\ area\ of\ display\ in\ mobile\ phone, cm2 \times \left(\frac{\frac{gCO2e}{cm2}}{\frac{gCO2e}{g\ display\ LCI\ module}} \right)$$

NOTE: There are several other ways to find out the environmental loadings for display units.

4.6.7 B1.1.7 PCBs

The areas and number of layers for each type of PCB (both rigid and flexible pieces) are identified as well as amounts (pieces) used for the mobile phone. An LCI data set expressing the environmental loadings per area layer is used for each PCB.

The individual footprints for all analysed PCBs - times their respective used amounts in the mobile phone - is the total result for PCBs.

NOTE: There are several other ways to find out the environmental loadings for PCBs such as described in clause 5.2.2 of ETSI TR 103 679 [i.3].

4.6.8 B1.1.8 Other PCBA components

The masses of other PCBA components, electronic components such as resistors, capacitors, inductors and LEDs are identified. LCI data sets expressed per mass of other PCBA components are applied.

4.6.9 B1.1.9 Packaging materials

There are no Packaging materials in the studied product system.

NOTE: Including the packaging materials may influence several impact categories. The present example chose not to include the packaging as the principles of aligning with ETSI ES 203 199 [i.1] are shown anyway.

4.6.10 B1.1.10 Black box modules

ICs identified in the black box modules - including cameras - are modelled as in B1.1.4 Integrated circuits, ICs.

4.6.11 B1.1.11 Software module

The main software component in this case is the operating system which according to clause 6.1.3 of ETSI ES 203 199 [i.1] can be considered optional due to allocation difficulties. Software module has, therefore not been included. Also other applications that users are able to install are excluded.

4.6.12 B1.2 PCBA Module Assembly

Data are gathered for the energy and materials used for final assembly, testing and package the mobile phone and the assembly process is modelled accordingly.

4.6.13 C1. ICT goods Use

The below approach [i.2] is used to estimate the electricity consumption during use stage for the mobile phone:

$$USE = A \times B \times C \times D \times 1/E \times F/G$$

Where:

- *USE* = Lifetime electricity use of a mobile phone [Wh]
- *A* = Battery capacity [Ah]
- *B* = Voltage [V]
- *C* = Lifetime of mobile phone [years]
- *D* = 365 [days per year]
- *E* = energy efficiency of the power adapter [%]
- *F* = 24 [h per day]
- *G* = time between having to fully charge the battery if doing 1 hour calls, 2 hours web browsing and 4 hour video playing [h]

NOTE: The scenario and the calculation model in the present example are highly specific and numerous other calculation models are possible for estimating the use stage electricity consumption of mobile phones.

4.7 Allocation of data

4.7.1 Goods raw material acquisition (A)

The allocations performed for the database data used are not transparently reported by the database. The 50/50 allocation method is used to allocate the environmental impacts between the Raw Material Acquisition and Raw Material Recycling.

4.7.2 Production (B)

Own assembly facility data (energy consumption, materials used (e.g. solder), waste produced) is allocated by dividing with relevant unit volume.

4.7.3 Use

There is no need for allocations within the use stage in the present document.

4.7.4 Goods End of Life Treatment

100 % of the mobile phones are assumed to go for global average ICT specific EoLT and WEEE Recycling.

The Circular Footprint Formulae (CFF) are used to calculate the EoLT loadings per f.u.

NOTE: To use CFF as shown in Annex R in ETSI ES 203 199 [i.1] is not mandatory and other calculations methods can flexibly be used to address allocation and material use impact calculations.

4.7.5 Generic processes (G1-G7)

See Raw Material Acquisition and Production.

4.7.6 Support activities

No support activities have been intentionally included.

4.8 Cut-off

The cut-off criterion is set as a 5 % addition to the first iteration LCA result for CC and RDMR. That is, if the excluded activities/processes do not increase the total respective CC and RDMR results with more than 5 %, the cut-off criterion is justified.

Based on these criteria several cut-offs are done from the studied product system:

- Some transports in Raw Material Acquisition.
- Some transports in Part Production.
- Electricity, Fuel and Raw Material consumptions within EoLT.
- Other EoLT activities (D3).

Additionally, B1.1.11 is excluded from the studied product system as the software is an operating system and is optional according to clause 6.1.3 in ETSI ES 203 199 [i.1].

4.9 Data quality

4.9.1 Methodological appropriateness and consistency

The applied LCI methods and methodological choices are in line with the goal and scope of the data. The methods have been applied consistently across all data.

4.9.2 Completeness (total LCA level)

90 % of applicable LCI flows in Table G.1 in ETSI ES 203 199 [i.1] are included in the LCI. The degree of coverage of the CC LCIA indicator in Table L.10 of ETSI ES 203 199 [i.1] is 98 % based on mass. The degree of coverage of the RDMR LCIA indicator in Table L.10 of ETSI ES 203 199 [i.1] is 98 % based on mass.

4.9.3 Uncertainty

For CC and RDMR the variability of the data elements used in the LCA is low enough to separate the Use stage from Raw Material Acquisition + Production + EoLT stages when the mobile phone is used 4 years worldwide.

4.9.4 Data representativeness

None of the data used have unknown representativeness, however, most of the data for the Raw Material Acquisition and Part Production stages can be characterized as "Representative data from a smaller number of sites and shorter periods, or "incomplete data from an adequate number of sites and periods" [i.2].

4.9.5 Data age (timeliness)

No data have an unknown age.

4.9.6 Acquisition method

Some of the data used are directly measured such as the number of Parts. Si die areas are estimated based on functionality of ICs. None of the data used are "nonqualified estimations".

4.9.7 Supplier independence

Most of the data used are "Independent source but based on unverified Information". "Verified data from independent source" to "Unverified information from industry" are used".

4.9.8 Geographical correlation

"Average data from a larger area" are used for Raw Material Acquisition and Production and Transports and EoLT. "Data from an area with similar production conditions" is used for electricity used in the Use stage. World average electricity is considered optimal for Raw Material Acquisition and Production.

4.9.9 Technological correlation

"Data from process studied of the exact company" is used for Assembly and amount of Use stage electricity. "Data from process studied of company with similar technology" is used for Parts production.

4.9.10 Cut-off rules (rules of inclusion/exclusion)

The cut-off criteria are homogeneously and transparently applied.

The average grades for the mobile phone LCA for each data quality indicator are shown in Table 1.

Table 1: Data quality indicators used in this mobile phone case study

Indicator score	1	2	3	4	5
Indicator					
Methodological appropriateness and consistency (MC)	Very good	Good	Fair	Poor	Very poor
Completeness (total LCA analysis level) (C)	Very good	Good	Fair	Poor	Very poor
Uncertainty (U)	Very good	Good	Fair	Poor	Very poor
Acquisition method (AM)	Directly measured data	Calculated data based on measurements	Calculated data based on assumptions	Qualified estimation (by experts)	Nonqualified estimation
Supplier independence (SI)	Verified data from independent source	Verified data from enterprise with interest in the study	Independent source but based on unverified information	Unverified information from industry	Unverified information from enterprise interested in the study
Data representativeness (DR)	Representative data from a sufficient sample of sites over an adequate period to even out normal fluctuations	Representative data from a smaller number of sites but for adequate periods	Representative data from an adequate number of sites but for shorter periods	Representative data from a smaller number of sites and shorter periods, or incomplete data from an adequate number of sites and periods	Representativeness unknown or incomplete data from a smaller number of sites and/or from shorter periods
Data age (T)	< 3 years	< 6 years	< 10 years	< 15 years	Age unknown
Geographical correlation (GC)	Data from the exact area	Average data from a larger area	Data from an area with similar production conditions	Data from an area with slightly similar production conditions	Unknown area
Technological correlation (TC)	Data from process studied of the exact company	Data from process studied of company with similar technology	Data from process studied of company with different technology	Data from process related to company with similar technology	Data from process related to company with different technology
Rule of inclusion/exclusion (Elements/Flows/ Process) (RIE)	Transparent, justified, homogeneous application	Transparent, justified, Nonhomogeneous application	Transparent, non-justified, Nonhomogeneous application	Not transparent on exclusion but specification of inclusion	Unknown

Table 2 shows the application of the above data quality indicators.

