

Supplement

ITU-T L Suppl. 60 (06/2024)

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

Supplements to ITU-T L-series Recommendations

ITU-T L.1410 – Example of a life cycle assessment (LCA) of a mobile phone

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Supplement 60 to ITU-T L-series Recommendations

ITU-T L.1410 – Example of a life cycle assessment (LCA) of a mobile phone

Summary

Supplement 60 to ITU-T L-series Recommendations shows how a life cycle assessment (LCA) of an information and communication technology (ICT) good, such as a mobile phone, is performed by an ICT manufacturer, based on Recommendation ITU-T L.1410.

For compliance with ITU-T L.1410 all body text and annexes need to be considered when performing an LCA. The LCA presented in this Supplement is fully compliant with Recommendation ITU-T L.1410 as described in clause 6.2 of that Recommendation, except for a few deviations listed in the 'Reporting' clause 5.12 of this Supplement.

History *

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Introduction

This Supplement has been developed to demonstrate the application of [ITU-T L.1410] for the environmental assessment of the life cycle impact of a mobile phone.

This Supplement was developed jointly by ETSI TC EE and ITU-T Study Group 5 and was published respectively by ITU as Supplement 60 to ITU-T L.1410 and as [b-ETSI TR 104 080], which are equivalent in technical content.

[ITU-T L.1410] defines a set of requirements to reflect the quality that practitioners should strive for. In order to foster results of life cycle assessments (LCAs) becoming more transparent and, for the quality of data and LCA tools to improve over time, the present document applies the requirements outlined in [ITU-T L.1410] in the following pages. [ITU-T L.1410] requires that deviation(s) from the requirements are clearly motivated and reported. For further details regarding compliance refer to clause 6.2 of [ITU-T L.1410].

This Supplement is intended for LCA practitioners wanting to assess mobile phone environmental impact and 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 6.3 of [ITU-T L.1410].
- Comparative analysis between an ICT product system featuring mobile phones and a reference product system.

Supplement 60 to ITU-T L-series Recommendations

ITU-T L.1410 – Example of a life cycle assessment (LCA) of a mobile phone

1 Scope

This Supplement aims to present an example of an objective and transparent life cycle assessment (LCA) of a mobile phone.

This Supplement will provide an example of an LCA of a mobile phone fully compliant with [ITU-T L.1410]. This Supplement will be technically aligned with [b-ETSI TR 104 080].

This Supplement can be read by anyone aiming for a better understanding of LCA of mobile phones. However, this Supplement is especially intended for LCA practitioners with a prior knowledge of [ITU-T L.1410].

The purpose of this Supplement is to:

- provide an example of an LCA of a mobile phone, aligned with the requirements of [ITU-T L.1410] 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 [ITU-T L.1410] as reference, this Supplement will apply it for the LCA of a mobile phone. This Supplement is valid for all types of mobile phones.

While [ITU-T L.1410] defines a set of requirements which reflect the quality that practitioners should strive for, this Supplement 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 [ITU-T L.1410], as such comparisons would require that the assumptions and context of each study are exactly equivalent.

2 References

- [ITU-T L.1015] Recommendation ITU-T L.1015 (2019), *Criteria for evaluation of the environmental impact of mobile phones*.
- [ITU-T L.1410] Recommendation ITU-T L.1410 (2024), *Methodology for environmental life cycle assessments of information and communication technology goods, networks and services*.
- [ISO 14040] ISO 14040:2006, *Environmental management – Life cycle assessment – Principles and framework*.
- [ISO 14044] ISO 14044:2006, *Environmental management – Life cycle assessment – Requirements and guidelines*.

3 Definitions

3.1 Terms defined elsewhere

This Supplement uses terms defined elsewhere:

See clauses 3.1 and 3.2 of [ITU-T L.1410].

4 Abbreviations and acronyms

This Supplement uses abbreviations and acronyms:

See clause 4 of [ITU-T L.1410].

5 Example of an LCA of a mobile phone fully compliant with Recommendation ITU-T L.1410

5.1 Introduction

The purpose of this Supplement is to show how an LCA of a mobile phone, based on [ITU-T L.1410], is performed by an information and communication technology (ICT) manufacturer.

