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Supplement for eco-specifications and rating criteria for mobile phones eco-rating programmes

ITU-T L-series Recommendations – Supplement 32

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ITU-T L-SERIES RECOMMENDATIONS

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

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Supplement 32 to ITU-T L-series Recommendations

Supplement for eco-specifications and rating criteria for mobile phones eco-rating programmes

Summary

Supplement 32 to ITU-T L-series Recommendations on eco-rating outlines a baseline assessment framework and defines a minimum set of criteria to be considered when assessing the environmental performance of mobile phones.

This Supplement is designed to enable manufacturers to assess mobile phones in order to demonstrate a minimum level of environmental performance and also to achieve enhanced environmental performance.

– clause 7 lists the criteria to consider when seeking compliance to the minimum level of environmental performance described in this Supplement;

– clause 8 addresses how products can achieve higher levels of environmental performance.

This Supplement does not promote any form of labelling and the methods by which ratings are displayed to consumers remain at the discretion of manufacturer or the sales entity.

History

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Introduction

It has recently been estimated that the sales of smartphones and mobile phones is around 2.3 billion units per year [b-Andrae, Edler, 2015]. To promote a more sustainable society, the information and communication technology (ICT) industry has recognized the need to provide relevant mobile phone information, especially with regard to environmental performance aimed at enabling consumers to make more informed purchasing decisions.

For several years, manufacturers and network operators have been reporting the sustainability credentials of mobile phones. However, inconsistencies among approaches cause confusion and have made comparisons difficult, and waste time and resources for both operators and manufacturers when collecting and providing very similar data.

This Supplement aims to help reduce detrimental effects, intends to deliver useful information to end users on the environmental performance of mobile phones and aligns with existing eco-rating programmes. This Supplement is written in a way so as to compliment the work represented in [UL 110].

This Supplement establishes a standalone, minimum set of requirements for mobile phones related to their environmental performance.

It should be noted that other documents e.g., [ITU-T L.1410] and [UL 110], can be used to complement these environmental performance baseline requirements for mobile phones.

It is acknowledged, however, that other aspects are important beyond environmental performance and beyond the environmental factors contained in this Supplement.

It is expected that the standardized approach in this Supplement can also make information available to original equipment manufacturers (OEMs) regarding best practices in the industry.

The following guiding principles have been utilized when preparing this Supplement:

– prioritization: focus on a primary group of attributes;
– alignment: complement or utilize other standards that are accepted by network operators and manufacturers;
– simplicity: provision of easy-to-understand information to consumers;
– differentiation: set a baseline to identify mobile phones that do not meet a minimum set of requirements and reference criteria from [UL 110] for demonstrating ambition levels above the baseline;
– transparency: provide stakeholders with information on the methodology;
– credibility: demonstrated collaboration of the mobile industry, with representatives from carriers or network operators and mobile phone manufacturers;
– consistency: Consider regional requirements.

Supplement 32 to ITU-T L-series Recommendations

Supplement for eco-specifications and rating criteria for mobile phones eco-rating programmes

1 Scope

This Supplement outlines an assessment framework and defines the baseline criteria to be considered by an eco-rating programme when assessing the environmental performance of mobile phones.

This framework establishes the basis for an eco-rating programme based on criteria that are relevant and transparent:

– relevance is important to ensure that the mobile phone is scored, against criteria having an environmental impact;

– transparency is the guarantee that all included criteria (and only these criteria) have been taken into account fairly.

In this context, the Supplement is intended to:

– identify attributes having an impact on the environmental footprint of a mobile phone;

– define the scoring method to quantify these impacts, reflecting the performance of the mobile phone from an environmental point of view.

This Supplement starts from the principles that an appropriate eco-rating programme should:

– apply to all mobile phones, irrespective of where the mobile phones are sold;

– address the market globally (e.g., national or regional aspects should not be taken into account by the eco-rating programme);

– work in concert with [UL 110] to identify advanced mobile phones implementing innovative solutions or functionalities.

This Supplement does not:

– mandate the consideration of any social or ethical aspects that might be associated with the design, manufacturing or marketing of mobile phones;

– include any aspects related to eco-labels (definition of the labels, criteria to obtain these labels, etc.).

Consideration was given to using life cycle assessments (LCAs) to compare products. The fact remains that the existence of several eco-rating programmes maintains some confusion within the user community. Initiatives exist to correct this situation, particularly under the leadership of operators seeking to align their own programmes (see Appendix III). However, this LCA approach is not included (see Appendices I and II).

This Supplement is intended to be used to facilitate global cooperation and is expected to be used in conjunction with other complementary international standards.

Figure 1 illustrates the aspects that are or are not in the scope of this Supplement.

2 References

[ITU-T L.1000] Recommendation ITU-T L.1000 (2011), *Universal power adapter and charger solution for mobile terminals and other hand-held ICT mobile phones*.

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

[IEC 61249-2-21] IEC 61249-2-21:2003, *Materials for printed boards and other interconnecting structures – Part 2-21: Reinforced base materials, clad and unclad – Non-halogenated epoxide woven E-glass reinforced laminated sheets of defined flammability (vertical burning test), copper-clad*.

[IEEE 1680.1] IEEE 1680.1 (2009), *IEEE standard for environmental assessment of personal computer products, including notebook personal computers, desktop personal computers, and personal computer displays.*

[ISO 1043-1] ISO 1043-1:2011, *Plastics – Symbols and abbreviated terms Part 1: Basic polymers and their special characteristics.*

[ISO 11469] ISO 11469:2016, *Plastics – Generic identification and marking of plastics products.*

[UL 110] UL 110 (2012), *Standard for sustainability for mobile phones.*

3 Definitions

3.1 Terms defined elsewhere

This Supplement uses the following term defined elsewhere:

3.1.1 mobile phone [b-ITU-T K.49]: Portable terminal equipment used for communication and connecting to a fixed telecommunication network via a radio interface.

3.1.2 primary energy [ITU-T L.1410]: The energy content of natural resources which can be used for energy production.

3.2 Terms defined in this Supplement

This Supplement defines the following terms:

3.2.1 homogeneous material: A material of uniform composition throughout or a material, consisting of a combination of materials, that cannot be disjointed or separated into different materials by mechanical actions such as unscrewing, cutting, crushing, grinding and abrasive processes.

3.2.2 maintenance release: Software or firmware update to enable a mobile phone to continue to operate as it was intended at the point of sale.

3.2.3 reference package: List of physical items (mobile phone, accessories, documentation, etc.) that is always used in its entirety by the manufacturer when claiming compliance with the criteria described in the Supplement. A reference package is defined by the manufacturer.

4 Abbreviations and acronyms

This Supplement uses the following abbreviations and acronyms:

5R	Rethink, Reduce, Recycle, Refurbish, Resale
ADP	Abiotic (resource) Depletion Potential
AMOLED	Active-Matrix Organic Light-Emitting Diode
CS	Corporate Sustainability
CSTN	Colour Super-Twist Nematic
DDR	Double Data Rate
e-MMC	electronic Multimedia Card
ENIG	Electroless Nickel Immersion Gold
GHG	Greenhouse Gas
GSM	Global System for Mobile Communications
GWP100	Global Warming Potential at 100 years
HVAC	Heating, Ventilation, and Air Conditioning
IC	Integrated Circuit
ICT	Information and Communication Technology
ILCD	International (reference) Life Cycle Data (system)
ITO	Indium–Tin Oxide
LCA	Life Cycle Assessment
LCD	Liquid Crystal Display
LCIA	Life Cycle Impact Assessment
MLCC	Multilayer Ceramic Capacitor
NAND	Not And (electronic logic gate)
OEM	Original Equipment Manufacturer
PCB	Printed Circuit Board
PCR	Product Category Rule
PGM	Platinum Group Metals
RAM	Random Access Memory
RF	Radio Frequency
SDRAM	Synchronous Dynamic Random Access Memory
TFT–LCD	Thin-Film Transistor–Liquid Crystal Display

5 Conventions

None.

6 Introduction to eco-rating programmes

Historically, the main objective of an eco-rating programme for mobile phones was to evaluate their environmental and sustainability attributes.

Eco-rating programmes were based on two main principles:

1) collection of information and estimation of the environmental impact of mobile phones; and

2) assessment of the different types of mobile phones through scoring methods unique to each rating scheme.

Typically, eco-rating programmes followed a common five-step process that results in three outcomes, as illustrated in Figure 1.