Table 2: Application of data quality indicators per life cycle stage for the mobile phone

Life Cycle Stage	MC score	C score	U score	AM score	SI score	DR score	T score	GC score	TC score	RIE score
A1-A2	2	2	3	2	4	3	3	3	4	1
B1.1	2	2	4	3	3	3	3	2	2	2
B1.2	2	1	3	2	1	1	1	1	1	2
C1	1	1	1	2	1	1	1	2	2	1
Average	**1,75**	**1,5**	**2,75**	**2,25**	**2,25**	**2**	**2**	**2**	**2,25**	**1,25**
Total Data Quality Rating										**(1,75 + 1,5 + 2,75 + 2,25 + 2,25 + 2 + 2 + 2 + 2,25 + 1,25 + 2,75 (weakest quality obtained) × 4) / (10 + 4) = 2,21.** **> 2,0 to ≤ 3,0 is "good quality"**
NOTE: The data quality of an LCA can be evaluated by several procedures. E.g. the analysis could be done in more detail for each main unit process and with different scoring levels.										

4.10 LCIA

The following impact categories are included: CC and RDMR.

The impact assessment method applied is: EF Method 3.0.

NOTE: EF Method 3.0 consists of 16 mid-point impact categories.

The Cumulative Energy Demand method or similar can be used as representative of Primary energy consumption.

4.11 Life cycle interpretation

4.11.1 Conclusions

4.11.1.1 CC

The results indicate that in the entire life cycle (cradle-to-grave) for CC and primary energy consumption, the Production (B) is the biggest contributor. Transport from Assembly Location to Use Location of the mobile phone is included in the Production stage contribution according to clause 6.2.3.3.3 in ETSI ES 203 199 [i.1]. B1.2 assembly accounts for less than 5 % of the total impact for CC. The Use stage contributes to around 10 % of the total CC and the percentage is dependent on the usage scenario and charger used.

4.11.1.2 RDMR

The results indicate that in the entire life cycle (cradle-to-grave) for RDMR, the Raw Material Acquisition (A) is the biggest contributor. Transport from Assembly Location to Use Location of the mobile phone is included in the Production stage contribution according to clause 6.2.3.3.3 in ETSI ES 203 199 [i.1]. B1.2 assembly accounts for less than 5 % of the total impact for RDMR. The Use stage contributes to around 0,5 % of the total RDMR.

4.11.2 Uncertainty

The uncertainty range for the Use stage CC result is around ±50 % whereas the uncertainty range for Raw Material Acquisition and Production stages together is some ±20 %.

The uncertainty range for the Use stage RDMR result is around ±50% whereas the uncertainty range for Raw Material Acquisition and Production stages together is around ±10 %.

Overall the uncertainty ranges are around ±16 % and ±10 % and for CC and RDMR, respectively.

By contribution analysis, the most contributing elementary LCI flows and unit processes are identified for CC and RDMR. Subsequently, the models applied and the data used are assessed with respect to precision.

Moreover, candidates for sensitivity analysis are identified, e.g.:

- Die area within ICs.
- Transport distance by Air from Assembly Location to Use Location.
- Other transports than Air for the above distance.
- Lifetime.
- Recyclability rate.

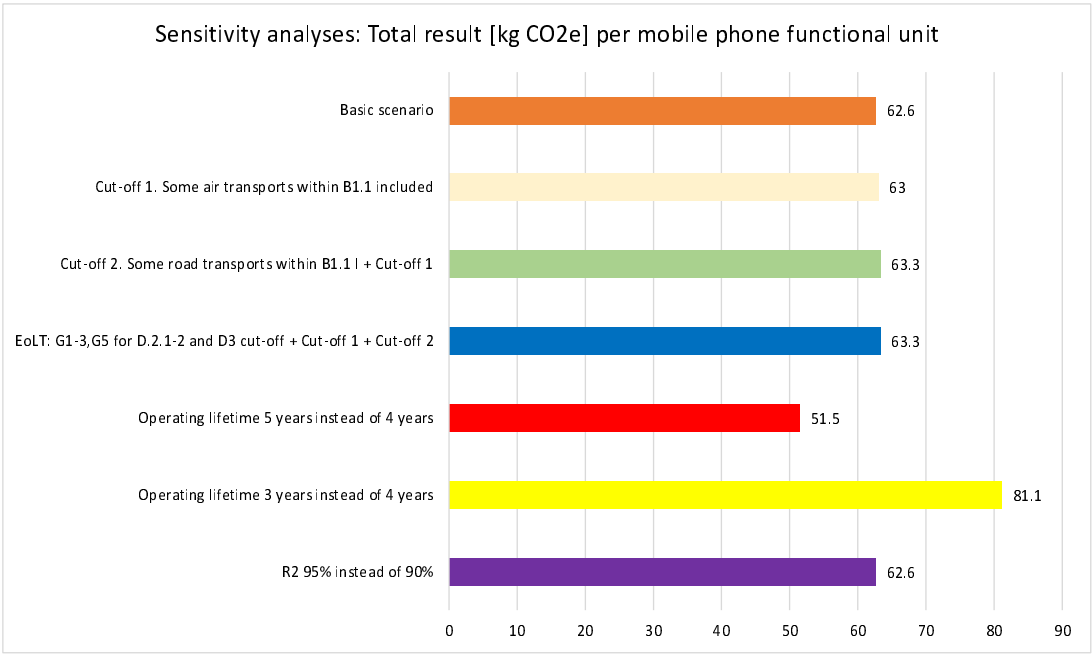
Moreover, the sensitivity of the cut-off parameters:

- some transports in Raw Material Acquisition;
- some transports in Part Production;
- electricity, Fuel and Raw Material consumptions within EoLT (D2.1 and D2.2);
- other EoLT activities (D3);

are tested by inserting a range of approximations from literature and previous studies including Electricity, Fuel and Raw Material consumptions and Road transport distances.

These sensitivity analyses for the cut-off reveal that the conclusions are stable and the basic scenario absolute values for CC and RDMR increase by less than 5 %. The operating lifetime results vary more than 5 % compared to the baseline but are not part of the cut-off section of the sensitivity analysis.

Figure 2 shows the sensitivity analysis for CC, as well as the basic scenario as defined in Table 1.

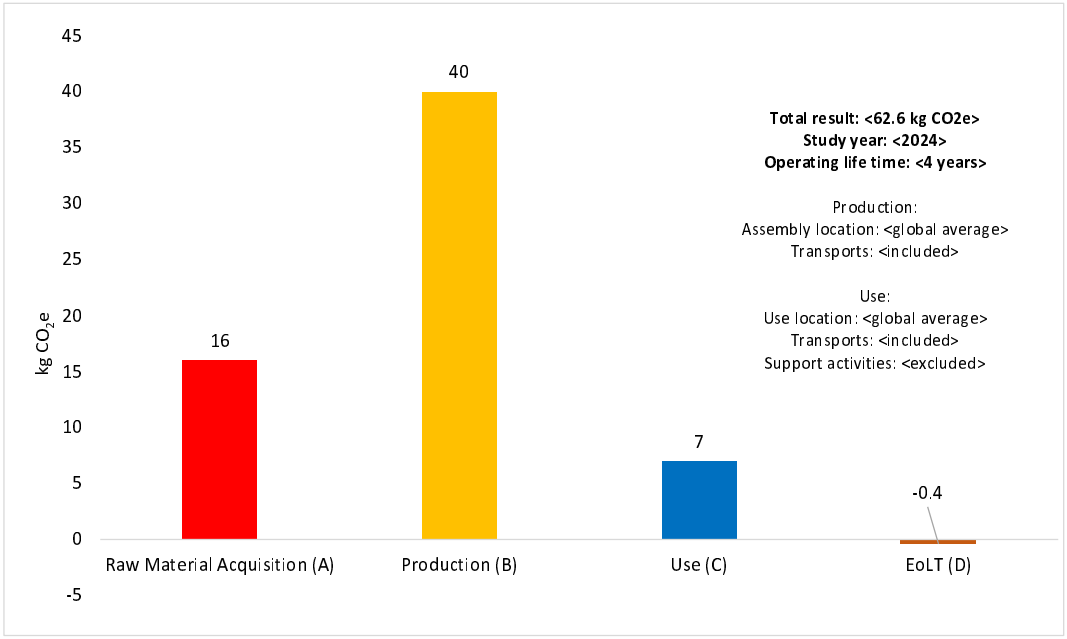


NOTE: For operating lifetime 5 years, 51.5 is derived as embodied footprint divided by 5, times 4 plus 4 years use impact. For operating lifetime 3 years, 81.1 is derived as embodied footprint divided by 3, times 4 plus 4 years use impact.