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

For compliance with [ITU-T L.1410] all body text and annexes need to be considered when performing an LCA, i.e., this example as such is fully compliant with [ITU-T L.1410] as described in clause 6.2 of [ITU-T L.1410] except for a few deviations listed in the 'Reporting' clause 5.12 of this Supplement.

5.2 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 depletion including mineral, fossil, and renewable 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 [b-ETSI TR 103 697], data availability and a screening, it is judged that beyond the mandatory CC, RDMR is enough to exemplify the application of [ITU-T L.1410].

NOTE 2 – Many more impact categories exist and just 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 an ICT good to external use cases to gain information about the typical environmental performance of an ICT good to assist in policy choices.

5.3 Scope definition

The studied product system is a mobile phone for business-to-consumer (B2C) with typical functionality such as voice, short message service (SMS) and Internet browsing. Except for 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 of [ITU-T L.1410]. 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 7.1.3 of [ITU-T L.1410] 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 are 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 [ITU-T L.1410] 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 [b-Galen]. 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 (such as factories, roads, vehicles and telecommunications) are excluded. Also, capital goods, such as 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 life cycle inventory (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.

5.4 System boundaries

Table 2 of [ITU-T L.1410] 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 end-of-life treatment (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.

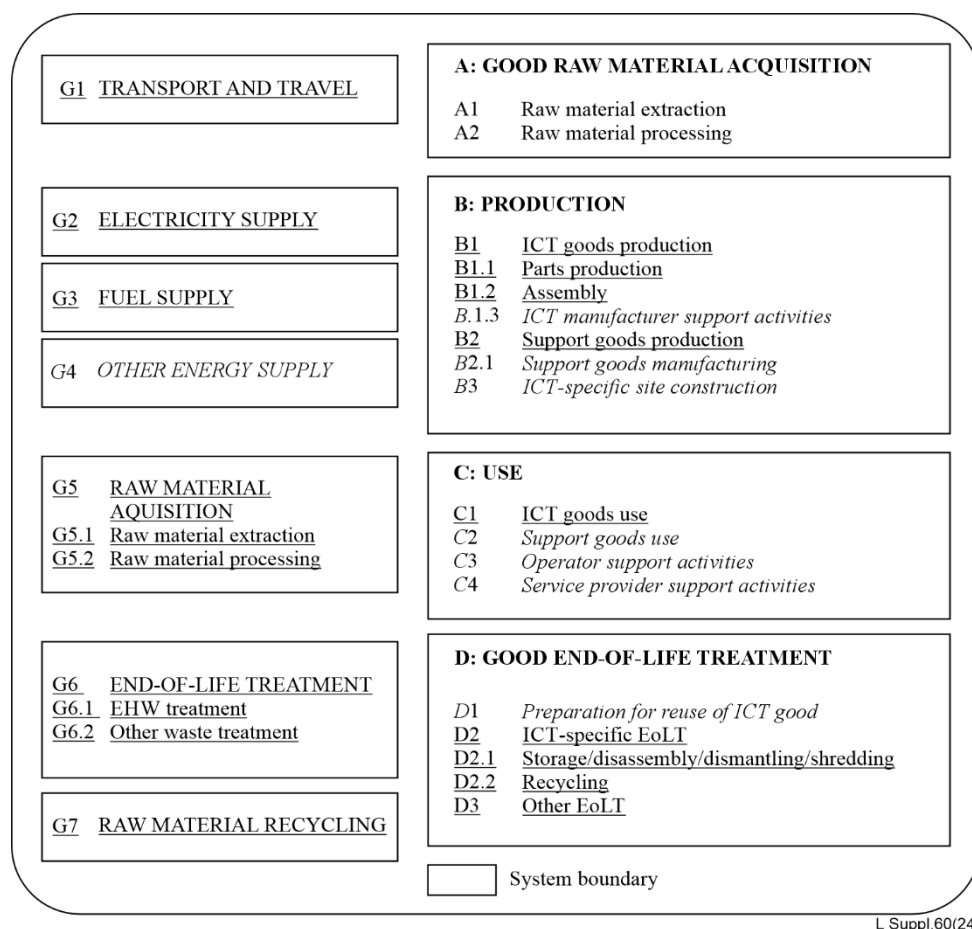
Moreover, C2, C3 and C4 are not applicable to the studied product system.