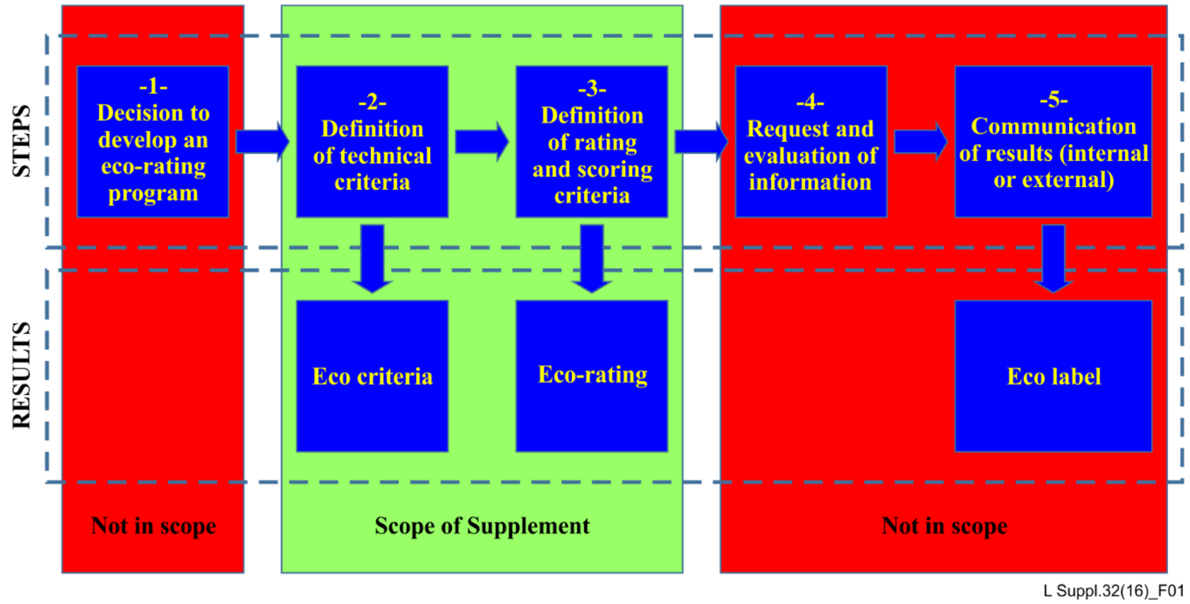

Figure 1 – Eco-rating programme common process steps and outcomes

Organizations or companies may decide to develop eco-rating programmes for mobile phones, as indicated in step 1 of Figure 1, based on specific needs, such as consumer demand, corporate sustainability (CS) initiatives or environmental footprint assessment.

Step 2 reflects the activity of defining the technical criteria required to assess the environmental and sustainability performance of mobile phones. These criteria are mostly based on life cycle assessment (LCA) principles and responsible mobile phone design features. This process requires technical expertise and a detailed description of the various attributes to be evaluated.

Step 2 results in the identification of eco criteria. Each criterion is the compiled result of the detailed evaluation of the technical and comparison specifications defined in step 2 of the eco-rating programme.

In step 3, a scoring methodology is described, taking into account the different eco-specification criteria identified and selected for the evaluation of the mobile phone. Step 3 leads to the creation of an eco-rating used to rate mobile phones.

After the definition of the eco-specifications and rating criteria, step 4 initiates the process of assessment, based on information and technical details provided by mobile phone manufacturers.

Last, step 5 communicates the results of the mobile phone evaluation. This communication results in a public disclosure process of eco-rating information through websites, in-store merchandizing, etc., and made available online or at points of sale. The results of the eco-rating process are presented under a particular scheme, e.g., logo or figure.

The compilation of data needed to evaluate primary energy consumption, use of raw materials and potential greenhouse gas (GHG) emissions remains an indispensable process for assessing the environmental impact associated with a product. This process is complicated and can seem expensive for mobile phones whose lifetimes are relatively short, and for which technology is changing very quickly. In this context, this Supplement aims to define a limited set of criteria to be verified by a product claiming to limit its environmental impact. Attributes listed in Appendices IV and V will also be considered for inclusion in any future edition of this Supplement.

7 Eco criteria

7.1 Mobile phone sustainability and responsible design

7.1.1 Product durability, reparability and serviceability

Prolonging the useful life of a mobile phone is one of the most effective ways of reducing overall product environmental impact, as it delays the need for a replacement, and hence use of additional natural resources and emissions of carbon. Therefore it is important to consider the elements listed in clauses 7.1.1.1 to 7.1.1.3.

7.1.1.1 Mobile phone compliance with [ITU-T L.1000]

Incompatibility of chargers for mobile phones is an environmental challenge potentially creating quantities of waste. To promote harmonization, conformance with [ITU-T L.1000] should be recognized.

7.1.1.2 Mobile phone firmware/software updates and maintenance releases

Prolonging product useful life is one of the effective ways of reducing overall product environmental impact, as it delays the need for a replacement and hence use of additional natural resources and carbon emissions.

Providing firmware/software updates can prolong the life of a mobile phone by providing maintenance releases for the period of the manufacturer's warranty when technically possible.

7.1.1.3 Mobile phone personal data transfers to a new phone

Simplifying the transfer of data from an old to a new mobile phone should allow the old phone to be more readily reused or recycled, hence reducing overall resource demands.

Tools for simplifying personal data transfers could take the form of an application (app), a cloud based service or instructions detailing a manual process. Personal data transfers should include at a minimum camera-generated images and videos, and contacts. Instructions of tools should be publicly posted or made available on the mobile phone itself.

7.1.2 Use phase power consumption

Power consumption is a key area where manufacturers are improving their mobile phones.

7.1.2.1 Manufacturer-provided information on reduced energy phone usage

Mobile phone manufacturers are often in a position to provide detailed information about mobile phone energy usages under various operating conditions.

This information could be used to advise consumers on how to minimize battery discharge. Other possibilities may include standby energy saving settings that are automatically activated after a certain period of time. It may also include the flight-safe mode that switches off the transmit/receive functions. This information should be made available on the handset menu or on the manufacturer's website.

7.1.2.2 External power supply average efficiency and no-load power

The primary manufacturer-specified external power supply meets the minimum requirements of [ITU-T L.1000] or criterion 10.2 of [UL 110].

7.2 Sustainable materials

The use of sustainable materials is key in managing resources, as is the reduction of substances of concern, whether for environmental, social or health reasons, as described in clauses 7.2.1 to 7.2.5.

7.2.1 Mobile phone material restriction aspects

Information should be publicly posted, listing mobile phones that meet the requirements of the current EU Restriction of hazardous substances [b-EU RoHS, 2011] Directive provisions (including applicable exclusions and exemptions) or the [UL 110] in effect at the time the product is first sold, for the material restriction aspects of the [b-EU RoHS, 2011] Directive.

Refurbished products should continue to meet the [b-EU RoHS, 2011] Directive provisions or [UL 110] criteria that were in effect at the time the product was put on the market the first time.

7.2.2 Mobile phone battery material restriction

Indications should be publicly posted, listing whether the mobile phone meets the material restriction requirements of the current EU Battery Directive [b-EU BD, 2006] or criterion 11.1 of [UL 110].

7.2.3 Mobile phone dangerous material restriction

Indications should be publicly posted, listing whether the mobile phone meets the material restriction requirements of Annex XVII to the EU Registration, evaluation, authorisation and restriction of chemicals [b-EU REACH, 2006] regulation, in effect at the time the product is first sold or clause 8.2 of [UL 110].

7.2.4 Mobile phone homogenous material limit

Indications should be publicly posted, listing whether the mobile phone does not contain more than the homogeneous material limit of any material listed in a required criterion within [UL 110], in effect at the time the product is first sold.

To encourage manufacturers to produce equipment going beyond the basic requirements of [b-EU REACH, 2006], conformance with [UL 110] should be rewarded.

7.2.5 Low halogen electronics

Indications should be publicly posted, listing whether the mobile phone meets 900/900/1 500 mg/kg bromine and chlorine restrictions for printed board laminates as per the requirements of [IEC 61249-2-21] or criterion 11.5 of [UL 110].

7.3 Packaging and logistics efficiency

Packaging and logistics efficiency are also key measures, as described in clause 7.3.1.

It should be noted that criteria related to packaging and logistics apply to the reference package as defined by the manufacturer.

7.3.1 Packaging and printed material

7.3.1.1 Product volume ratio

Indications should be publicly posted, listing the ratio of the total volume of the product, user guide and accessories to the volume of one outer point of sale packaging as defined by the manufacturer.

It is expected that manufacturers will minimize the total volume of the package to increase the efficiency of the supply chain. The ratio of the total volume of the product should achieve the minimum performance value as defined in criterion 15.8 of [UL 110].