Figure 2: Sensitivity analysis for CC for mobile phone

4.12 Reporting

All omissions and deviations towards [i.1] are transparently reported. As the aim is to assess the mobile phone as such, the selected reporting is based on the lifetime. Per year calculations can be made if needed. Furthermore, the reporting formats of ETSI ES 203 199 [i.1] are used in the final report. Figure 3 shows the GWP100 diagram.



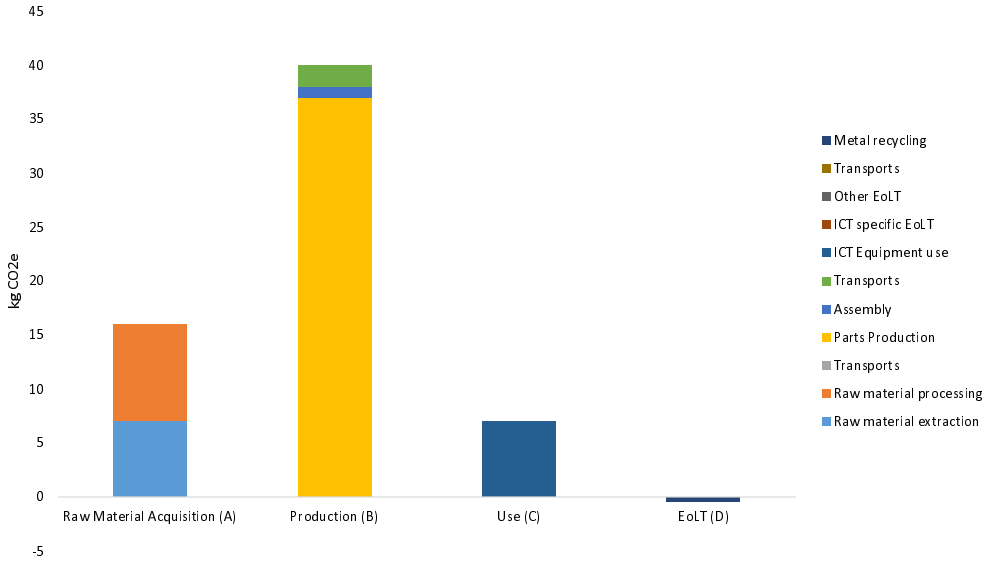
NOTE: This LCA result cannot be compared to the result of another LCA unless all assumptions and modelling choices are equal.

Figure 3: GWP100 result diagram example for mobile phone for Mandatory activities/processes (diagram for Global Warming Potential (GWP100) (CO_2e))

Within Production, the transports are responsible for around 2 kg CO_2e.

NOTE: Occasionally due to LCA tool/LCI database limitations the Raw Material Acquisition, Production (including Transport from Assembly Location to Use Location) has to be reported together.

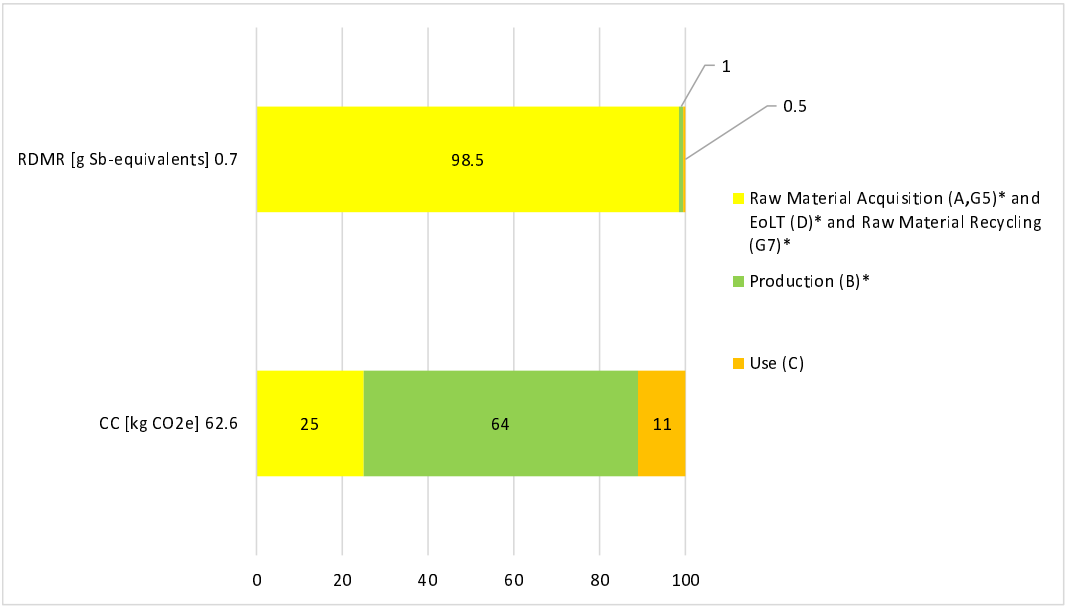
Figure 4 shows the GWP100 diagram for the repartition between sub-unit processes.



NOTE: This LCA result cannot be compared to the result of another LCA unless all assumptions and modelling choices are equal.

Figure 4: GWP100 result: distribution between sub-unit processes within each life cycle stage per functional unit for mobile phone

Figure 5 shows the environmental impact categories overview for the present case study.



NOTE 1: This LCA result cannot be compared to the result of another LCA unless all assumptions and modelling choices are equal.

NOTE 2: It is judged that extending Figure 5 to the other 14 EF 3.0 impact categories, as well as the single score for EF 3.0, would not enhance the understanding of which life cycle stages, parts and processes are most important from an environmental viewpoint for the mobile phone at hand. However, such stretched analyses could be worthwhile as more knowledge emerges.

Figure 5: Environmental impact category indicators overview for mobile phone

Table 3 shows the life cycle stages overview.

Table 3: Mobile phone application of Table L.2 in ETSI ES 203 199 [i.1]

Tag	Life cycle stage/Process	Unit process	Included (Yes/No)	Electricity mix (specific/country/world average	Support activities included (Yes/No)	Transport activities included (Yes/No)	Other generic activities included (Yes/No)	Motivation/Comment
A	Goods Raw Material Acquisition							
A1	Raw material extraction		Yes	Specific electricity mixes are defined by LCI database	No	Yes	Yes	Transports and energy mixes are transparent from LCI databases used for Iron/Steel, Aluminium, Copper, Gold and Silver and all other applicable Raw Material Groups from Table D.1 in ETSI ES 203 199 [i.1]
A2	Raw material processing		Yes	Specific electricity mixes are defined by LCI database	No	Yes	Yes	Transports and energy mixes are transparent from LCI databases used for Iron/Steel, Aluminium, Copper, Gold and Silver and all other applicable Raw Material Groups from Table D.1 in ETSI ES 203 199 [i.1]
B	Production							
B1	ICT goods production							
B1.1		Parts production	Yes	World	No	Yes	Yes	As all Parts are considered as global averages no separate Part reporting is made here
B1.2		Assembly	Yes	World	No	Yes	Yes	Transport to Use Location is included
B1.3		*ICT manufacturer support activities*	*No*	*World*	*No*	*No*	*No*	
B2	Support goods production							
B2.1		Support goods manufacturing	*No*					
B3		ICT specific site construction	*No*					
C	Use							
C1	ICT goods use		Yes	World	No	No	No	
C2	*Support goods use*		*No*					
C3	*Operator support activities*		*No*					
C4	*Service provider support activities*		*No*					

Tag	Life cycle stage/Process	Unit process	Included (Yes/No)	Electricity mix (specific/country/world average	Support activities included (Yes/No)	Transport activities included (Yes/No)	Other generic activities included (Yes/No)	Motivation/Comment
D	Goods End of Life Treatment							
D1	*Preparation for extended operating lifetime*		*No*					
D2	ICT specific EoLT							
D2.1		Storage/Disassembly/Dismantling/ Shredding	Yes	World	No	Yes	Yes	G1, G2, G3, G5 Cut-off. Tested in sensitivity analysis
D2.2		Recycling	Yes	World	No	Yes	Yes	G1, G2, G3, G5 Cut-off for D2.2.1-5. Tested in sensitivity analysis
D3	Other EoLT		Yes	World	No	Yes	Yes	Cut-off. Tested in sensitivity analysis

Table 4 shows the reporting of generic processes.

