Ecodesign preparatory study on mobile phones, smartphones and tablets

Final Task 1 Report

Scope (definitions, standards and legislation)

Written by Fraunhofer IZM, Fraunhofer ISI, VITO
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1. GLOSSARY

Term	Definition
3D	Three-dimensional
3G	3rd Generation
3TG	Tin, Tantalum, Tungsten and Gold
4G	4th Generation
5G	5th Generation
AICS	Australian Inventory of Chemical Substances
ASTM	American Society for Testing and Materials
BAJ	Battery Association of Japan
BAT	Best Available Technologies
BBP	Butyl Benzyl Phthalate
BNAT	Best Not yet Available Technologies
BSI	Bundesamt für Sicherheit in der Informationstechnik
BYOD	"Bring Your Own Device"
CAHRA	Conflict Affected and High Risk Areas
CAT-iq	Cordless Advanced Technology – internet and quality
Cd	Cadmium
CEN	European Committee for Standardization
CENELEC	European Committee for Electrotechnical Standardization
CLP	Classification, Labelling and Packaging
CMR	Carcinogenic, Mutagenic Or Toxic For Reproduction
CO2	Carbon Dioxide
CRM	Critical Raw Material
CS	Corporate Sustainability
CSGD	Consumer Sales and Guarantees Directive
CSV	Character-Separated Values
DBP	Dibutyl Phthalate
DECT	Digital Enhanced Cordless Telecommunications
DEHP	Bis(2-ethylhexyl) Phthalate
DG GROW	Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs
DIBP	Diisobutyl Phthalate
DRC	Democratic Republic of Congo
DSL	Digital Subscriber Line
DSL	Canadian Domestic Substances List
EC	European Commission
ECHA	European Chemicals Agency
ECMA	European Computer Manufacturers Association
EDGE	Enhanced Data Rates for GSM Evolution
EE	Environmental Engineering
EEE	Electrical and Electronic Equipment
EMS	Environmental Management System
EN	European Norm
ENCS	Japanese Existing and New Chemical Substances
EoL	End of Life
EPEAT	Electronic Product Environmental Assessment Tool
EPR	Extended Producer Responsibility

EPS	Expanded Polystyrene
eSIM	Embedded Subscriber Identity Module
ESO	European Standardisation Organisation
ETSI	European Telecommunications Standards Institute
EU	European Union
FAQ	Frequently Asked Question
FR	Flame Retardant
GHz	Gigahertz
GPP	Green Public Procurement
GPRS	General Packet Radio Service
GPS	Global Positioning System
GPSD	General Product Safety Directive
GHS	Globally Harmonised System
GSM	Global System for Mobile Communications
HiNA	High Network Availability Network
ICA	Italian Competition Authority
ICRT	International Consumer Research and Testing
ICT	Information and Communications Technology
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronic Engineers
ILO	International Labour Organization
IMS	IP Multimedia Subsystem
IMT	International Mobile Telecommunications
iNEMI	International Electronics Manufacturing Initiative
IOT	Internet Of Things
IP	Internet Protocol
ISDN	Integrated Services Digital Network
ISO	International Standard Organization
IT	Information Technology
ITE	Information technology equipment
ITU	International Telecommunication Union
IZM	Institut für Zuverlässigkeit und Mikrointegration
JRC	Joint Research Centre
JTC	Joint Technical Committee
KECL	Korean Existing Chemicals List
kPa	Kilopascal
LCA	Life Cycle Analysis
LCD	Liquid Crystal Display
LCO	Lithium Cobalt Oxide
LED	Light Emitting Diode
LFP	Lithium Iron Phosphate
Li-ion	Lithium-ion
LIB	Lithium-Ion Battery
LLCC	Least Life Cycle Cost
Ltd.	Limited
LTE	Long Term Evolution
m	Meter

M2M	Machine-to-Machine
mA	Milliampere
MCCPs	Medium Chain Chlorinated Paraffin
MEErP	Methodology for the Ecodesign of Energy-related Products
MHz	Megahertz
MIL-STD	United States Military Standard
mm	Millimetre
MMS	Multimedia Messaging Service
NACE	Nomenclature statistique des activités économiques dans la Communauté européenne
NCM	Lithium Nickel Manganese Cobalt Oxides
NDSL	Canadian Non-Domestic Substances List
NGO	Non-Governmental Organisation
Ni	Nickel
NiCd	Nickel-Cadmium
NiMH	Nickel-Metal Hydride
OECD	Organisation for Economic Co-operation and Development
OEM	Original Equipment Manufacturer
OHS	Occupational Health and Safety
OS	Operating System
OTA	Over The Air
PAIA	Product Attribute to Impact Algorithm
Pb	Lead
PBB	Polybrominated Biphenyls
PBDE	Polybrominated Diphenyl Ethers
PBT	Persistent, Bio-accumulative and Toxic
PC	Personal Computer
PCB	Printed Circuit Board
PCR	Post-Consumer Recycled
PEF	Product Environmental Footprint
PEGCR	Product Environmental Footprint Category Rules
PIANOo	Dutch Public Procurement Expertise Centre
PICCS	Philippine Inventory of Chemicals and Chemical Substances
POS	Point of Sale
PRO	Producer Responsibility Organization
PRODCOM	Production Communautaire
PSTN	Public Switched Telephone Network
PSU	Power Supply Unit
RAPEX	Rapid Exchange of Information System
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals
RED	Radio Equipment Directive
RGB	Red, Green, Blue
RoHS	Restriction of Certain Hazardous Substances
RPM	Revolutions Per Minute
SAR	Specific Absorption Rate
SCIP	Secure Communications Interoperability Protocol
SIM	Subscriber Identity Module
SMS	Short Message Service