7.3.1.2 Dissimilar packaging material

Dissimilar materials used in the packaging whose masses are greater than 25 g should be separable.

Recyclability of packaging materials can only be achieved domestically (the route that most of the mobile phone packaging will go down) if it can be easily separated into its constituent materials (see criterion 4.8.2.1 of [IEEE 1680.1]).

7.3.1.3 Plastics packaging marking

Plastics packaging should be marked according to [ISO 11469], [ISO 1043-1] or country specific marking.

It is good practice that total plastics materials be marked accordingly for parts whose masses are greater than 25 g. A recyclable item of packaging that is not marked as recyclable may still not get recycled.

7.3.1.4 No printed complete user manual

Unless required by regulation, the mobile phone should come without a printed complete user manual.

Manuals add mass and volume to packaging. Excluding texts required under regulatory safety or other legal constraints, it is expected that the reference package will not include any physical manual. This requirement does not apply to separately printed material regarding the warranty; regulatory or safety information; a getting-started or quick start guide that only provides essential information necessary for the device to be powered up for the first time.

7.4 Product repair and end-of-life

To assess the disposal impact of the product, we evaluate the parameters described in clauses 7.4.1 and 7.4.2.

7.4.1 Phone disassembly for recycling and proper end-of-life disposal

It is good practice that a mobile phone can be disassembled for recycling and proper disposal at the end of life.

This should allow recycling professionals, without the use of tools or by using commercially available tools (i.e., tools available for purchase publicly), to facilitate disassembly for removal of components requiring special treatment (e.g., battery and external cables) prior to recycling.

7.4.2 Repair of the mobile phone

Repairing a mobile phone prolongs its useful life; this is one of the most effective ways of reducing overall product environmental impact. Posting repair information online or otherwise providing information publicly regarding repair services including providing contact details allows customers to utilize proper repair services.

Manufacturers should provide repair services through a programme that may include the use of manufacturer-authorized professionals and which must be provided to customers in the markets where the manufacturer retails the mobile phone, at least for the duration of the warranty.

8 Eco-rating scheme and scoring methodology

The eco-rating scheme should be designed to provide simple, transparent and consumer-focused environmental information to empower consumer choice and to influence original equipment manufacturers (OEMs) on sustainable design.

Baseline requirements are established in this Supplement. A mobile phone must achieve these baseline requirements in order to be considered as "eco-qualified" in accordance with this Supplement.

Enhanced environmental performance can be demonstrated in accordance with the optional points, scoring and ranking methodology described in [UL 110].

9 Eco-rating validation process

This Supplement provides the minimum criteria and methods to collect the data necessary to demonstrate compliance for eco-rating.

The method by which a party applies these eco-rating criteria to a product is designed to be operated on a voluntary basis.

In particular:

– the methods should be managed to ensure consistency by the operatives within the manufacturing and distribution supply chain;

– the methods used to run the eco-rating programme should be designed to be consistent with this Supplement;

– the data or other evidence generated as a result of the eco-rating process shall be accurate and traceable.

It remains the sole responsibility of the organization(s) managing the eco-rating programme to demonstrate compliance with this Supplement.

Appendix I

Why LCA methods are not yet included in this Supplement

Information and communications technology (ICT) is a key element in the industry response to climate change; numerous standards bodies and industry consortia are working on standardized methodologies to evaluate the environmental impact of ICT products, networks and services. Their approaches are based on life cycle assessment (LCA).

LCA examines the environmental impact of a product or service over its life – from the extraction of raw materials to product disposal, including manufacture, distribution and use. Some methodologies have been published and others are in final draft stages.

Each methodology sets out clear objectives, but LCA is a complex tool. The result is that this could lead to considerable confusion regarding what these approaches can and cannot do. There could also be confusion over what is being measured – the environmental impact of ICT products and services or the ICT sector as a whole.

The result, predictably, is that expectations may exceed the capabilities and stated objectives of these methodologies. In particular, there seems to be an expectation that LCA can deliver all of the answers, when in fact it is designed to do something much more specific.

As with any tool, LCA should be used for the purpose for which it was designed: for identifying the most environmentally impactful points in the life cycle and directing reduction efforts accordingly. LCA is also appropriate for comparing the environmental impact of different supply chains (e.g., sourcing copper in Australia as opposed to Brazil) or comparing different technologies [e.g., reading a (physical) newspaper compared to using an e-reader], under conditions where assumptions, formulas, data sources, boundaries conditions, etc. are identical.

If these conditions are not verified, LCA cannot provide a reliable means of comparing similar products (e.g., one smart phone with another). This is primarily because of the degree of uncertainty associated with LCA outcomes. Many choices and assumptions have to be made for complex products and their supply chains. This is particularly problematic if LCA is to be used at the point of purchase for consumer information on environmental performance of one product versus another.

However, if both LCAs use the same methodology, data sources, formulas, etc., and the mobile phones have comparable technical functions and physical characteristics, the results of two different LCAs of mobile phones can be comparable where these mobile phones are produced by different manufacturers.

Therefore, the use of LCA to compare products in a meaningful way needs well defined and internationally accepted product category rules (PCRs), as well as an obligation to use exactly the same methodologies and assumptions with the objective to reduce the level of uncertainties.

Appendix II

Considerations regarding inclusion of LCA data

II.1 Rationale

When preparing this Supplement, the experts recognized that materials have impacts on the environmental performance of ICT mobile phones.

Typically, a measurement of screen size, printed circuit board (PCB) area and integrated circuit (IC) density provides a relatively quick indication of the amount of material utilized by a given mobile phone. Essentially, the higher the figure, the greater the amounts of material resources utilized and the lower the figure, the lower.

However, in general it was also recognized that a low-tier mobile phone containing less material (i.e., one with a lower LCA rating) will likely also have fewer features and less functionality than a high-tier, so-called "smartphone", which by necessity has a larger screen, larger PCB surface area or higher IC density..

Moreover, having access to the advanced features available with a high-tier smartphone may reduce the need for an end-user to purchase additional consumer ICT products, such as a satellite navigation system device, compact camera or compact video recorder. Hence, in order to present the net environmental impact of a product, the LCA calculation for material usage must be counterbalanced directly against any additional features and functionality.

In order to achieve this, a meaningful (from an end-user perspective), workable, functional, standards-based, and independently verifiable measurement methodology must be developed to categorize each type of feature or functionality that a new smartphone may employ and add a weighting function to offset or counterbalance the simplified LCA material usage rating.

Failure to take additional functionality into account in order to counterbalance the proposed simplified LCA criteria will result in high-tier smartphone products bearing the worst eco-ratings, comparable to large screen low-tier phones that lack such features. In this case, allocating the lowest eco-rating to a high-tier smartphone may provide a partial estimate of the environmental impact for end users to consider.

On the other hand, developing such a counterbalance system would:

– be unduly complex and potentially subjective;
– need all existing mobile phone features and functionalities to be catalogued and weighted to represent likelihood of reducing net environmental impact due to technological convergence, eliminating the need for the consumer to buy additional ICT products;
– need to be built in such a way that forthcoming features or functionalities (yet to be designed) could be rated and weighted in order to ensure consistency and ongoing viability of the rating system.

To overcome this issue, some eco-rating programmes use a so-called functionality moderator by which a phone can benefit from (for example):

– the number of personal mobile phones it could replace;
– the number of applications that could improve the "sustainability behaviour" of the user of the mobile phone;
– the possibility to perform near field communication;
– the possibility to perform video-conferencing.

An appropriately defined functionality moderator can show the positive possibilities of smartphones compared to less advanced phones.

If used only based on LCA criteria, an eco-rating programme will score a small mobile phone better than a very large smartphone. On the other hand, when a functionality moderator is appropriately developed, a smartphone can score better than a low-feature phone.

II.2 Conclusions

Given these obstacles, it is premature and not yet viable to only include simplified LCA criteria within an international standard, without assessing the impact of advanced functionalities.

Inclusion of both simplified LCA criteria and advanced functionalities must be based on methods described in this Supplement that are standard based, consistently measured (irrespective of who undertakes the assessment) and independently verifiable.

If it is deemed necessary to define categories of smartphones (i.e., low-, mid- and high-tier) in order to enable comparability, it must be done in a consistent and meaningful way. However, this is compounded by technical convergence and rapid evolution.

These obstacles should be considered in any discussions relevant to the inclusion of simplified LCA criteria.

Appendix III

Discussions about LCA, eco-design and eco-rating

III.1 Introduction

As shown in [b-Andrae *et al*., 2016], due to the high competition between companies, the industry is acting resourcefully and a lot of progress has been made to develop eco-friendly equipment, in particular by considering LCA results. LCA can be used to support eco-design by adding up all design measures into one score [b- Andrae, 2016].