Table 4: Reporting of Generic processes for LCA of mobile phone

Generic process	Generic process categories included	Unit processes included (for each generic process category)	Important issues
G1. Transports & Travel	Road Air	Direct (during transport) emissions Fuel supply chain (the Raw Material Acquisition, Production and Transport of the Fuel)	No travel included
G2. Electricity	World electricity mixes	Fuel supply chain, Direct emissions (during electricity production)	
G3. Fuels	Oil Diesel Petrol Jet-fuel Coal Gas	Fuel supply chain: Extraction and Production	
G4. Other energy			
G5. Raw material acquisition	See Table D.1 in ETSI ES 203 199 [i.1]	Extraction Processing	e.g. Nitrogen gas (N_2) used in B1.1.4, solder paste used in B1.2. Paper additives and plastic additives are data gaps.
G6. End-of-life treatment	G6.1 EHW G6.2 Landfill	G6.1: EHW (destruction and energy recovery) Special EHW landfill G.2: Incineration Landfill One "site LCI model" for landfill site	Cut-off
G7. Raw material recycling	Metal recycling	Smelting Refining	

Table 5 shows the reporting of transports/travel.

Table 5: Reporting of transports/travel

Mode	CO_2e emission factor (see note 4)	Raw material acquisition transports		Production stage transports excluding final transport		Final transport (see note 1) (Production to use stage)		Use stage transports		EoLT transports		Total transports		Total travel (see note 6)	
		Transport work (see note 2)	GWP100	Transport work	GWP100	Transport work	GWP100	Transport work	GWP 100	Transport work	GWP 100	Transport distance (see note 3)	GWP100	Transport distance (see note 3)	GWP100
		{ton×km}	{kg CO_2e}	{ton×km}	{kg CO_2e}	{ton×km}	{kg CO_2e}	{ton × km}	{kg CO_2e}	{ton × km}	{kg CO_2e}	{km}	{kg CO_2e}	{km}	{kg CO_2e}
Air	Air: 1,1 kg CO_2e/[ton×km]	Occasionally included in LCI modules in database.		Cut-off. Tested in sensitivity analysis.		0.0002 ton×9 500 km = 1,9 tkm.	2.1					9 500	2,1		
Road	Road: Lorry: 0,09 kg CO_2e/[ton×km]	Occasionally included in LCI modules in database.		Cut-off. Tested in sensitivity analysis.		Lorry, 0,0002 ton×1/0,7 {load factor 70 %} × 2 000 km = 0,57 tkm	0.051					2 000	0,051		
Ship	N.A			N.A			N.A							N.A	

NOTE 1: The final transport of ICT Equipment from assembly to operator, including pre- and post transports connected to the main transport.
NOTE 2: Average in terms of distance, transport mode, load factor, chargeable mass, etc.
NOTE 3: Average in terms of distance, transport mode, load factor, chargeable mass, etc.
NOTE 4: This include direct fuel consumption and also fuel supply chain.
NOTE 5: Specify used transport mode.
NOTE 6: Includes all kinds of travel throughout life cycles, e.g. commuting, business travel and maintenance travel when applicable. Specify travels taken into account.
NOTE 7: Other impact categories to be added as applicable.

Table 6 shows the reporting of Raw Materials.

Table 6: Reporting of Raw Materials used in the material content declaration

	Raw Material Content (g) per piece mobile phone	Share of Recycled raw material used, R1 in CFF (%)	Share of material content recycled in the EoLT stage (%), R2 in CFF	Material recovery of Content per piece mobile phone (g)
Iron/Steel alloys	0,5	70	90	0,45
Aluminium alloys	25	30	90	22,5
Copper alloys	14	30	90	12,6
Silver	0,1	70	90	0,09
Gold	0,03	70	90	0,027
Plastics	25	0	0	0
Battery materials	50	0	90	45
Others	85	0	0	0
TOTAL	**200**			

Table 7 shows the reporting of Parts Production.

Table 7: Reporting of Parts Production

	Part categories included	Part Unit processes included	Handling of special issues
B1.1.1 Batteries	Lithium Battery	Raw Material Acquisition, Battery cell assembly, Battery module (pack) assembly	Mass is around 50 g
B1.1.2 Cables	N.A.	Raw Material Acquisition, Cable final assembly	N.A.
B1.1.3 Electro-mechanics	Connectors (g)	Raw Material Acquisition, Part final assembly	
B1.1.4 Integrated circuits (ICs)	Processors, DSPs ASICs Memories Microprocessors Transistors and diodes	Front-end: Special IC Raw Materials Acquisition, Wafer production, Chip production ("the wafer fab") Back-end: Raw Material Acquisition, IC encapsulation	
B1.1.5 Mechanics / materials	Mechanical Parts (g) is the sum of *main mechanical Parts* (g) such as housing and *smaller sub-parts*	Raw Material Acquisition, Part final assembly	
B1.1.6 Displays	LCD Screen	Cradle-to-gate	Around 100 cm^2 active area
B1.1.7 Printed circuit boards (PCBs)	Plastic, FR4	Raw Materials Acquisition, Raw materials Acquisition for special PCB materials, Raw materials Acquisition for PCB semi-produced composite materials, PCB final assembly	Around 50 cm^2in total. Different types.
B1.1.8 Other PBA components	Resistors (g) Capacitors (g) Inductors (g) Quartz crystal oscillators (g)	Raw Material Acquisition, Part final assembly	
B1.1.9 Packaging materials	N.A.	Raw Material Acquisition, Part final assembly	N.A.
B1.1.10 Black box modules	Cameras	See ICs	
B1.1.11 Software	N.A.	N.A	N.A.

Table 8 shows the reporting of the use stage energy consumption.

Table 8: Reporting of use stage energy consumption

	Energy consumption {kWh/year}	Source {long term average/standardized measurement/ modelled	Motivation/ comment
ICT equipment (mobile phone)	9 (energy)	Typical annual average primary energy consumption scenario for the studied mobile phone	Derived from the "Cumulative Energy Demand" method provided by the applied LCA tool
ICT equipment (mobile phone)	3,5 (electricity)	Typical annual average electricity consumption scenario for the studied mobile phone	Simplified purpose of LCA study. The emission factor for the used electricity mix is 0,5 $kgCO_2e/kWh$. It based on an appropriate global average electricity mix referenced exactly by the database provided by the applied LCA tool
Support equipment	**N.A.**		**Not included in studied product system**

Table 9 shows the reporting of the EoLT stage.

Table 9: Reporting of EoLT stage

	Process categories included	Process Unit processes included	Handling of special issues
D1. Preparation for extended operating lifetime	N.A.	N.A.	
D2. ICT specific EoIT	D2.1 Storage/Disassembly/Dismantling/Shredding D2.2 Recycling D2.2.1 Battery recycling ICT specific metal/mechanical parts/fractions EoLT D2.2.2 PCBA recycling D2.2.3 Cable recycling D2.2.4 Mechanics recycling D2.2.5 Other ICT recycling D3. Other EoLT	Recycling, recovery and treatment	All cut-off
D3. Other EoLT			Cut-off

Table 10 shows the reporting of LCI results.

Table 10: Reporting of LCI results

	TOTAL	Raw materials acquisition, Production and EoLT	Use
Primary energy use [i.5]	245 kWh	209 kWh	36 kWh
Total electricity use	87 kWh	73 kWh	14 kWh
[i.5] Based upon a method for Cumulative Energy Demand provided by LCI database provider.			
"This LCA result cannot be compared to the result of another LCA unless all assumptions and modelling choices are equal".			

Table 11 shows the reporting of impact category indicators.

Table 11: Reporting of impacts category indicators

Mid-point Impact Assessment Categories included	Impact category indicator value	LCIA methodology reference
Climate Change (CC) (mandatory)	62,6 kg CO_2e	EF Method v3.0
RDMR	0,7 g Sb-equivalents	EF Method v3.0
"This LCA result cannot be compared to the result of another LCA unless all assumptions and modelling choices are equal".		

Table 12 shows the summary of fulfilment of the requirements.