sRGB	Standard Red, Green, Blue
SUOTA	Software Update Over The Air
SVHC	Substance of Very High Concern
TCO	Tjänstemännens Centralorganisation
TEC	Typical Energy Consumption
TR	Technical Report
TSCA	US Toxic Substances Control Act
TÜV	Technischer Überwachungsverein
TV	Television
UL	Underwriters Laboratories
ULE	Ultra Low Energy
UMTS	Universal Mobile Telecommunications System
US	United States
USB	Universal Serial Bus
VAT	Value Added Tax
VITO	Vlaamse Instelling voor Technologisch Onderzoek
VoIP	Voice over IP
vowLAN	voice over wireless LAN
vPvB	very Persistent and very Bio-accumulative
W	Watt
WEEE	Waste Electrical and Electronic Equipment
WFD	Waste Framework Directive
WG	Working Group
WiFi	Wireless Fidelity
WLAN	Wireless Local Area Network

2. INTRODUCTION

According to the Ecodesign Working plan 2016-19, "Given their specificity, a separate track is proposed for ICT products ..., that will also fully take into account their circular economy potential, which is particularly relevant in the case of mobile / smart phones". Within this context, DG GROW launched this preparatory study on mobile phones, smartphones and tablets in order to assess the feasibility of proposing Ecodesign and/or Energy Labelling requirements for these product groups. Preparatory studies aim to assess and specify generic or specific ecodesign measures for improving the environmental performance of a defined product group, sometimes in combination with energy label criteria. The ecodesign preparatory studies therefore provide the scientific foundation for defining these generic and/or specific ecodesign requirements as well as energy labelling criteria. The overall objective is to clearly define the product scope, analyse the current environmental impacts of these products and related systems (extended product scope) and assess the existing improvement potential of any measures. In particular, aspects relevant to the circular economy, are in the scope. The central element of the MEErP (Kemna 2011; Mudgal et al. 2013), being the underlying assessment methodology, is to prioritise today's possible improvement options from a Least Life Cycle Cost (LLCC) perspective. Identification of the improvement options are based on possible design innovations, Best Available Technologies (BAT) for the short term and Best Not yet Available Technologies (BNAT) for long term, which can help in mitigating the impacts of these products. Policy options are assessed through a scenario analysis and the different outcomes have to be evaluated from the perspective of the EU targets, taking into account potential impacts on the competitiveness of enterprises in the EU and on the consumers.

The overall objective of Task 1 is to **define the scope and system boundaries of the product group** of the preparatory study. This paramount task will set a foundation to identify applicable test standards and legislation or voluntary programs and set appropriate boundaries for the subsequent tasks, in which improvement options will be identified for the different products groups in scope. The product classification and definition should be relevant from a technical, functional, economic and environmental point of view, so that it can be used as a basis for the whole study. Also functional parameters and product performance parameters are in the focus of Task 1 analysis.

3. SUBTASK 1.1 - PRODUCT SCOPE

The objective of subtask 1.1 is the definition of the product scope and the specification of (technical, measurable) product parameters that clearly identifies relevant products.

3.1. Technical characteristics of the product group

The main technical feature of **mobile phones and smartphones** is the radio interface. This distinguishing criterion was already formulated by the Working Plan studies. It allows for voice and data communication over a cellular radio network, which is provided by a telecommunication network operator. In order to get access to the telecommunication network, a subscriber identity module (SIM) must activated in the mobile device. With a SIM card, which might be an embedded-SIM (eSIM) integrated in the device, the mobile device can be registered in the network of the operator service. The telecommunication service provider then allocates network resources to the mobile phone / smartphone including network access and roaming services. The frequencies and technologies of the cellular access networks are standardised and not free of charge. At the present, most cellular network operators support the second, third, and fourth technology generation. The 4th generation (4G) is known under the specification Long Term Evolution (LTE) and LTE-Advanced. LTE provides increased broadband connectivity for internet-based (cloud-based) applications including video streaming. First products support 5G, although this usually is not a true 5G technology, but an enhanced version of existing communication standards.

The applications, for which smartphones and tablets can be used, are almost infinite. This is actually the essence of smartphone technology: Besides making and receiving phone calls, through software applications in combination with the embedded hardware and connectivity to other devices, smartphones can serve a non-quantifiable amount of functions, including[1]: gaming, navigation, recording, editing and playing videos, music, and other audio, dictation, messaging, data storage of any kind, chemical and biochemical analysis, level, distance measurements, noise level measurements, object recognition, online purchases, interior planning, engineering planning, home and other automation control, office programs, tracking of contacts to control spread of diseases, torch, mirror, magnifying glass, microscopy and many many more. The use is highly individual due to the fact that the customer can select and adjust specific functionalities by installing application software (apps) from various sources (app stores, etc.). The individual software configuration may influence the energy consumption and battery life, but does not change the main function which is the basic voice and data communication over a cellular radio access or other wireless telecommunication network.

Display sizes of smartphones can exceed 6,5 inch diagonal, which was the upper limit in the JRC study (Cordella et al. 2020), but we did not identify products beyond 7 inches.

Mobile phones other than smartphones are **feature phones** with limited functionality, but which are also relevant as "senior phones". Due to the lower complexity the environmental impact of these devices is significantly lower than that of smartphones, and use intensity is significantly different as well.