However, data collection for an LCA used within the design process should not take a longer time than other data collection, suggesting that simplified or rapid LCA methods are the most feasible. The data quality should, of course, still be high enough, despite the LCA calculations being rapid.

Previous research shows that application of LCA and eco-design have both been improved and expanded, owing largely to the development of more environmentally friendly materials, newly emerging technology, and legislation mandating better handling of consumer electronics – both in manufacturing and in waste treatment. Generally, academic research is good at finding more or less complicated approaches for eco-design that treat sustainability as a separate issue from the actual design. This is not wrong *per se*, but industry usually prefers practical tools that are integrated into the design process. Alternatively, LCA experts in industry give opinions about the sustainability credentials of design concepts.

To some degree, eco-rating tools combine with eco-design methods as, occasionally, their criteria can be used as eco-metrics and total scores can be used as targets for next generation products. At this point, reaching a certain eco-rating score could be one of the requirements in the design process.

The fact remains that the existence of several eco-rating programmes maintains some confusion within the user community. Initiatives exist to correct this situation, particularly under the leadership of operators seeking to align their own programmes.

III.2 Open Eco Rating (OER)

The Open Eco Rating programme claims to combine the best elements of several network rating systems. It replaces the eco-ratings used by Telefónica O_2, Vodafone and Orange, so that these networks can now share a common eco-rating across all mobile devices they offer.

OER consists of four aspects:

1) corporate performance;
2) simplified proxy LCA;
3) responsible design;
4) functionality moderator;

and 85 criteria.

Simplified proxy LCA is measured by the global warming potential at 100 years (GWP100) and abiotic resource depletion potential (ADP) indicators.[1]

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[1] ADP is based on CML characterization factors from "Problem oriented approach: non baseline (CML, 2001) – abiotic depletion (elements, reserve base) – ADP elements [b-Van Oers *et al*., 2002]".

III.2.1 Corporate score

The Corporate aspects are outside the scope of this Supplement.

III.2.2 Simplified proxy LCA

The model for simplified proxy LCA is based on full LCAs of mobile phones. It shows, rather well, the absolute impact of an individual phone and that, generally, a phone with a larger display and more advanced functionalities (e.g., large storage memory capacity) has a higher absolute environmental impact than a simple or low-tier one. The benefits obtained by using lower amounts of gold, tin, silver, tantalum and indium make it possible to improve the LCA score. Moreover, the lower eco-rating scores obtained for GWP100 by larger or advanced phones in simplified LCA are somewhat balanced by more functionalities not provided by smaller phones. Still, the simplified LCA aspect should be improved with more criteria, such as renewable electricity.

III.2.3 Responsible design

This aspect represents several unique characteristics of a phone, such as materials content, packaging material types, power efficiency, reparability and durability.

III.2.4 Functionality

This aspect of OER queries whether the mobile phone under evaluation replaces the need for three different hardware devices, e.g., digital camera or a GPS. Many large or advanced smartphones will score rather well (high), whereas small budget phones will score worse (low). The precision of this crude approach is debatable, but still no agreed approach exists to include the functionalities in the simplified proxy LCA.

III.3 Summary

The simplified LCA score is not easily improved as currently calculated in OER. However, the approach facilitates a balance between improved material efficiency and linearly increasing GWP100 scores. In the next version of OER, the possibility of adding renewable energy to the model would bring the OER closer to a full LCA and other LCA approaches used in eco-design methods.

Functionality and 5R (rethink, reduce, recycle, refurbish, resale) are not integrated at the moment in the LCA aspect, but are to a certain degree in the responsible design aspect. Moreover, the use of renewable energy is included to some degree in the corporate aspect.

In summary, the unfair limitations of OER LCA are not crucial for the overall OER score and all manufacturers will be treated equally. OER aims at roughly right instead of precisely wrong. [UL 110] and OER both help push mobile phones in a more sustainable direction. [UL 110] has a ranking system with e.g., certified and platinum levels, whereas OER is yet to establish the levels for different segments.

From a wider perspective, it remains to be seen whether eco-rating can replace other eco-evaluation tools altogether, within the design process of consumer electronics. Clearly, eco-rating methods generally have clearer possibilities of rewarding elimination of unsustainable materials than LCA.

Appendix IV

Importance of climate change, primary energy consumption, and abiotic resources depletion

IV.1 Introduction

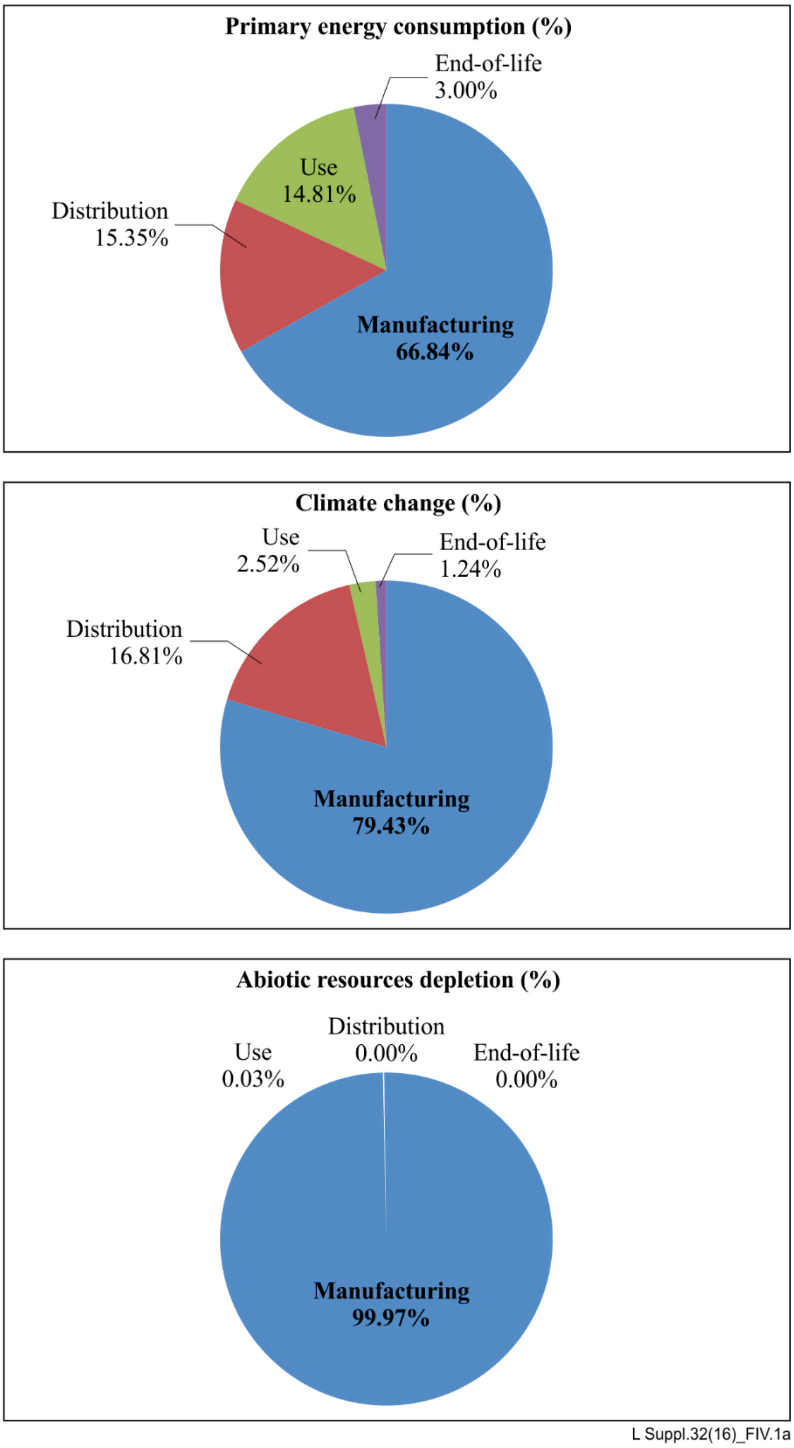
From 2012 to 2014, an operator carried out full LCAs (cradle-to-grave scope, including raw material extraction, manufacturing, distribution, use and end-of-life stages) for three different mobile phone tiers, with a functional unit defined as "use the mobile phone for 2 years in France". The same assumptions and boundary conditions were used for each of the LCAs. Moreover, several LCAs with a more limited scope (only one life cycle stage or restrictions to specific parts of the mobile phone, such as main electronic board) have also been achieved, confirming the results shown in Table IV.1. For further reference about the method used to carry out these three LCAs, refer to [b-Andrae, Vaija, 2014].