Table 12: Summary of fulfilment of the requirements (Source: ETSI ES 203 199 [i.1])

Clause in ETSI ES 203 199 [i.1]	Requirement	Fulfilled	Not fulfilled	Explanation/Motivation
Introduction	Deviation(s) from the requirements shall be clearly motivated and reported.	YES		
5.2	Full compliance towards ETSI ES 203 199 [i.1] can be claimed if all mandatory requirements are fulfilled.	YES		
5.3	A third-party review is also needed if the comparison result is to be externally communicated.	N.A.		
5.3	In case of comparative assessment between ICT goods LCAs the operating lifetime shall be set equal.	N.A.		
6.1	ETSI ES 203 199 [i.1] has to be taken into account.	YES		
6.1.1	The following four high-level life cycle stages (RMA, P, U, EOLT) shall apply to ICT goods, Networks and Services and shall be assessed as applicable in LCAs based on [i.1] in accordance with the goal and scope.	YES		
6.1.1	Table 2 in clause 6.2.3.1 of ETSI ES 203 199 [i.1] defines the detailed life cycle stages which further defines the system boundary and which are to be considered when assessing the life cycle impact of ICT goods, networks and services. In particular, it is important to cover all processes whose relevance is marked as mandatory in Table 2.	YES		
6.1	Transports and energy supplies shall be included in all life cycle stages.	YES		

Clause in ETSI ES 203 199 [i.1]	Requirement	Fulfilled	Not fulfilled	Explanation/Motivation
6.1	At the time of publication, to collect appropriate data related to raw materials transport and to separate data related to raw material acquisition stage and production stage is considered challenging due to LCA tool limitations, lack of data, limitations in data granularity and the nature of ICT supply chains. Deviation(s) from this requirement shall be clearly motivated and reported.	YES		
6.1	Instance transports of goods between production and use stages shall be taken into account.	YES		
6.1.2	The ICT goods, networks and services product system to be assessed shall be clearly described as well as relevant functions and characteristics.	YES		
6.1.2.1	For the ICT good under study, applicable types of parts, as well as amounts of these, shall be defined.	YES		
6.1.2.2	In the goal and scope phase it shall be outlined which network building blocks are covered.	N.A.		
6.1.2.2	For the ICT network under study, applicable types of nodes and infrastructure, as well as amounts of these, shall be defined.	N.A.		
6.1.2.3	For the ICT service under study, applicable types of ICT network elements and infrastructure, as well as amounts of these, shall be defined.	N.A.		
6.1.3.1	Software shall be considered as well as hardware.	YES		
6.1.3.1	For specific software applications, such as music distribution applications, the software is to be seen as an ICT service and shall be assessed according to the requirements outlined for services.	N.A.		
6.1.3.1	In these cases the hardware needed to operate the software shall be considered as well.	YES		
6.1.3.1	For users of generic operating systems embedded in products, the life cycle impact of usage of this software may be considered as negligible. However, for the developer of this software the impact of the usage of this software shall be taken into account.			
6.1.3	Operating lifetime is critical for the interpretation of the results of LCAs and shall therefore always be reported when presenting LCA results.	YES		
6.1.3	Operating lifetime estimates and assumptions shall also be clearly described in the reporting.	YES		
6.2.1	During the LCA scoping phase the building blocks of the ICT goods, Networks or Services shall be identified.	YES		
6.2.2.1	The functional unit shall be chosen in accordance with the goal and scope of the LCA.	YES		
6.2.2.1	The functional unit requires inclusion of the relevant quantifiable properties and the technical/functional performance of the system. This means that the operating lifetime of all included ICT goods shall be specified.	YES		
6.2.2.1	the number of users/subscribers supported by the Network and the traffic profile shall be included where applicable.	N.A.		
6.2.2.1	The functional unit shall be clearly defined and measurable.	YES		
6.2.2.1	The reference flow shall reflect the functional unit chosen.	YES		
6.2.2.2	The functional unit shall be chosen in the context of goal and scope of the LCA and shall be further clarified by system boundary and cut-off rules.	N.A.		
6.2.2.2	To comply with ETSI ES 203 199 [i.1], the following functional unit shall be applied where applicable. annual ICT goods use (per one year of ICT good use), or total ICT good use per lifetime of ICT good.	YES		
6.2.2.2	For relevant LCA results realistic use scenarios shall be captured.	YES		

Clause in ETSI ES 203 199 [i.1]	Requirement	Fulfilled	Not fulfilled	Explanation/Motivation
6.2.2.3	ICT networks can be seen as a system composed of different types of ICT goods. For the purpose of ETSI ES 203 199 [i.1] the following functional unit shall be applied where applicable for ICT networks used during at least one year: • annual network use.	N.A.		
6.2.2.3	For relevant LCA results realistic use scenarios shall be captured.	N.A.		
6.2.2.4	For the purpose of ETSI ES 203 199 [i.1], the following functional unit shall be applied where applicable. Annual Service use.	N.A.		
6.2.2.4	For relevant LCA results realistic use scenarios shall be captured.	N.A.		
6.2.2.4	Corresponding realistic use scenarios shall be defined.	N.A.		
6.2.2.4	The annual service use shall be defined with respect to the usage scenario to make it possible to define the reference flow.	N.A.		
6.2.3.1	The selection of the system boundary shall be consistent with the goal of the study.	YES		
6.2.3.1	Consequently, the system boundaries here define the life cycle stages and the unit processes that shall be taken into account in an LCA of an ICT product system.	YES		
6.2.3.1	Table 2 in ETSI ES 203 199 [i.1] includes further details the life cycle stages to be included in LCAs of ICT goods, Networks and Services. The different life cycle stages are further described in clauses 6.2.3.4.2 to 6.2.3.4.5 of ETSI ES 203 199 [i.1]. Mandatory in Table 2 of ETSI ES 203 199 [i.1] means that the life cycle stage shall be included.	YES		
6.2.3.1	Mandatory life cycle stages or unit processes shall not be cut-off before considered for inclusion by using alternate data.	YES		
6.2.3.1	In Table 2 in ETSI ES 203 199 [i.1] "Mandatory" means that the life cycle stage, if applicable to the studied product system, shall always be taken into account in an LCA for ICT.	YES		
6.2.3.3.1	In order to set the system boundary of ICT goods the life cycle stages listed in clause 6.1.1 in ETSI ES 203 199 [i.1] shall be detailed.	YES		
6.2.3.3.1	As stated in clause 6.1.3 of ETSI ES 203 199 [i.1], the environmental impact from both hardware and software shall be considered, if applicable.	YES		
6.2.3.3.1	For the ICT good under study, applicable types of parts, as well as amounts of these, shall be defined.	YES		
6.2.3.3.2	Table H.1 in ETSI ES 203 199 [i.1] provides a mandatory set of Raw Materials (both ICT specific and generic) which shall be included in the LCA of ICT goods.	YES		
6.2.3.3.3	Annex E in ETSI ES 203 199 [i.1] lists a mandatory set of Parts to be included where applicable to the studied ICT product system, when performing an LCA of ICT goods, as well as mandatory Part unit processes which shall be included for each Part.	YES		
6.2.3.3.3	As an example, if batteries are part of the studied ICT goods product system they shall be included in within the system boundary and for every battery the Battery Cell manufacturing and Battery module manufacturing shall be included.	YES		
6.2.3.3.3	The Assembly (B1.2) shall include as minimum PCBA Module Assembly, Final Assembly, Warehousing and Packaging.	NO		Packaging materials are not part of studied product system.
6.2.3.3.3	In case Support goods is part of the studied product system, Support goods Production (B2) is mandatory.	N.A.		
6.2.3.3.3	Support goods (B2.1) which shall be included if applicable to the studied product system are at least air conditioners, cables and power supply systems.	N.A.		