A specific type of mobile phones are **satellite phones**, which utilize satellites to communicate with landline, cellular, or other satellite phones in most regions of the world. These phones are mainly made for emergency communications in order to coordinate response and recovery efforts in remote areas or in areas where existing cellular or landline networks are damaged or overloaded during a natural disaster (e.g., severe weather or earthquake) or other catastrophic situations. Satellite mobile phones are supposed to maintain command and control functions during an emergency when existing communications networks are not functioning. These phones are designed to be relatively rugged and simple to operate. With these features satellite phones are also of interest for outdoor activities in remote areas. Mobile satellite phones are typically designed or at least promoted as rugged and reliable, also in terms of long call and standby times, as they might be operated far from grid access for charging. Some of these characteristics make satellite phones an interesting case and benchmark for other mobile phones as well.

There are also smartphones which can make calls with a satellite network, but rely on e.g. a WiFi connection to a satellite connection hub on a vessel ("BYOD[2] devices").

Cordless phones operate with landline telephony and increasingly with Voice over IP (VoIP)[3], and typically consist of a handset and a charging cradle and base station. A system or sales unit can comprise one or more handsets. The base station for these cordless phones can also be integrated into an Internet-enabled router. The by far dominating data transmission technology between handset and base station is DECT

[1] Many of these require external accessories and devices, which are outside the product scope

[2] BYOD: "Bring your own device", which in this case means, that a regular cellular phone can be used on a vessel through WiFi to a satellite communication gateway and as such can make calls through a satellite based network; BYOD in another context means, that employees bring their private devices to work, integrating them temporarily in the company's IT network

[3] Internet telephony

(Digital Enhanced Cordless Telecommunications). vowLAN (voice over wireless LAN) is much less widespread. The base station can either be connected to the public telephone network (ISDN, DSL or fibre-optic cable) or transmission is provided by an IP-based system - or both options are implemented. The main function is enabling telephone calls. Possible secondary functions include texting (SMS), an alarm function, room monitoring (baby monitor), radio reception, music streaming, and internet access if the systems are IP-based. The rechargeable batteries in the handset are charged either by placing the handset on a special charging cradle or using the charging function integrated into the base station. Radio waves within defined frequency ranges (DECT in Europe: 1880 - 1900 MHz) are used to transmit data between the base station and handsets.

Cordless phones are very infrequently used "mobile" and sit most of the time in the charging cradle. This rather puts energy efficiency of the charging cradle in the spotlight. On the basis of application, the market is segmented into personal and enterprise application. The personal and residential application uses single cell DECT phones, whereas enterprise applications use multi-cell DECT phones providing on-premise coverage and local mobility through handover between pico-cell base stations.

Tablet computers are small handheld computers with a touch sensitive screen, with similar technical characteristics as smartphones, but a larger form factor. Tablet computers are frequently seen as a sub-segment of notebook computers. Basically two sub-categories have to be distinguished: Slates, where input mainly is made by use of a virtual keyboard shown on the touchscreen display – with or without a smart pen -, and detachables, which come with a physical keyboard, which can be attached to – or detached from – the tablet. Such detachable tablets are similar to notebook computers as mobile computing device. However, also slate tablets frequently can be connected to an external physical keyboard through Bluetooth or an USB interface.

"Convertables" are another product segment among notebook computers, but convertables feature a permanently attached keyboard, which can be rotated and folded backwards to allow using the convertible in a "tablet mode".

Tablets may or may not support access to a cellular telecommunications network, as making voice calls is not the main function. For video calls tablets are much more popular. Tablets are made to run on battery power and to be connected to the grid typically only to recharge the battery.

The operating system of tablet computers might be those made for mobile handheld devices, iOS and Android in particular, but some tablets also run on adapted versions of typical PCs' operating systems, such as Windows.

Display sizes of tablets start above 7 inches.

3.2. Functional unit

Definition of a functional unit is essential for assessment of the environmental performance and to compare design options in Task 6. Typically, delivering a service over a given product lifetime, is the functional unit applied with the MEErP for most consumer products. As many material efficiency measures materialise over an extension of the product lifetime, the lifetime has to be seen as variable in this assessment, and delivering a service over a given period, instead of one product lifecycle, has to be analysed.

Therefore, this study refers to two kinds of functional units:

Enabling use of all online (over a telecommunication network and – for tablets and smartphones in particular - data traffic over the internet) and offline functionality of device, e.g. voice traffic, internet traffic, taking photos and videos, etc. per

(1) one product lifecycle (i.e., calculating impacts per product),

(2) one year of use.

The kind of data traffic, due to the multitude of possible applications, is not reflected in the functional unit. The amount of voice and data traffic depends on the individual needs of the user.

There are multiple functions of these mobile products, which are not directly related to data traffic over the internet or a telecommunications network, such as taking photos or videos, offline office applications and image editing, playing locally stored music files etc. These are important aspects of the overall functionality, but voice and/or data traffic are considered the primary function.

This functional unit includes also potential secondary use of a device.

All devices in scope of the study might be used in a private or professional context. Frequently the same device is even used in parallel as a consumer device and a business device (BYOD, "bring your own device").

The smartness of smartphones and tablets potentially leads to replacement effects of other products: The market for digital still cameras is declining due to technology advancements of smartphone cameras, smartphones also increasingly replace other navigation devices, and are an alternative to game consoles. Tablets are used for video streaming and might replace TV sets. This potential is acknowledged and materialises in many cases, but also the effect that a user "owns" a similar functionality on several stand-alone devices in parallel is frequently observed. These side effects on other product categories and the related substitution potential will be addressed where evidence is available, but is not at the core of the quantitative assessments.