Table IV.1 – Definition of mobile phone tiers

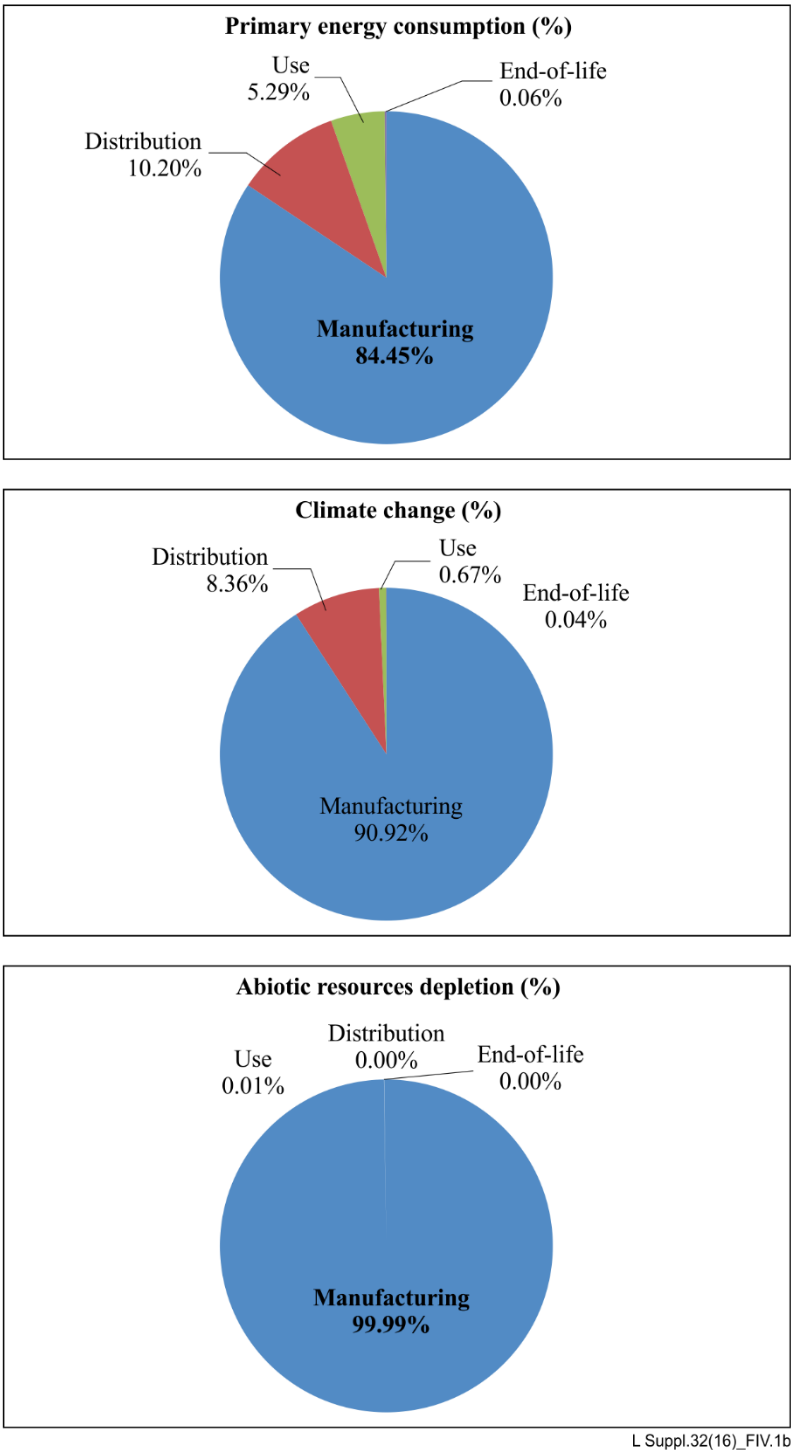
	Mobile phone tier 1	**Mobile phone tier 2**	**Mobile phone tier 3**
CPU (number of core; frequency)	Integrated chip with GSM baseband, RF transceiver and power management capabilities	1; Between 500 MHz and 1 GHz	2 Or more ; more than 1 GHz
RAM memory capacity	Less than 4 MB	Between 256 MB and 512 MB	More than 1 GB
Flash memory capacity	Less than 32 MB	Between 512 MB and 4 GB	More than 16 GB
Display (technology; colours)	CSTN or TFT–LCD; 65 k colours	TFT–LCD; 256 k colours	AMOLED or TFT–LCD; 16 M colours
Display size	Less than 46 mm (1.8 inches)	Between 64 (2.5) and 102 mm (4.0 inches)	More than 102 mm (4.0 inches)
Touchscreen	No	Yes	Yes
Touchscreen technology	N/A	Capacitive touchscreen	Capacitive touchscreen
Camera resolution	No camera or less than 0.3 MP	Between 2 and 5 MP	More than 8 MP
Ability to browse internet using web browser	No	Yes	Yes
AMOLED: active-matrix organic light-emitting diode; CSTN: colour super-twist nematic; GSM: global system for mobile communications; N/A: not applicable; TFT–LCD: Liquid crystal display–thin-film transistor.			

Based on these LCAs, results have been obtained for several impact indicators, such as climate change, primary energy consumption or abiotic resources depletion.

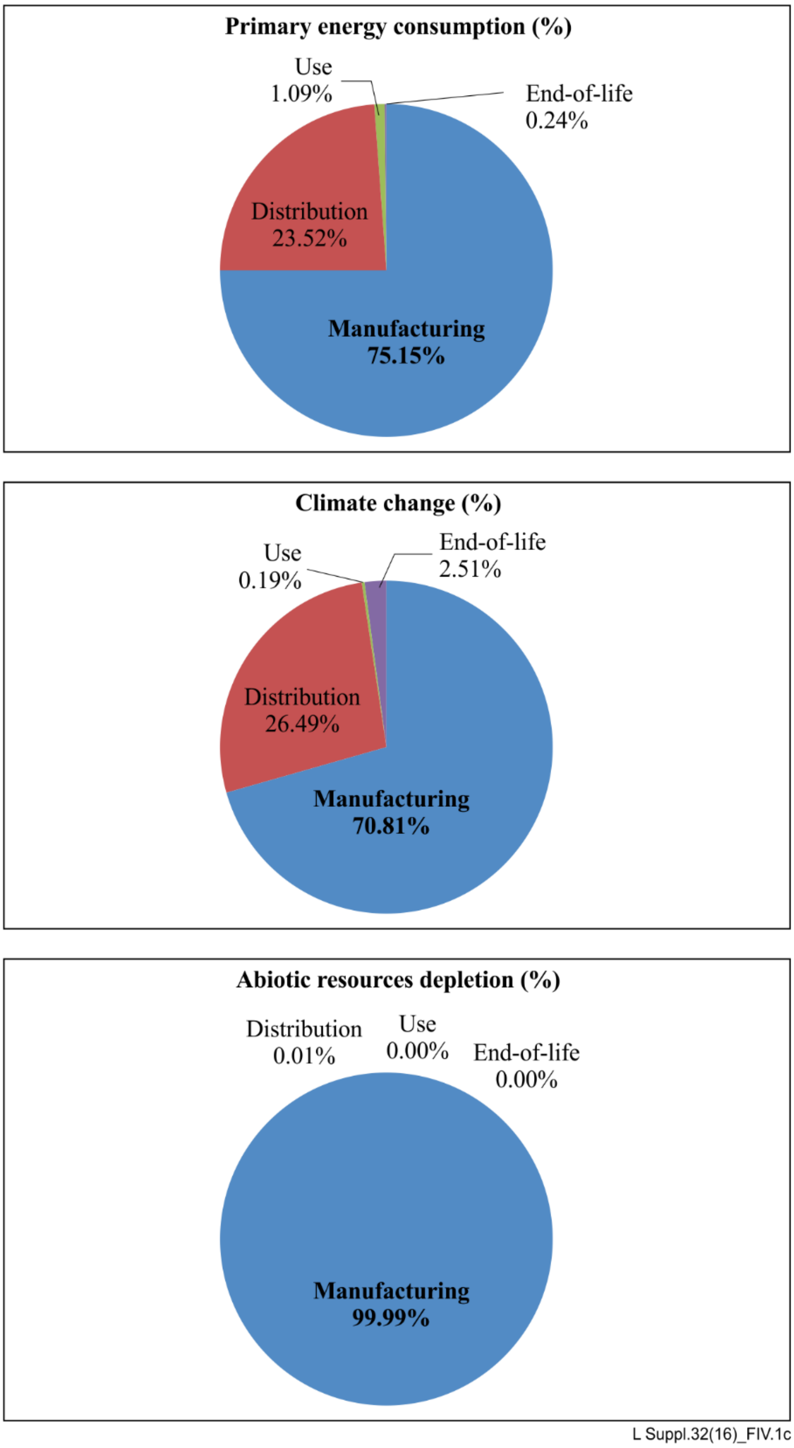
Figure IV.1 shows the results for the three impact indicators for the three types of mobile phone.



a) Mobile phone tier 2



b) Mobile phone tier 3



c) Mobile phone tier 1

Figure IV.1 – Overall results of LCA studies

Several lessons can be derived from the LCA studies. Typically, it should be noted that, for the three LCAs and for all the studied impact indicators, the manufacturing phase is the most significant.