Clause in ETSI ES 203 199 [i.1]	Requirement	Fulfilled	Not fulfilled	Explanation/Motivation
6.2.3.3.3	As stated in Table 2 of ETSI ES 203 199 [i.1] Construction of ICT specific Site (B3) is mandatory if the ICT specific site is included in the studied product system.	N.A.		
6.2.3.3.3	Site building blocks needed for B3.1, which at least shall be included if applicable to the studied product system, are antenna towers, fences and shelters.	N.A.		
6.2.3.3.4	The Raw Material Acquisition and Production for the additional PCBAs used during the operating lifetime of the ICT goods are mandatory.	N.A.		
6.2.3.3.5	As shown in Figure 11 of ETSI ES 203 199 [i.1], Preparation for extended operating lifetime (D1), ICT specific EoLT (D2) and Other EoLT (D3) are within the mandatory system boundary for EoLT.	N.A.		
6.2.3.3.5	Annex F lists a mandatory set of EoLT processes to be included where applicable when performing an LCA of ICT goods which includes the EoLT stage.	YES		
6.2.3.3.5	It is thus recognized that compliance to all requirements in Annex F in in ETSI ES 203 199 [i.1] may not be possible at the time [i.1] is published. Deviation(s) from the requirements shall be clearly motivated and reported.	YES		
6.2.3.4	The Network shall be defined in terms of ICT goods, Support goods and ICT infrastructure (e.g. cables duct).	N.A.		
6.2.3.4	For each included product types number of units shall be defined as well as corresponding lifetime	N.A.		
6.2.3.4	For assessment of Networks, operator activities shall always be included.	N.A.		
6.2.3.5.1	In addition to the use of ICT goods and networks, an ICT service may also have additional impacts associated with application software development, use of consumables, infrastructure for sales and logistics, associated travel and transport (in addition to those already included for the ICT goods and networks) which shall also be included as appropriate.	N.A.		
6.2.3.5.1	The impact of the data centres where the service is operated shall be assessed.	N.A.		
6.2.3.5.1	The data centre shall be studied and assessed in the same way as other ICT goods.	N.A.		
6.2.3.5.1	The system boundary of the ICT services provided by the ICT network shall be established based on either the actual use scenario of the ICT services, if available, or on an estimated use scenario.	N.A.		
6.2.3.5.2	Energy consumption, material inputs and environmental releases shall be assessed in accordance with the system boundary.	YES		
6.2.4	Cut-offs shall be avoided as far as possible.	YES		
6.2.4	ISO 14044 [i.6], clause 4.2.3.3 recommendations shall be used as closely as possible.	YES		
6.2.4	All cut-off criteria stated by ISO 14040 [i.5] and ISO 14044 [i.6] are to be considered before cut-off of a certain process - and the process shall be included if significant to at least one criterion.	YES		
6.2.4	The intention of the present standard is to include all mandatory activities of Table 2 in ETSI ES 203 199 [i.1]. If these activities are not included such cut-offs shall be clearly motivated.	YES		
6.2.4	Any cut-off made shall be clearly described and documented.	YES		

Clause in ETSI ES 203 199 [i.1]	Requirement	Fulfilled	Not fulfilled	Explanation/Motivation
6.2.5.1	A qualitative description of the data quality and any efforts taken to improve it shall be disclosed while considering the following data quality indicators: • Methodological appropriateness and consistency • Completeness (total LCA level) • Uncertainty • Data representativeness • Data age (timeliness) • Acquisition method • Supplier independence • Geographical correlation • Technological correlation • Cut-off rules (rules of inclusion/exclusion)	YES		
6.2.5.1	In selecting emission factors for use in calculating GHG emissions under this methodology the following guidance shall be followed: Emission factors used should be the most up to date from publicly available sources.	YES		
6.2.5.1	Where emission factors are sourced from non public sources, or are not the most up to date ones, a justification for their use shall be provided.	YES		
6.2.5.1	The specific GWP values used shall be those taken from the latest UN IPCC reports. For further guidance see Table W.1 of ETSI ES 203 199 [i.1].	YES		
6.2.5.2	In general data age and technology are especially important in LCAs for ICT goods, Networks and Services due to the fast technology evolution and the growth in network traffic. e.g. for data traffic, up-to-date figures shall always be used.	YES		
6.2.5.2	For support activities (e.g. ICT manufacturer support activities and operator support activities) primary data shall be used for all individual processes under the financial or operational control of the organization undertaking the LCA.	YES		
6.2.5.2	… and data shall be representative of the processes for which they are collected.	YES		
6.3.1.1	Data shall be collected for each unit process that is included within the system boundary in accordance with Annex B of ETSI ES 203 199 [i.1].	YES		
6.3.1.1	Data shall be collected for all mandatory processes outlined in Table 2 of ETSI ES 203 199 [i.1].	YES		
6.3.1.1	When data has been collected from public sources, the source shall be referenced.	YES		
6.3.1.2	Data shall be collected at least for the processes marked with mandatory in Table 2 of ETSI ES 203 199 [i.1], unless these are found negligible in accordance with the cut-off rules.	YES		
6.3.1.4	Use time, goods type, data traffic and network access type give important statistical data that needs to be collected in order to quantify the use of ICT systems.	N.A.		
6.3.1.2.1	it should be noted that, for many products (especially end-user goods), periods of idling and power off may be significant and are important to consider when modelling the traffic profile/ model the usage profile and shall be included if applicable.	YES		
6.3.1.2.3	The LCA practitioner is encouraged to use the most accurate assessment of the energy mix that is consumed by the ICT goods under assessment, when calculating the potential environmental impact from the use stage/ shall use the applicable electricity mix to calculate the potential environmental impact from the use stage more exactly.	YES		
6.3.2.1	The general requirements for data calculations in ISO 14040 [i.5] and ISO 14044 [i.6] shall be applied.	YES		

Clause in ETSI ES 203 199 [i.1]	Requirement	Fulfilled	Not fulfilled	Explanation/Motivation
6.3.2.1	All calculation procedures shall be explicitly documented and the assumptions made shall be clearly stated and explained.	YES		
6.3.2.1	The same calculation procedures shall be consistently applied throughout the study.	YES		
6.3.2.1	A check on data validity shall be conducted during the process of data collection to confirm that the data quality requirements for the intended application have been fulfilled.			
6.3.2.3	the evaluation of the environmental load shall consider both a fixed part which is independent of the usage and a variable part which correlates to the usage.	N.A.		
6.3.3.1	The same allocation method shall be used for all environmental loads for all products from a common process.	YES		
6.3.3.1	The study shall identify the processes shared with other product systems and deal with them according to the stepwise procedure presented below.	YES		
6.3.3.2	Data for generic processes (G1 to G7) shall be allocated as a whole (i.e. for the full lifecycle for the generic process) to the associated life cycle stage of the product system.	YES		
6.3.3.2	However all Raw Material Acquisition (G5) shall be allocated to the life cycle stage Raw Material Acquisition (A).	YES		
6.3.3.3	Data for relevant part of the organization/operation shall be allocated to the relevant part of the project/product system life cycle.	YES		
6.3.3.3	If no detailed information on organization/operation is available the allocation shall be based on organizational/economic data.	YES		
6.3.3.8	End-user goods (e.g. PCs, smart phones) which are accessing more than one ICT Network (e.g. 4G, 5G, WLAN) shall be allocated to these ICT Networks based on use time.	N.A.		
6.3.3.8	The assumptions regarding use time for access to different ICT Networks and off line work shall be described and motivated.	N.A.		
6.3.3.8	Impact from shared Network resources (e.g. transmission goods, core nodes and data centres) shall be allocated to an access Network based on data traffic.	N.A.		
6.3.3.8	The assumptions regarding data traffic shall be described and motivated.	N.A.		
6.3.3.9	The impact from each ICT network supporting the service should be allocated to the service based on access use time or data traffic. More specifically, the following allocation principle of ICT Network data to an ICT Service shall be used: Data for End-users goods: to be allocated based on active use time of the ICT Service. Etc.	N.A.		
6.3.3.9	Data traffic is also preferred for e.g. mobile access networks as mobile access networks show a large dependency between data traffic and energy consumption and need a traffic model that takes data traffic into account.	N.A.		
6.3.3.9	Data for data centres and Service provider activities: The data centre(s) where the ICT Service is operated as well as the service provider activities shall be allocated based on number of subscriptions and service users or amount of data/transactions.	N.A.		
7	ISO states that the selection of impact categories shall reflect a comprehensive set of environmental issues related to the product system being studied, taking the goal and scope into consideration.	YES		