3.3. Existing product definitions and classifications

3.3.1. Legislation, standards, labels

Some product types share features with what is commonly understood to be smartphones, mobile phones and tablets, but are supposed to be excluded from the scope of this product group study. Some definitions of such products are listed in the table below as well to clarify what is excluded from the scope. These excluded products are, inter alia

- E-Readers[4]
- Digital photo frames[5]
- Control panels[6]
- Palm-top organisers[7]
- Handheld radio transceivers (for bidirectional communication, but not through a provider operated telecommunication network, such as "walkie-talkies")

Further, excluded are devices with a built-in DECT station, such as some corded desktop phones, which are sold without cordless handsets.

[4] not yet covered by any eco-design regulation, but the external power supply Commission Regulation (EU) 2019/1782

[5] covered by Commission Regulation (EU) 2019/2021

[6] covered by Commission Regulation (EU) 2019/2021

[7] without the functionality to make and receive phone calls

Table 1: Key product category definitions for smartphones / mobile phones, cordless phones, and tablet computers, and other product groups with similar features

Reference	Scope	Definition	Included in the scope of this product group study
DE-UZ 106 (2020) - Blue Angel Eco-Label for Mobile Phones	Mobile phones	Portable, cordless phones that transmit telephone calls via mobile phone networks. The mobile phone is equipped with a module (SIM card) which allows the identification of the individual subscriber. In addition to the telephony function the mobile phone can provide several other functions, such as, for example, transmission of text messages, mobile use of Internet services, execution of programmes or recording and replay of video and audio signals.[8]	yes
UL Standard 110, Edition 2 - Standard for Sustainability for Mobile Phones (2017) ITU-T L.1015: Criteria for evaluation of the environmental impact of mobile phones[10]	Mobile phones	A wireless handheld device that is designed to send and receive transmissions through a cellular radiotelephone service including only the device itself and not packaging or accessories. Slates/tablets, as defined in the most recent applicable version of Energy Star specification, are excluded from this definition.[9]	yes
TÜV Rheinland, 2 PfG E 2073:07.2018, Criteria for the award of Green Product Mark Mobile Phones[11]	Mobile phones	A wireless handheld device that is designed to send and receive transmissions through a cellular radiotelephone service including only the device itself and not packaging or accessories.	yes

[8] https://produktinfo.blauer-engel.de/uploads/criteriafile/en/DE-UZ%20106-201707-en%20Criteria.pdf

[9] https://www.shopulstandards.com/ProductDetail.aspx?productId=ULE110_2_B_20170324(ULStandards2)

[10] ITU-T L.1015 references UL 110

[11] The criteria specification expired in 2018

Reference	Scope	Definition	Included in the scope of this product group study
TCO Certified Generation 8, for smartphones	Smartphone	A smartphone is defined as a portable device, with a touch screen with display size of ≥ 3" to ≤ 7", used for long-range communication over a cellular network of specialized base stations known as cell sites. A certified wireless or wired headset may be used for communication, as it is the best way to reduce emission towards the head. Connection to mains via an external power supply is considered to be mainly for battery charging purposes and an onscreen virtual keyboard or a digital pen is used for input.[12]	yes
TCO Certified Generation 8, for tablets	Tablet	A tablet is defined as a portable computer with a display size > 7", that is primarily for battery mode usage and has a touch screen interface. This means that connection to mains via an adapter is considered to be mainly for battery charging purposes and the onscreen virtual keyboard or a digital pen is in place of a physical keyboard.[13]	yes
Regulation (EU) No 617/2013	Tablet computer	'Tablet computer' means a product which is a type of notebook computer that includes both an attached touch-sensitive display and an attached physical keyboard;	no (due to "attached physical keyboard")
	Slate computer	'Slate computer' means a type of notebook computer that includes an integrated touch-sensitive display but does not have a permanently attached physical keyboard	yes

[12] https://tcocertified.com/files/certification/tco-certified-generation-8-for-smartphones.pdf

[13] If a detachable keyboard docking station is supplied together with the tablet for the intention of the product being converted to a notebook computer, then the product must be tested as specified for notebooks.

Reference	Scope	Definition	Included in the scope of this product group study
ENERGY STAR® Program Requirements Product Specification for Computers Eligibility Criteria Version 7.1	Slate/Tablet[14]	A computing device designed for portability that meets all of the following criteria: a) Includes an integrated display with a diagonal size greater than 6.5 inches and less than 17.4 inches; b) Lacking an integrated, physical attached keyboard in its as-shipped configuration; c) Includes and primarily relies on touchscreen input; (with optional keyboard); d) Includes and primarily relies on a wireless network connection (e.g., Wi-Fi, 3G, etc.); and e) Includes and is primarily powered by an internal battery (with connection to the mains for battery charging, not primary powering of the device).	yes
	E-Reader	A device designed for display and consumption of static images. The display is characterized by a low refresh rate and a display made of bistable materials where no energy is needed to maintain a visible image, only to alter the image.	no
DE-UZ 131 (2020) - Blue Angel Eco-Label Digital Cordless Phones	Digital cordless phone	Digital cordless phones consist of a base station and one or more handsets that communicate wirelessly with one another by radio. The base station connects to the landline network or Internet. The rechargeable batteries in the handset are charged either by placing the handset on a special charging cradle or using the charging function integrated into the base station. Radio waves within defined frequency ranges are used to transmit data between the base station and handsets.	yes

[14] same definition applies in IEEE 1680.1

Reference	Scope	Definition	Included in the scope of this product group study
ENERGY STAR® Program Requirements Product Specification for Telephony Eligibility Criteria Version 3.0, Rev. Oct-2014	Cordless telephone	A Telephone with a base station and a handset. The cradle of a Cordless Telephone or its External Power Supply is designed to plug into a wall outlet. Although the Cordless Telephone base has a permanent physical connection to the network, there is no physical connection between the portable handset and the network.	yes
Regulation (EU) 2019/2021[15]	Digital photo frame	'digital photo frame' means an electronic display that displays exclusively still visual information.	no
	Control panel	'control panel' means an electronic display whose main function is to display images associated with product operational status; it may provide user interaction by touch or other means to control the product operation. It may be integrated into products or specifically designed and marketed to be used exclusively with the product.	no