For climate change and primary energy consumption, the distribution phase is also a key factor due to the impact of the air transport of the assembled product from Asia to France.

For the use phase, the French electricity mix (based on the *European life-cycle database* [b-ELCD, undated]– Electricity mix 230 V, France – FR" database) was used. As in France, electricity is mainly generated by nuclear power; the impact on the climate change indicator is not significant. If an electricity mix applicable for the People's Republic of China was used instead, the results would have been different (see Figure IV.2).

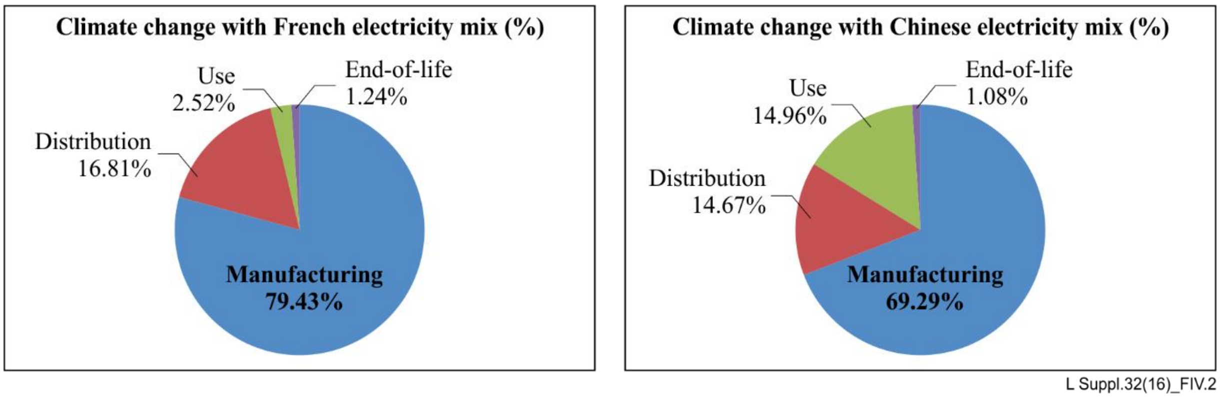


Figure IV.2 – Comparison of impacts of French and Chinese energy mix on climate change indicator for mobile phone tier 2

Note that the distribution of the environmental impact on climate change in the life cycle of mobile phone tier 3 carried out by operators is similar to the distribution of impacts seen in the manufacturer's environmental report (see Figure IV.3).

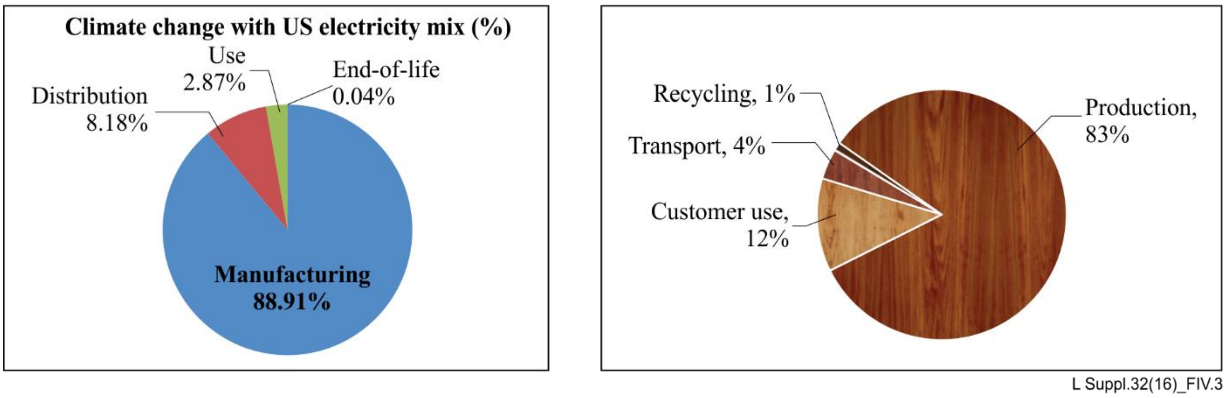


Figure IV.3 – Comparison for climate changes between operators LCA and manufacturer's environmental report

In order to better identify the relevant items for the manufacturing part, the life cycle stage was assessed in detail for the three mobile phones.

Focusing on the mobile phone tier 2 and its packaging, it appears that the key element is the mobile phone with its battery for both impact indicators (climate change and abiotic resources depletion). It should be noted that the point of sale packaging contribution was found to be negligible in these LCAs (see Figure IV.4).

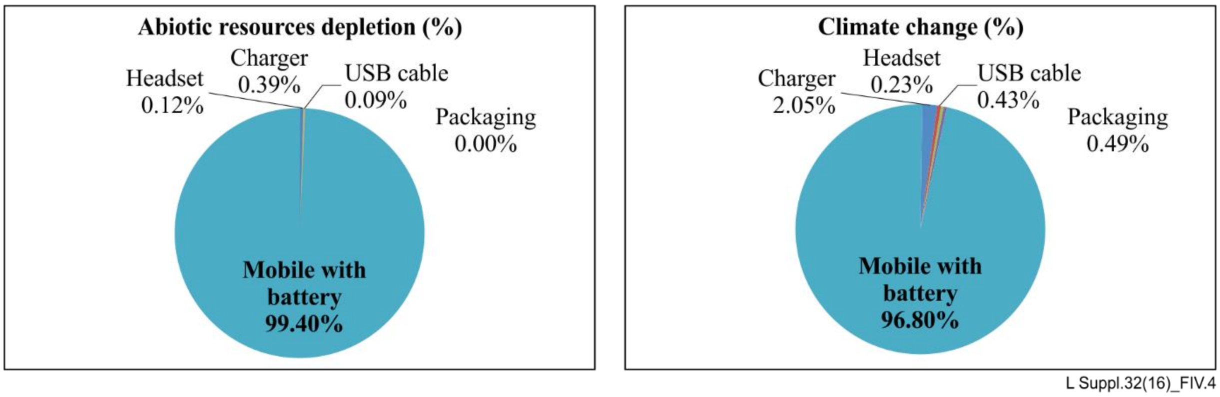


Figure IV.4 – Abiotic resources depletion and climate change indicators for mobile phone tier 2 with its packaging

Focusing on the mobile phone tier 2 with its battery, the most important impacting part is the screen for abiotic resources depletion potential (see Figure IV.5). This can be explained by the use of indium contained in the indium–tin oxide (ITO) layers of the TFT–LCD and touch panel. For this LCA, the [b-CML, 2002] methodology was used in order to assess the abiotic resource depletion environmental impact. This method is recommended by the European Joint Research Centre (see clause 3.9 of [b-JRC]) and is part of the international reference life cycle data system (ILCD) life cycle impact assessment (LCIA) [b-ILCD]. It is based on the reserve base approach and uses antimony as a reference in order to establish a characterization factor of substances. For indium the characterization factor is equal to 5.55E+2, for comparison gold's characterization factor is 3.6E+1 and that for silver is equal to 8.42E+0 [b-CML–ADP]. The touch panel and TFT–LCD models also contain gold (e.g., for the wire bonding in the touchscreen controller integrated circuit) which also contributes to the high impact of this sub-assembly.

As far as abiotic resource depletion is concerned, the motherboard is the second key criterion because of the gold, silver, platinum group metals (PGMs), tin, copper and tantalum contained in the different components.

For the climate change indicator, the most important part impacting climate change is the motherboard. Indeed, this sub-assembly contains active components with large silicon dies manufactured in cleanrooms. These facilities require large quantities of energy for heating, ventilation and air conditioning (HVAC) and filtration systems.