Clause in ETSI ES 203 199 [i.1]	Requirement	Fulfilled	Not fulfilled	Explanation/Motivation
7	In the LCA it shall be ensured that the inventory elementary flows (see Annex G in ETSI ES 203 199 [i.1]) are correctly linked with appropriate LCIA characterization factors.	YES		
7	For climate change, the most recent global warming characterization factors from the Intergovernmental Panel on Climate Change [b-IPCC] for each GHG shall be used and the timeframe should be 100 years.	YES		
7	The mid-point category Climate change is mandatory.	YES		
7	For other impact categories there is no methodological consensus in the LCA community, thus the practitioner shall decide which impact categories to consider and how to calculate them, based on the studied ICT product system and purpose of the LCA study.	YES		
7	All impact categories and category indicators included shall be disclosed (Table L.10) and justified.	YES		
8.2	The sources of uncertainty and methodological choices made shall be assessed and disclosed.	YES		
8.3	The results of the LCI or LCIA phases shall be interpreted according to the goal and scope of the study.	YES		
8.3	The interpretation shall include a sensitivity check of the significant inputs, outputs and methodological choices and defined use scenarios, in order to understand the uncertainty of the results.	YES		
9.1	The reporting of ICT product systems shall fulfil the reporting rules as defined by ISO 14040 [i.5] and ISO 14044 [i.6].	YES		
9.1	In the case of reporting, a public GHG inventory report, the key accounting principles (relevance, accuracy, completeness, consistency and transparency) shall be met.	YES		
9.1	In addition to the reporting obligations outlined by ISO 14040 [i.5] and ISO 14044 [i.6], the report shall include the following information: • contact information; • studied goods, networks and services product system name and description; • type of inventory (i.e. final product cradle-to-grave or intermediate product cradle-to-gate inventory); • goals of the study. The reporting of results shall include: • total GHG emissions reported as amount of CO2e per functional unit for ICT good, network and service that have been assessed; • percentage for each life cycle stage contributing to the total results; • electricity (with use stage separated from the other stages); • primary energy (see note); • fuels; • value and sources of emission factors for CO2 and CO2e and Global Warming Potential (GWP) metric used in the report; • other data, justifications and explanations as stated throughout this report. NOTE: Primary energy and electricity cannot be summarized because electricity is contributing to the total primary energy.	YES		
9.1	In addition the rules outlined in this clause and what is stated in Annex L shall be followed for reporting of studies claiming compliance with ETSI ES 203 199 [i.1].	YES		

Clause in ETSI ES 203 199 [i.1]	Requirement	Fulfilled	Not fulfilled	Explanation/Motivation
9.1	The report resulting from the application of ETSI ES 203 199 [i.1] shall contain a compliance statement saying either that the LCA fully complies with ETSI ES 203 199 [i.1] (in case of full compliance) or that the LCA partially complies with ETSI ES 203 199 [i.1] with the exception of transparently listed and justified requirements (partial compliance).	YES		
9.1	The extent in which Support activities and other optional/recommended activities are excluded for different parts of the life cycle shall be clearly described and for recommendations also motivated in the study report.	YES		
9.1	For each product system (including ICT goods, Network and Service) the following aspects, being of special importance to ICT applications, shall be transparently motivated and described in accordance with the principles defined in this clause: • Operating lifetime: All lifetime assumptions shall be stated and motivated.	YES		
9.1	Cut-off: Any cut-off made shall be clearly stated and motivated.	YES		
9.1	Allocations: Basis for allocations made shall be described, especially for recycling, use of recycled materials, distribution of facility data and support activities.	YES		
9.1	Data sources: Data sources (i.e. specific/generic) shall be clearly stated and deviations towards Table 2 of ETSI ES 203 199 [i.1] shall be motivated.	YES		
9.1	For each product system (including ICT goods, Network and Service) an additional graph shall be presented whenever optional activities in Table 2 of ETSI ES 203 199 [i.1] have been included.	YES		
9.1	The emission factors used shall be clearly stated. The source used and the year they represent shall be clearly stated.	YES		
9.1	In the case of emission factors for grid electricity the source, year and location (specific, country, global average) shall be clearly stated.	YES		
9.1	Where emission factors are sourced from non public sources, or are not the most up to date ones, a justification for their use shall be provided.	YES		
9.2.1	For each impact category studied, diagrams corresponding to Figure 14a and Figure 14b of ETSI ES 203 199 [i.1] shall be reported for the corresponding category indicator result.	YES		
9.2.1	Due to the importance of operating lifetime to results, information regarding this shall always be present in the graph, together with some other basic modelling statements including total result for the indicator, LCA study year operating lifetime, etc. as shown below.	YES		
9.2.1	Due to the importance of operating lifetime to results, information regarding this shall always be present in the graph, together with some other basic modelling statements including total result for the indicator, LCA study year operating lifetime, etc. as shown below.	YES		
9.2.1	Figure 14b of ETSI ES 203 199 [i.1] shall be presented whenever optional activities/processes from Table 2 of ETSI ES 203 199 [i.1] have been included in the studied product system.	N.A.		
9.2.1	For transports, the total result including all transports throughout the life cycle Table L.4 of ETSI ES 203 199 [i.1] shall be stated in the immediate proximity of the diagram (Figure 14a and Figure 14b of ETSI ES 203 199 [i.1]).	YES		
9.2.1	If used data sets do not report transports separately any missing transport shall be listed and motivated.	YES		
9.2.1	Figure 16 of ETSI ES 203 199 [i.1] shall be accompanied by the disclaimer "This LCA result cannot be compared to the result of another LCA unless all assumptions and modelling choices are equal".	YES		

Clause in ETSI ES 203 199 [i.1]	Requirement	Fulfilled	Not fulfilled	Explanation/Motivation
9.2.1	A graph summarizing distribution of selected environmental impact category indicators between life cycle stages shall be prepared together with absolute figures as shown in the Table L.10 of ETSI ES 203 199 [i.1].	YES		
9.2.1	Figure 18 of ETSI ES 203 199 [i.1] shall be accompanied by the disclaimer "This LCA result cannot be compared to the result of another LCA unless all assumptions and modelling choices are equal". See further explanation in the scope.	YES		
9.2.2.1	Any deviation to Table 2 and clause 6.2.3 of ETSI ES 203 199 [i.1] with respect to mandatory life cycle stages/unit processes shall be clearly stated and motivated.	YES		
9.2.2.1	Any deviation to Table 2 and clause 6.2.3 of ETSI ES 203 199 [i.1] with respect to mandatory life cycle stages/unit processes shall be clearly stated and motivated.	YES		
9.2.2.1	Additionally, inclusion of generic processes for the different life cycle stages shall be clearly stated and reported.	YES		
9.2.2.1	Deviations for Generic processes shall be reported according to Table L.3.	YES		
9.2.2.2	The use of raw materials shall be transparently reported as outlined below.	YES		
9.2.2.2	The most important metals from recycling point of view shall always be included. For appropriate reporting format refer to Table L.5.	YES		
9.2.2.2	Deviation(s) from the requirements shall be clearly motivated and reported	YES		
9.2.2.3.1	Compliance to Table E.1 shall be reported according to below and any deviation shall be described and motivated. Compliance to Table E.1 shall be reported according to below and any deviation shall be described and motivated.	YES		
9.2.2.4.1	Compliance to Table E.1 shall be reported according to below and any deviation shall be described and motivated.	YES		
9.2.2.4.1	The model of distribution over time of different usage modes including power off and idle and the rationale for those shall be transparently reported. For appropriate reporting format refer to Table L.7 of ETSI ES 203 199 [i.1].	YES		
9.2.2.4.2	The rationale for the energy consumption values for the Support goods use shall be transparently described and motivated. For appropriate reporting format refer to Table L.7 of ETSI ES 203 199 [i.1].	N.A.		
9.2.2.5	If EoLT is included any deviations towards Annex F shall be transparently reported and motivated. For appropriate reporting format refer to Table L.8 of ETSI ES 203 199 [i.1].	YES		
9.2.3	For LCI the following items shall be reported transparently: total use of primary energy and electricity.	YES		
9.2.3	Additionally, results for elementary flows according to Table G.1 of ETSI ES 203 199 [i.1] could be transparently reported on an optional basis. If such reporting is not made it is mandatory to describe unexpected results, lack of data and other findings associated with the elementary flows.	YES		
9.3.1	Operating lifetime is important also for Networks, but is associated with the lifetime of the different nodes, which shall be reported	N.A.		
9.3.1	It shall be reported following the format of Table L.11 of ETSI ES 203 199 [i.1] which also describes the studied Network.	N.A.		
9.3.1	Figure 18 of ETSI ES 203 199 [i.1] shall be accompanied by the disclaimer "This LCA result cannot be compared to the result of another LCA unless all assumptions and modelling choices are equal".	N.A.		