Some tablets are also equipped with telecommunications connectivity, but for this type of products this is not a must, and the definition of tablets has to be established on another basis. Most important, tablets need to be distinguished from laptops unambiguously. Actually, tablets (and "slates") are already covered under Commission Regulation (EU) No 617/2013[16], see Table 1: In this regulation slates are defined without attached keyboard, tablets with a physical keyboard, although not defining, if the keyboard is permanently attached (which is the case for "convertables", but not for "detachables"). Devices shipped without permanently attached keyboard are tablets in the sense of this study, and all devices with permanently attached keyboards are outside the scope.

Material efficiency options to be identified in this study for smartphones are assumed to be applicable to a certain extend to tablets as well. The currently ongoing revision of Commission Regulation (EU) 617/2013 might exclude these computers from its scope.

[15] Actually all products in scope of the display eco-design regulation (EU) 2019/2021 are explicitly excluded from the scope of this study, digital photo frames and control panels are listed here only as they are technically closest to "tablets"

[16] https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A32013R0617

3.3.2. JRC study on material efficiency of smartphones

The JRC study on material efficiency of smartphones (Cordella et al. 2020) defined – for the purpose of that study – a smartphone as follows:

"A **smartphone** is a handheld electronic device designed for mobile communication (making phone calls, text messaging), internet connection and other uses (e.g. multimedia, gaming). It can be used for long-range communication over a cellular network of specialized base stations known as cell sites. It is functionally similar to tablets and other wireless, portable computers, since

- designed for battery mode usage, and connection to mains via an external power supply is mainly for battery charging purposes,
- presenting an operating system, WiFi connectivity, web browsing capability, and ability to accept original and third-party applications (Apps),

It has a display size between 4 and 6.5 inches, a high-resolution touch screen interface in place of a physical keyboard, a fissure for a Subscriber Identity Module (SIM), and usually a camera."

As the Subscriber Identity Module (SIM) does not necessarily require a SIM card, but eSIM is available through a dedicated on board chip, this part of the definition needs to be opened up to these other SIM technologies.

The reference to cellular networks excludes satellite phones (satphones), which rely on orbiting satellites for being connected to a telecommunications network, not through a terrestrial cellular network.

Cellular network functionality is provided by other devices as well, such as some Internet of Things applications, so this alone does not qualify as a definition for smartphones, or mobile phones in general.

3.3.3. NACE / PRODCOM

NACE[17] is the classification of economic activities in the European Union (EU). NACE is a four-digit classification providing the framework for collecting and presenting a large range of statistical data according to economic activity in the fields of economic statistics and in other statistical domains. NACE Rev. 2, a revised classification, was adopted at the end of 2006. PRODCOM[18] is a survey for the collection and dissemination of statistics on the production of industrial goods in the European Union. The PRODCOM data structure follows the NACE classification (see Task 2 for PRODCOM data).

The relevant NACE codes for this study are

> *26302100 - Line telephone sets with cordless handsets*
>
> *26302200 - Telephones for cellular networks or for other wireless networks*, which apparently includes satellite phones

and it can be assumed, that all products covered by these codes are within the scope of this study.

Tablets are covered by

[17] Nomenclature statistique des activités économiques dans la Communauté européenne

[18] *Prod*uction *Com*munautaire

26201100 - Laptop PCs and palm-top organisers

However, 26201100 comprises also other products besides tablets, namely laptop and notebook computers in particular.

Explicitly excluded are products under following NACE codes

26302320 – Machines for the reception, conversion and transmission or regeneration of voice, images or other data, including switching and routing apparatus

26302330 – Telephone sets (excluding line telephone sets with cordless handsets and telephones for cellular networks or for other wireless networks); videophones

26302340 – Portable receivers for calling or paging

26302370 – other apparatus for the transmission or reception of voice, images or other data, including apparatus for communication in a wired or wireless network, other than transmission or reception apparatus of HS 8443[19], 8525[20], 8527[21] or 8528[22,23]

3.4. Scope definition

The product scope definition applied in this study is as follows:

A **mobile phone** is a cordless handheld electronic device designed for long-range voice communication over either a cellular telecommunications network or a satellite based telecommunications network, requiring a SIM card, eSIM or similar means to identify the connected parties *[to exclude other types of two-way radios, such as "walkie-talkies"]*. It is designed for battery mode usage, and connection to mains via an external power supply is mainly for battery charging purposes. A **smartphone** is furthermore characterized by a sophisticated operating system, WiFi connectivity, mobile use of internet services, and the ability to accept original and third-party software applications. A smartphone has an integrated touch screen display with a diagonal size between 4 and 7 inches. Devices with more than one and/or foldable displays are characterized as smartphones if at least one of the displays falls into the size range in either opened or closed mode.

A **cordless phone** is a cordless handheld electronic device designed for long-range voice communication over a landline telecommunications network *[to include DECT and other cordless landline phones]*, which is connected to a base station through a radio interface.

[19] Printing machinery; used for printing by means of plates, cylinders and other printing components of heading 84.42; other printers, copying machines and facsimile machines, whether or not combined; parts and accessories thereof

[20] Transmission apparatus for radio-broadcasting or television, whether or not incorporating reception apparatus or sound recording or reproducing apparatus; television cameras, digital cameras and video camera recorders

[21] Reception apparatus for radio-broadcasting, whether or not combined, in the same housing, with sound recording or reproducing apparatus or a clock.