The screen (TFT–LCD and touch panel) is also a major criterion for the climate change indicator, as TFT–LCD manufacturing also utilizes cleanroom processing similar to semiconductor production. Even if the scale of the transistor channel length is in the 2–4 µm range (instead of IC, whose critical dimension is being driven down to nanoscale to increase computing speed and reduce cost) and the manufacturing stage only requires four to eight mask-steps [instead of 40 for not AND (NAND) flash memory], the surface of the screen is much larger than the area of the silicon dies.

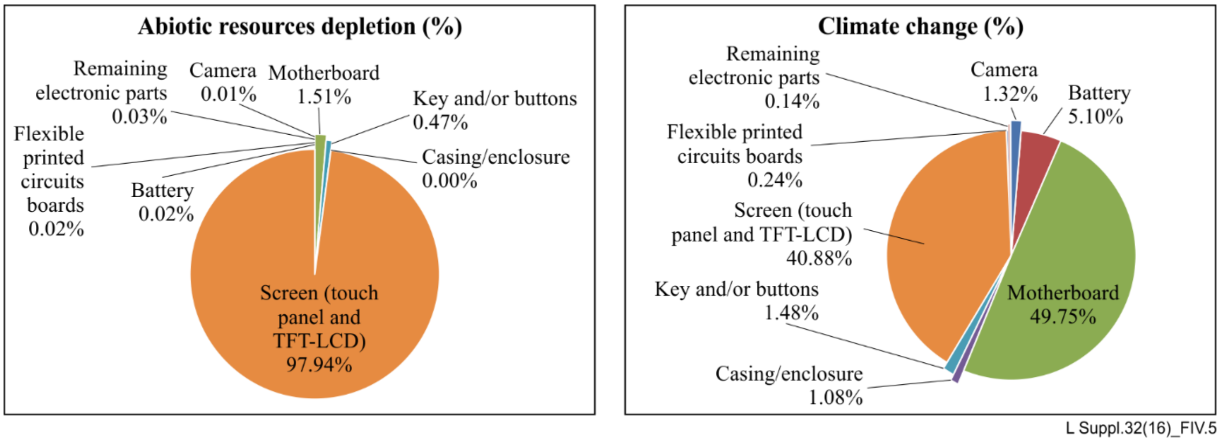


Figure IV.5 – Abiotic resources depletion and climate change indicators for mobile phone tier 2 with its battery

Several key sub-assemblies in the motherboard have been identified (see Figure IV-6).

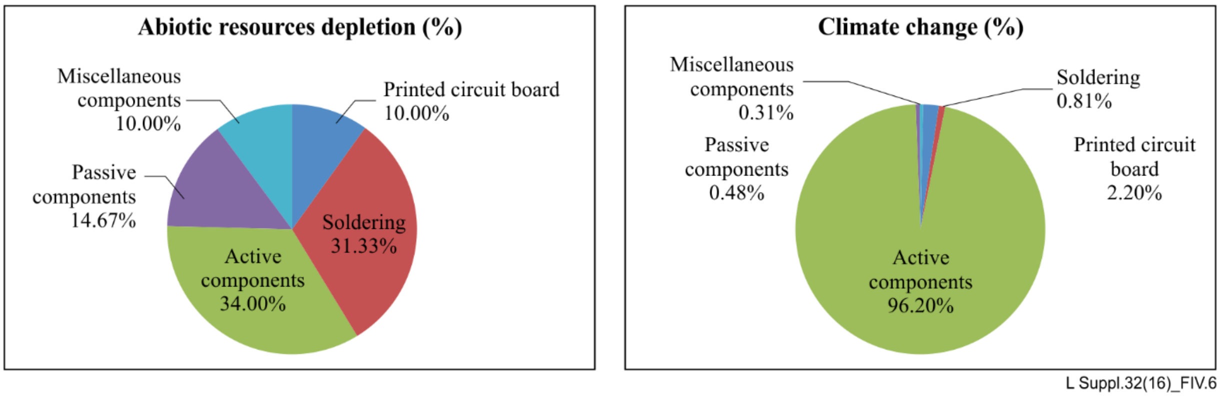


Figure IV.6 – Abiotic resources depletion and climate change indicators for mobile phone tier 2 with its motherboard

The impact of active components such as the integrated circuits [processor, synchronous dynamic random access memory (SDRAM) or NAND], can be explained by the gold used for wire bonding. In the past, The solder composition was based on a tin–silver–copper (SnAgCu) alloy (also known as SAC). As silver is rated as the ninth scarcest element in CML methodology (tin is rated 20 out of 74 different elements), the SAC impact on abiotic resources depletion is rated very high.

The impact of passive components is due to components such as tantalum capacitors (tantalum is rated sixth in CML methodology) and the use of noble metals such as palladium in multilayer ceramic capacitors (MLCCs).

For the miscellaneous category, including connectors, the metal platings (e.g., gold, silver or nickel) mainly explain this impact.

Finally, the impact of the printed circuit board is the result of the presence of copper and its surface treatments, such as electroless nickel immersion gold (ENIG).

IV.2 Conclusion

In this Supplement, the key criteria explaining the environmental impact on climate change, primary energy consumption and abiotic resources depletion have been considered. However, LCA studies carried out by several operators demonstrate that these criteria could be further addressed in the future to try to ensure a more transparent assessment of the environmental impact of mobile phones. However, this should only be done when a consistent and accurate measurement methodology, developed in an open consensus-based forum of experts, can be agreed upon, which takes into account additional features and functionality of a smartphone, and hence the overall environmental impact, taking into account the fact that high-tier smartphones negate the need for other ICT products, including satellite navigation systems and compact cameras.

Appendix V

Discussions about other eco-rating criteria

V.1 Introduction

Upstream life cycle based metrics are necessary for eco-rating of mobile phones. The metrics described in clause V.2 are based on full LCAs of mobile phones such as [b-Andrae, Vaija, 2014]. Such LCA studies show that some metric types drive the LCA scores more than others. Clause V.2 gives some initial types of metrics that mobile phone manufacturer need to be able to provide.

V.2 Cradle-to-use eco-environmental impacts metrics

V.2.1 Raw material acquisition and part production

V.2.1.1 Number of screens

The mobile phone manufacturer should be able to provide data on the number of screens.

V.2.1.2 Type of screen

The mobile phone manufacturer should be able to provide data on whether the mobile phone has a touchscreen.

V.2.1.3 Type of screen technology

The mobile phone manufacturer should be able to provide data on which screen technology is used by the mobile phone under evaluation.

This is not currently in any eco-rating scheme, but recent life cycle assessments [b-Amasawa *et al*., 2016] tend to show that AMOLED's environmental footprint for climate change is lower than for TFT–LCD (by a factor of ~3 compared to results obtained for TFT–LCD display models selected from generic databases). The inclusion of this technical differentiation would be a major factor in an eco-rating system, but it first requires the creation of models, for AMOLED and TFT–LCD, with similar boundaries and functional units, before being implemented.

NOTE –TFT–LCD; AMOLED and miscellaneous technologies like e-ink or passive matrix are examples of screen technologies. More technologies exist.

V.2.1.4 Total active area of each screen

The mobile phone manufacturer should be able to provide data about the surface area (active area) of each screen.

V.2.1.5 Source of electricity used for screen production

The mobile phone manufacturer should be able to provide data about the total share of renewable energy (total from biofuels, biomass, hydropower, solar energy, wind power and tidal or wave power) used to generate electricity at tier 1 manufacturers.

NOTE – Tier 1 manufacturers are those supplying screens directly to the final assembly of the mobile phone.

V.2.1.6 Total area of silicon dies included in integrated circuits above 12 pins

The mobile phone manufacturer should be able to provide data about the total area of silicon dies located within the integrated circuit chips above 12 pins, or mounted as bare dies on the printed boards. Figure V.1 shows a very strong correlation between the silicon die area of IC chips having 12 or more pins and the total silicon die area in 50 different mobile phones ranging from 128.19 mm^2 to 1 333.09 mm^2 total silicon die area. However, other options could consider an appropriate number of larger chips rather than focusing on the "above 12 pins" elements.