Clause in ETSI ES 203 199 [i.1]	Requirement	Fulfilled	Not fulfilled	Explanation/Motivation
9.3.1	Additionally a graph summarizing distribution of environmental impact category indicators between life cycle stages shall be prepared together with absolute figures as shown in the Table L.10 of ETSI ES 203 199 [i.1].	N.A.		
9.3.1	Figure 19 of ETSI ES 203 199 [i.1] shall be accompanied by the disclaimer "This LCA result cannot be compared to the result of another LCA unless all assumptions and modelling choices are equal".	N.A.		
9.3.1	Details of network energy consumption shall be reported with a split of different elements of the network. An example of Table for Reporting is provided In Table L.12 of ETSI ES 203 199 [i.1].	N.A.		
9.4.1	Operating lifetime is important also for Services, but it is associated with the lifetime of the different nodes, which shall be reported.	N.A.		
9.4.1	Allocation of Network data to the Service shall be reported. It should be reported according to Table L.13 of ETSI ES 203 199 [i.1].	N.A.		
9.4.1	Additionally a graph summarizing distribution of impact category indicators between life cycle stages for the Service product system under study shall be presented together with absolute figures as shown in the Table L.10 of ETSI ES 203 199 [i.1].	N.A.		
9.4.1	Figure 22a and Figure 22b of ETSI ES 203 199 [i.1] shall be accompanied by the disclaimer "This LCA result cannot be compared to the result of another LCA unless all assumptions and modelling choices are equal".	N.A.		
10	Any critical review shall be performed according to the requirements in ISO 14040 [i.5] and ISO 14044 [i.6] and in ETSI ES 203 199 [i.1].	N.A.		
10	The scope and type of critical review desired shall be defined in accordance with ISO 14044 [i.6], clauses 4.2.3.8 and 6.	N.A.		
11.1	Infrastructure, e.g. highways for transportation, is generally assumed to exist independently of introduction of new services and shall be excluded.	N.A.		
11.1	The handling of time perspective and scale shall be disclosed and motivated in ETSI ES 203 199 [i.1].	N.A.		
11.1	To be able to quantify the net environmental impact when introducing an ICT based Service the environmental impact of both the ICT Service itself and of the reference product system need to/shall be assessed from a life cycle perspective.	N.A.		
11.1	To make sure that the comparative assessment gives a relevant result, the full life cycle of both systems shall always be considered.	N.A.		
11.1	From an LCA perspective the reference product system and the ICT service based system shall mimic each other as far as possible.	N.A.		
11.1	And the practitioner shall model both systems in an unbiased way.	N.A.		
11.2	Goods shall be compared with other goods.	N.A.		
11.2	ICT networks shall be compared between themselves.	N.A.		
11.2	And ICT services shall be compared between themselves.	N.A.		
11.3.1	In this comparative LCA study, the scope of the LCA study shall be defined in such a way that the two systems can be compared.	N.A.		
11.3.1	Systems shall be compared using the same functional unit and equivalent methodological considerations, such as performance, system boundary, data quality, allocation procedures and cut-off rules.	N.A.		
11.3.1	Any differences between systems regarding these parameters shall be identified and reported.	N.A.		

Clause in ETSI ES 203 199 [i.1]	Requirement	Fulfilled	Not fulfilled	Explanation/Motivation
11.3.2	Also in this case, the scope of the LCA study shall be defined in such a way that the two systems can be compared.	N.A.		
11.3.2	Both systems shall be assessed using the same functional unit and equivalent methodological considerations, such as performance, system boundary, data quality, allocation procedures and cut-off rules.	N.A.		
11.3.2	Any differences between systems regarding these parameters shall be identified and reported.	N.A.		
11.3.3	The assessment of the ICT based system shall be performed in accordance with Part I.	N.A.		
11.3.3	When making comparisons, it is important to keep in mind that the functional unit used shall be applicable to both the reference product system and the system of ICT goods, networks and services.	N.A.		
11.3.3	For the reference product system applicable requirements in ETSI ES 203 199 [i.1] shall be applied, e.g. requirements regarding data quality, cut-off, etc.	N.A.		
12.2	All the requirements stipulated in Part I for a system boundary definition shall be applied.	N.A.		
12.2.1	The functional unit shall take into account the general rules outlined in Part I, clause 6.2.2 "Functional unit" and ISO 14044 [i.6], clause 4.2.3.2.	N.A.		
12.2.1	Additionally, the functional unit shall be defined so that it is applicable both to the ICT goods, networks and services product system and the reference product system.	N.A.		
12.2.1	The reference flow shall be defined to quantify the functional unit.	N.A.		
12.2.1	In other words, for the functional unit of one meeting, for instance, the reference flow for the systems of ICT goods, networks and services and the reference product system shall be defined.	N.A.		
12.2.2	Two different system boundaries shall be defined which are applicable for the ICT goods, networks and services product system and for the reference product systems respectively.	N.A.		
12.2.2	considerations shall be paid to which electricity is used when assessing the environmental impact of the ICT goods, networks and services product system and the reference product systems.	N.A.		
12.3	The calculation for the inventory analysis shall be performed in accordance with Part I, clause 6.3 of ETSI ES 203 199 [i.1].	N.A.		
12.4	The calculation for the inventory analysis shall be performed in accordance with Part I, clause 6.3 of ETSI ES 203 199 [i.1].	N.A.		
13	Any cut-off made during a study shall be clearly stated in the study report, e.g. the exclusion of life cycle processes which are considered insignificant should be justified.	N.A.		
Annex B	A mandatory list of generic activities (unit processes) that have been found to be of importance for LCA of ICT goods, Networks and Services can be found in Annex D of ETSI ES 203 199 [i.1].	YES		
Annex B	The following emissions shall be taken into account if applicable to the studied impact category(ies): • Emissions to air. • Emissions to water. • Emissions to soil.	YES		
Annex B	The following resource objects shall be taken into account if applicable to the studied impact category(ies): • Material resource use (or material depletion). • Energy resource use (or energy resources depletion).	YES		
Annex B	A list of emissions and resource objects that shall be included, if applicable to the studied product system and impact category(ies), can be found in Table G.1 of ETSI ES 203 199 [i.1].	YES		

Clause in ETSI ES 203 199 [i.1]	Requirement	Fulfilled	Not fulfilled	Explanation/Motivation
Annex B	Further, the following inputs shall also be included if applicable to the studied impact category(ies): • Electricity. Editorial: Electricity mandatory and always applicable? Other forms of delivered energy (district heating and cooling). Fuels (typically indicates the fuels are incinerated on-facility or in a vehicle connected to the facility). Primary products (products that are part of the final product in operation). Secondary products (products that are not part of the final product in operation). Transports, travel and other services (can be seen as a special non-material secondary product input).	YES		
Annex B	Finally, the following flows shall also be included if applicable to the studied impact category(ies): Water discharge (to municipal sewage or recipient). Waste fractions (residual waste fractions or waste fractions that need further treatment, also including material recycling and energy recovery). Product output (the main purpose with the unit process or activity).	YES		
Annex C	Any support activities included in the LCA scope shall be clearly reported in term of organization activities considered.	YES		
Annex D	G7….Other material shall be considered.	YES		
Annex E	Table E.1 of ETSI ES 203 199 [i.1] lists parts which shall be taken into account, when applicable to the ICT good (not ICT network), when performing an LCA of ICT goods, as well as the corresponding categories and unit processes.	YES		
Annex E	Table E.1 of ETSI ES 203 199 [i.1] lists parts and Assembly unit processes which shall be taken into account (if applicable to the LCA goal and scope and the studied product system) when performing an LCA of ICT goods, as well as the corresponding categories and unit processes.	YES		
Annex G	Table G.1 of ETSI ES 203 199 [i.1] contains elementary flows which shall be taken into account in LCA analyses for ICT.	YES		
Annex G	The substance names listed in Table G.1 shall be used in ETSI ES 203 199 [i.1].	YES		
Annex G	Deviation(s) from the requirements shall be clearly motivated and reported.	YES		
Annex H	Table H.1 of ETSI ES 203 199 [i.1] lists a minimum Raw Materials groups (chemicals, fuels, metals, plastics, packaging materials and additives) which shall be taken into account in LCAs of ICT goods, if applicable to the studied ICT product system.	YES		
Annex L	This annex contains Tables that shall be used to report the result of the assessment.	YES		
Annex L	Deviation(s) from the requirements shall be clearly motivated and reported.	YES		

History

Document history		
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