[22] Monitors and projectors, not incorporating television reception apparatus; reception apparatus for television, whether or not incorporating radio-broadcast receivers or sound or video recording or reproducing apparatus

[23] for clarity, HS 8443, 8525, 8527, and 8528 are outside the scope as well

It is designed for battery mode usage, and connection to mains via an external power supply is mainly for battery charging purposes.

A **tablet** is a type of notebook computer designed for portability that includes an integrated touch-sensitive display with a diagonal size greater than 7 inches but does not have an integrated, physical attached keyboard in its as-shipped configuration *[including "detachables", but excluding "convertibles"; model specific keyboard or keyboard docking station might be supplied as an accessory]*. A tablet relies on a wireless network connection, which might or might not be a telecommunications network *[e.g., WiFi, 3G, LTE, etc.; but contrary to smartphones connectivity with a telecommunications network is not a required functionality, other means of at least internet connectivity are]*, and is primarily powered by an internal battery (with connection to the mains for battery charging, not primary powering of the device). A tablet is furthermore characterized by an operating system, mobile use of internet services, and the ability to accept original and third-party software applications.

The scope includes accessories shipped with the device, such as external power supply, a charging cradle, a base station for cordless landline phones, a headset, a detachable keyboard, cables.

4. SUBTASK 1.2 – MEASUREMENTS/TEST STANDARDS

This subtask identifies and shortly describes the existing test standards that are relevant for the technical and environmental performance of the products within the scope of this study. It builds upon the measurements and test standards identified in the JRC Technical Report "Guidance for the Assessment of Material Efficiency: Application to Smartphones" (Cordella et al. 2020).

Testing of mobile devices such as mobile phones, smartphones and tablets is undertaken to assure the quality of the devices. It is conducted on both the hardware and software level, which comprises a variety of activities including verification and validation of hardware devices and software applications.

Tests can be run at different product development stages and typically include unit tests, factory tests and certification tests. Unit tests are usually conducted on parts of the mobile devices by the developers at an early stage of the development. Factory tests are run during the manufacturing and assembling stage. Finally, certification tests are performed before a device is put on the market. Most governments require that mobile devices comply with specifications and protocols to protect users' health and to assure compatibility across other devices. The major testing categories comprise:

- Safety, Specific Absorption Rate (SAR), health and ergonomics testing
- Conformance and interoperability testing (e.g. 3GPP standards, OTA testing)
- Performance testing (acoustic, graphics, etc.)
- Software testing
- Material testing (plastics)
- Battery life testing
- Durability testing

The following subchapters identify and shortly describe the most important standards. Since material efficiency aspects play a major role in this preparatory study, a more detailed analysis is provided on aspects related to battery life and durability. However, the original standards are available for purchase, and have important and specific requirements that cannot be fully copied due to copyright restrictions. This often includes drawings specifying the required test equipment and procedures. Since standards are updated, it is important to refer to the latest revision of the required standard when conducting tests for certification.

4.1. EN, ISO/IEC, ETSI, ITU test standards

European Norms (EN) relevant for this product group are developed by CEN (European Committee for Standardization), CENELEC (European Committee for Electrotechnical Standardization) and ETSI (The European Telecommunications Standards Institute). On the international level ISO standards are aligned with IEC (International Electrotechnical Commission), and ITU (International Telecommunication Union) develops relevant standards in the telecommunications domain.

4.1.1. Main standards and testing methods on safety, SAR, health and ergonomics

Safety standards, including standards on fire safety, are relevant as they define minimum safety requirements a device has to meet. This is relevant not only for new products, but also repaired and refurbished units.

- IEC 60065:2014 - Audio, video and similar electronic apparatus - Safety requirements.
- IEC 60950-1:2005+AMD1:2009+AMD2:2013 CSV - Information technology equipment - Safety - Part 1: General requirements.
- IEC 62209-1:2016 - Measurement procedure for the assessment of specific absorption rate (SAR) of human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices. Devices used next to the ear (Frequency range of 300 MHz to 6 GHz).
- IEC 62368-1:2014 - Audio/video, information and communication technology equipment - Part 1: Safety requirements.
- ISO 9241-400:2007 - Ergonomics of human--system interaction -- Part 400: Principles and requirements for physical input devices.
- Standard ECMA-74 (2019) - Measurement of Airborne Noise emitted by Information Technology and Telecommunications Equipment

4.1.2. Main communication standards

Communication standards are relevant as they define major features of the product group, thus also defining performance. Some of these communication standards and protocols also specify energy consumption.

- GSM and related 2G and 2.5G standards (e.g. GPRS and EDGE)
- UMTS and related 3G standards (e.g. HSPA and HSPA+)
- LTE and related 4G standards (incl. LTE Advanced and LTE Advanced Pro)
- 5G NR and related 5G standards (ITU/IMT-2020)
- Wi-Fi (IEEE-802.11)
- IP Multimedia Subsystem (IMS)
- Over the Air antenna testing (OTA)
- Bluetooth®
- VoIP
- GPS
- MMS
- Video Telephony
- DECT

Digital Enhanced Cordless Telecommunications (DECT™) is the ETSI standard for short-range cordless communications, which can be adapted for many applications and can be used over unlicensed frequency allocations world-wide. DECT is suited to voice (including PSTN and VoIP telephony), data and networking applications with a range up to 500

metres[24]. In total, there are roughly 380 ETSI standards in place on DECT technology, including test procedures and specifications for all communication protocol layers[25]. The most commonly used spectrum allocation is 1 880 MHz to 1 900 MHz in Europe. This spectrum is unlicensed and technology exclusive, which ensures an interference free operation. DECT ULE (Ultra Low Energy) has been developed to open the technology to the M2M (machine-to-machine) market. Among the ETSI DECT standards of particular importance is ETSI EN 301 406 - Digital Enhanced Cordless Telecommunications (DECT); Harmonised Standard covering the essential requirements of article 3.2 of the Directive 2014/53/EU; as it defines testing requirements for electromagnetic radiation, which is referenced, e.g. in the Blue Angel requirements for cordless phones.