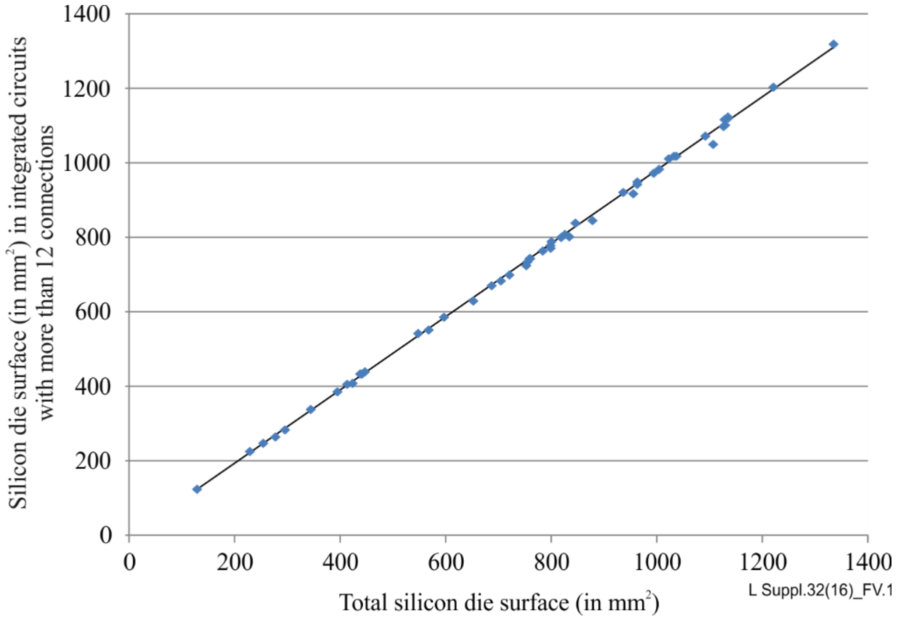


Figure V.1 – Correlation between the silicon die area of IC chips having 12 or more pins and the total silicon die area in 50 different mobile phones

V.2.1.7 Memory capacity

The mobile phone manufacturer should be able to provide data about the memory capacity of the mobile phone.

NOTE – This metric does not refer to extra memory capacity added by the user.

V.2.1.8 Memory type

The mobile phone manufacturer should be able to provide data about the memory types used within the mobile phone.

NOTE – NAND (also known as flash memory or e-MMC) from RAM (also known as DDR or SDRAM) are examples of memory types. More types exist.

V.2.1.9 Source of electricity used for integrated circuits above 12 pins

The mobile phone manufacturer should be able to provide data about the total share of renewable energy (total from biofuels, biomass, hydropower, solar energy, wind power and tidal or wave power) used to generate electricity at tier 1 manufacturers.

NOTE – Tier 1 manufacturers are those supplying integrated circuits directly to the final assembly of the mobile phone.

V.2.1.10 Availability of camera function

The mobile phone manufacturer should be able to provide data about whether the mobile phone has a camera function.

V.2.1.11 Number of cameras

The mobile phone manufacturer should be able to provide data about the number of cameras.

V.2.1.12 Camera sensor size

The mobile phone manufacturer should be able to provide data on the size of the camera sensor.

In some operators' eco-rating and in Open Eco-Rating (OER) systems (Appendix III gives information on this programme), the camera's sensor size is used as a main parameter to assess the camera's environmental footprint. Indeed, the sensor is manufactured in cleanrooms with similar industrial process to the ones used for integrated circuit silicon dies.

V.2.1.13 Camera resolution

The mobile phone manufacturer should be able to provide data on the number of megapixels available when using the mobile phone camera function.

In some operators' eco-rating and in Open Eco-Rating (OER) systems (Appendix III gives information on this programme), the camera's resolution is used as a fall-back solution, if the manufacturer is not able to provide the sensor's size. Using the camera's resolution is less precise, as the ratio megapixels per square millimetre of sensor tends to increase due to technological updates (similar to "die shrink").

V.2.1.14 Source of electricity used for camera sensor production

The mobile phone manufacturer should be able to provide data about the total share of renewable energy (total from biofuels, biomass, hydropower, solar energy, wind power and tidal or wave power) used to generate electricity at tier 1 manufacturers.

NOTE – Tier 1 manufacturers are those supplying camera sensors directly to the final assembly of the mobile phone.

V.2.1.15 Production technology for printed wiring boards

The mobile phone manufacturer should be able to provide data on the technologies used (e.g., FR-4) for producing the printed wiring boards used in the mobile phone under evaluation.

V.2.1.16 Total area of printed wiring boards

The mobile phone manufacturer should be able to provide data on the two dimensional area of the printed wiring boards.

V.2.1.17 Number of layers of printed wiring boards

The eco-rating scheme should contain metrics that ask for the number of layers of the printed wiring boards.

V.2.1.18 Mass of printed wiring boards

The mobile phone manufacturer should be able to provide data on the mass of the printed wiring boards.

V.2.1.19 Total mass of the mobile phone (with battery, without charger)

The mobile phone manufacturer should be able to provide data on the total mass of the mobile phone including its battery, excluding the charger.

V.2.1.20 Total mass

The mobile phone manufacturer should be able to provide data on the total mass including the mobile phone, its battery, the charger, the accessories, and the packaging materials.

V.2.1.21 Total mass of charger (or adapter) with cable

The mobile phone manufacturer should be able to provide data on the total mass of the charger (or adapter) with cable.

V.2.1.22 Total mass of the battery

The mobile phone manufacturer should be able to provide data on the total mass of the battery.

V.2.1.23 Type of battery technology

The mobile phone manufacturer should be able to provide data on which battery technology is used by the mobile phone under evaluation.

V.2.2 Substances linked to abiotic resource depletion

Appendix II gives explanations of the assessment of the abiotic resource depletion indicator. On average, the six substances in clauses V.2.2.1 to V.2.2.6 are the ones with the highest contribution to this indicator in a mobile phone with the CML-ADP-elements-reserve base-method [b-CML-ADP].

V.2.2.1 Total mass of indium

The mobile phone manufacturer should be able to provide data on the total mass of indium contained in the mobile phone under evaluation.

V.2.2.2 Total mass of gold

The mobile phone manufacturer should be able to provide data on the total mass of gold contained in the mobile phone under evaluation.

V.2.2.3 Total mass of silver

The mobile phone manufacturer should be able to provide data on the total mass of silver contained in the mobile phone under evaluation.

V.2.2.4 Total mass of tin

The eco-rating scheme should contain a metric that asks for the total mass of tin contained in the mobile phone under evaluation.

V.2.2.5 Total mass of tantalum

The mobile phone manufacturer should be able to provide data on the total mass of tantalum contained in the mobile phone under evaluation.

V.2.2.6 Total mass of platinum

The mobile phone manufacturer should be able to provide data on the total mass of platinum contained in the mobile phone under evaluation.

V.2.3 Distribution

V.2.3.1 Location of the final assembly site

The mobile phone manufacturer should be able to provide data on the location of the final assembly site for the mobile phone.

NOTE – [ITU-T L.1410] defines final assembly.

V.2.3.2 Source of electricity used at the final assembly site

The mobile phone manufacturer should be able to provide data on the total share of renewable energy (total from biofuels, biomass, hydropower, solar energy, wind power and tidal or wave power) used to generate electricity at the final assembly site for the mobile phone.

V.2.4 Use of eco-environmental metrics

V.2.4.1 Battery technology

The mobile phone manufacturer should be able to provide data on the battery technology used.

Future evolutions in this field, such as lithium-ceramic (made with a ceramic electrolyte and solid lithium anode) or even lithium-air (designed for use with atmospheric oxygen at the cathode and a solid lithium anode), may result in components with much higher energy density (lithium-air's specific energy is around 10 times higher than that of lithium ions). Furthermore, using air instead of chemicals, such as lithium hexafluorophosphate ($LiPF_6$) electrolyte, will most probably help to reduce the environmental footprint of the device. Once again, and as for AMOLED, the first steps will be to create specific models, with similar boundaries and functional units, to compare these battery technology footprints with that of lithium ions.

V.2.5 Functionality

V.2.5.1 Hardware

The mobile phone manufacturer should be able to provide data on whether the mobile phone under evaluation includes or replaces the need for hardware (e.g., camera, navigation system and video conferencing).

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[b-CML–ADP] http://www.leidenuniv.nl/cml/ssp/databases/cmlia/cmlia.zip (in the zip file the data is in the Excel "CML-IA_XX_20YY" in sheet "characterisation factors" and in column L – i.e., "abiotic depletion (elements, reserve base)". N.B. the Excel file is frequently updated therefore its name will change. In CML-IA_XX_20YY the XX refers to the month and YY to the year of the updated file).

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[b-ILCD]	http://eplca.jrc.ec.europa.eu/uploads/CF-v1.0.6-FEB2015.rar (in the zip file see in the "ELCDIII_Archive – FEB2015.zip" file and in folder "ILCD"/"LCIA methods". N.B. the method might be further updated, if the link is not working go to: http://eplca.jrc.ec.europa.eu/?page_id=86 in the "Updated LCIA Characterisation Factors" section to download the latest version).
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