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 M.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.



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Figure M.1 – The system boundary of the product system for LCA of the mobile phone

5.5 Data collection

5.5.1 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, and external data sources. Data quality evaluation is always important, and the chosen approach needs to be motivated.

5.5.2 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.

5.5.3 Use (C)

Energy consumption during the mobile phone use stage in the described specific scenario is estimated based on the third alternative in clause 7.3.1.2.1 of [ITU-T L.1410] (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.

5.5.4 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).

5.5.5 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.

5.5.6 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.

5.6 Data calculation

This clause presents some examples of data calculations.

5.6.1 B1.1.1 Battery

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 Table E.1 of [ITU-T L.1410].

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

5.6.2 B1.1.2 Cables

There are no cables in the studied product system.

5.6.3 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.

5.6.4 B1.1.4 Integrated circuits, ICs

The mass and type (logic or memory) of each integrated circuit (IC) inside the mobile phone is identified, as well as the 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 ICs:

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

Where:

H = Die area of IC [cm^2]

I = Environmental loadings/ $(\text{cm}^2 \times \text{masklayer})$

J = $1/\text{front-end yield} \times \text{masklayers}$ for technology node (Scope 1,2,3 front-end)

K = Mass IC [kg]

L = $1/\text{back-end yield} \times \text{environmental loading/kg IC}$ (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 ICs:

$$M \times N$$

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 those described in section 5.2.1.1 of [b-ETSI TR 103 697].

5.6.5 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.

5.6.6 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 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:

$$\text{Active area of display in mobile phone, cm}^2 \times \left(\frac{\frac{\text{gCO}_2\text{e}}{\text{cm}^2}}{\frac{\text{gCO}_2\text{e}}{\text{g display LCI module}}} \right)$$

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

5.6.7 B1.1.7 PCBs

The areas and number of layers for each type of printed circuit board (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 those described in section 5.2.2 of [b-ETSI TR 103 697].

5.6.8 B1.1.8 Other PCBA components

The masses of other printed circuit board assembly (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.

5.6.9 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 [ITU-T L.1410] are shown anyway.

5.6.10 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.

5.6.11 B1.1.11 Software module

The main software component in this case is the operating system which according to clause 7.1.4 of [ITU-T L.1410] can be considered optional due to allocation difficulties. Software module has, therefore not been included. Other applications that users are able to install are also excluded.

5.6.12 B1.2 PCBA Module assembly

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

5.6.13 C1. ICT goods Use

The following method [ITU-T L.1015] is used to estimate the electricity consumption during the 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.

5.7 Allocation of data

5.7.1 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.

5.7.2 Production (B)

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

5.7.3 Use

There is no need for allocations within the use stage in this study.

5.7.4 Goods end-of-life treatment

100% of the mobile phones are assumed to go for global average ICT specific EoLT and waste electrical and electronic equipment (WEEE) recycling.

The circular footprint formulae (CFF) are used to calculate the EoLT loadings per f.u.

NOTE – To use CFF is not mandatory and other calculations methods can flexibly be used to address allocation and material use impact calculations.

5.7.5 Generic processes (G1-G7)

See Raw material acquisition and Production.

5.7.6 Support activities

No support activities have been intentionally included.

5.8 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 made 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 7.1.4 of [ITU-T L.1410].

5.9 Data quality

5.9.1 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.

5.9.2 Completeness (total LCA level)

90% of applicable LCI flows in Table G.1 of [ITU-T L.1410] are included in the LCI. The degree of coverage of the CC life cycle impact assessment (LCIA) indicator in Table L.10 of [ITU-T L.1410] is 98% based on mass. The degree of coverage of the RDMR LCIA indicator in Table L.10 of [ITU-T L.1410] is 98% based on mass.

5.9.3 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.