Among the DECT standards CAT-iq defines several profiles for high quality wideband voice services with multiple lines, as well as low bit-rate data applications, which are in particular relevant for internet-connected systems. Relevant CAT-iq standards comprise:

- CAT-iq 1.0 "HD Voice" (ETSI TS 102 527-1)
- CAT-iq 2.0 "Multi Line" (ETSI TS 102 527-3)
- CAT-iq 2.1 "Green" (ETSI TS 102 527-5), including power-saving modes for handset and base
- CAT-iq Data (ETSI TS 102 527-4), light data services and software upgrade over the air (SUOTA)
- CAT-iq IOT (ETSI TS 102 939), Smart Home connectivity (IOT) using DECT Ultra Low Energy on base

4.1.3. Main standards and testing methods for performance testing

Performance measurements are an important point of reference when defining e.g. conditions for energy measurements. Some eco-labels also require such tests according to the following standards as perfomance as such is part of the label criteria.

- ISO 3741:2010 - Acoustics -- Determination of sound power levels and sound energy levels of noise sources using sound pressure -- Precision methods for reverberation test rooms
- ISO 3744:2010 - Acoustics -- Determination of sound power levels and sound energy levels of noise sources using sound pressure -- Engineering methods for an essentially free field over a reflecting plane
- ISO 3745:2003 - Acoustics -- Determination of sound power levels of noise sources using sound pressure-- Precision methods for anechoic and hemi-anechoic rooms
- ISO 7779:2010 - Acoustics -- Measurement of airborne noise emitted by information technology and telecommunications equipment
- ISO 9296:2017 - Acoustics -- Declared noise emission values of information technology and telecommunications equipment
- ISO 11201:2010 - Acoustics -- Noise emitted by machinery and equipment -- Determination of emission sound pressure levels at a work station and at other specified positions in an essentially free field over a reflecting plane with negligible environmental corrections
- ISO 12646:2015 - Graphic technology -- Displays for colour proofing -- Characteristics
- ISO 3664:2009 - Graphic technology and photography – Viewing conditions
- IEC 61966-2-1:1999 - Multimedia systems and equipment - Colour measurement and management - Part 2-1: Colour management - Default RGB colour space – sRGB.

[24] https://www.etsi.org/technologies/dect

[25] A full list of related standards in the public domain is accessible here: https://www.etsi.org/committee/1394-dect

4.1.4. Main standards and testing methods for software

There is a large amount of different types of mobile application testing, such as functional testing, performance testing, memory leakage testing, interrupt testing, usability testing, installation testing, certification testing, security testing, load testing, etc. An internationally recognised software testing method was developed by IEEE with the ISO/IEC/IEEE 29119 series.

- ISO/IEC/IEEE 29119: Is a series of software testing standards defining an internationally agreed set of standards for software testing that can be used by any organization when performing any form of software testing. It comprises test process descriptions that define the software testing processes at the organizational level, test management level and dynamic test levels. The standard supports dynamic testing, functional and non-functional testing, manual and automated testing, and scripted and unscripted testing.

Further relevant software standards are:

- ISO/IEC 25010 Software quality; International series of standards for quality assessment of software products and software development processes; 8 quality criteria, amongst others compatibility, performance efficiency, reliability.
- IEEE standard 1061 Software quality; A methodology for establishing quality requirements and identifying, implementing, analyzing, and validating the process and product software quality metrics. The methodology spans the entire software life cycle.

4.1.5. Main standards and testing methods on plastics and other materials

- ISO 1043-1:2011 - Plastics - Symbols and abbreviated terms - Part 1: Basic polymers and their special characteristics. The standard defines abbreviated terms for the basic polymers used in plastics, symbols for components of these terms, and symbols for special characteristics of plastics.
- ISO 1043-2:2011- Plastics - Symbols and abbreviated terms - Part 2: Fillers and reinforcing materials. The standard specifies uniform symbols for terms referring to fillers and reinforcing materials.
- ISO 1043-3:2016 - Plastics - Symbols and abbreviated terms - Part 3: Plasticizers. The standard provides uniform symbols for components of terms relating to plasticizers to form abbreviated terms.
- ISO 1043-4:1998 - Plastics - Symbols and abbreviated terms - Part 4: Flame retardants. The standard provides uniform symbols for flame retardants added to plastics materials.
- ISO 11469:2016 - Plastics - Generic identification and marking of plastics products. The standard specifies a system of uniform marking of products that have been fabricated from plastics materials. Provision for the process or processes to be used for marking is outside the scope of this International Standard.
- IEC 61249-2-21:2003, Materials for printed boards and other interconnecting structures – Part 2-21: Reinforced base materials, clad and unclad – Nonhalogenated epoxide woven E-glass reinforced laminated sheets of defined flammability (vertical burning test), copper-clad; defining "non-halogenated" for PCB laminates

4.1.6. Main standards and testing methods for batteries

- IEC 61960-3:2017 - Secondary cells and batteries containing alkaline or other non-acid electrolytes. Secondary lithium cells and batteries for portable applications. Prismatic and cylindrical lithium secondary cells and batteries made from them.

- IEC 62133-1:2017 - Secondary cells and batteries containing alkaline or other non-acid electrolytes - Safety requirements for portable sealed secondary cells, and for batteries made from them, for use in portable applications – Part 1: Nickel systems.
- IEC 62133-2:2017 - Secondary cells and batteries containing alkaline or other non-acid electrolytes – Safety requirements for portable sealed secondary cells, and for batteries made from them, for use in portable applications – Part 2: Lithium systems.
- IEC 61951-2: Secondary cells and batteries containing alkaline or other non-acid electrolytes - Secondary sealed cells and batteries for portable applications - Part 2: Nickel-metal hydride.
- IEC 62902:2019: Secondary cells and batteries - Marking symbols for identification of their chemistry; only for batteries with a volume > 900 cm^3, not for handheld devices.
- IEC 62281:2019 RLV: Safety of primary and secondary lithium cells and batteries during transport.
- IEEE 1725-2011 - IEEE Standard for Rechargeable Batteries for Cellular Telephones.
- UL 1642: Safety of Lithium-Ion Batteries – Testing.
- UL 2054:2004: Standard for Household and Commercial Batteries.

A large number of additional standards and testing methods exist for industrial batteries (incl. batteries used in mobility and stationary applications), however, those are not relevant for the scope of this study.

IEC 61960-3 specifies performance tests, designations, markings, dimensions and other requirements for secondary lithium single cells and batteries for portable applications (hand-held equipment, transportable equipment and movable equipment). It provides a set of criteria and tests to evaluate the performance of secondary lithium cells and batteries. The standard specifies requirements and tests pertaining to discharge performance, capacity retention and recovery, endurance, internal resistance, and electrostatic discharge, among others. Section 7.6 "Endurance in cycles" describes a testing procedure to evaluate the cycle life of rechargeable batteries, in which cells or batteries are continuously charged and discharged while continuously measuring the available capacity. Sections 7.4 "Charge (capacity) retention and recovery" and 7.5 "Charge (capacity) recovery after long term storage" describe testing procedures to evaluate the calendar ageing of cells and batteries. IEC 61960 is commonly used by industry as well as in legislation, eco-labels and similar instruments to evaluate the performance of rechargeable batteries in IT, ICT and other applications.

IEC 62133 specifies requirements and tests for the safe operation of portable sealed secondary cells and batteries under intended use and reasonably foreseeable misuse, with 62133-1 pertaining to nickel cells and batteries containing alkaline electrolyte and 62133-2 pertaining to lithium cells and batteries containing non-acid electrolyte. The standard describes requirements and tests regarding case stress at high ambient temperature, external short circuit, free fall, mechanical shock, vibration, crushing of cells, and over-charging, among others.

4.1.7. Main standards and testing methods on durability

- ASTM C1895 – 20: Standard Test Method for Determination of Mohs Scratch Hardness. This method covers the procedures to determine the Mohs scratch hardness of ceramic tile, glass tile, and other hard surfaces.
- ASTM D7027 – 13: Standard Test Method for Evaluation of Scratch Resistance of Polymeric Coatings and Plastics Using an Instrumented Scratch Machine. This method describes a laboratory procedure using an instrumented scratch machine to produce and quantify surface damage under controlled conditions. It is able to characterize the scratch resistance of polymers by measuring significant material parameters. The scratch inducing and data acquisition process is automated.
- IEC 60529:1989/AMD2:2013/COR1:2019 Corrigendum 1 - Amendment 2 - Degrees of protection provided by enclosures (IP Code). This standard applies to the

classification of degrees of protection provided by enclosures for electrical equipment with a rated voltage not exceeding 72.5 kV.

This is an important international standard to classify and rate the degree of protection provided by mechanical casings and electrical enclosures against intrusion, dust, accidental contact, and water. The standard has the objective to go beyond simple terms such as "waterproof" and provide users with more detailed and measurable information. This standard defines the IP codes, which consist of two digits (IPXX). The first digit (from 0-6) defines the protection provided against the entry of foreign solid objects, such as fingers or dust (Table 2). The second digit (from 0-8) provides information on the degree of protection against the entry of moisture (Table 3).

Table 2: IP codes for the entry of foreign solid objects (Cordella et al. 2020)

Level	Object size	Description of the protection
X	-	No data available
0	-	No specific protection against contact and ingress of objects.
1	>50 mm	Protection ensured from contact with larger surfaces of the body (e.g. back of a hand), but no protection from deliberate contact with a smaller body part (e.g. finger).
2	>12.5 mm	Protection ensured from smaller body parts (e.g. finger) and other objects.
3	>2.5 mm	Protection from tools, thick wires, etc.
4	>1 mm	Protection from most wires, slender screws, large ants, etc.
5	Dust protected	Partial protection from harmful dust. Ingress is not entirely prevented, but it must not enter in sufficient quantity to interfere with the satisfactory operation of the equipment.
6	Dust tight	Complete protection from contact with harmful dust.

Table 3: IP codes for the entry of moisture (Cordella et al. 2020)

Level	Protection against	Effective against	Details
X	No data available	-	-
0	No special protection	-	-
1	Dripping water	Dripping water (vertically falling drops) shall have no harmful effect on the specimen when mounted in an upright position onto a turntable and rotated at 1 RPM.	Test duration: 10 min. Water equivalent to 1 mm rainfall per min.
2	Dripping water when tilted at 15°	Vertically dripping water shall have no harmful effect when the enclosure is tilted at an angle of 15° from its normal position. Four positions are tested within two axes.	Test duration: 2.5 min. for every direction of tilt (10 min. total). Water equivalent to 3 mm rainfall per minute.
3	Spraying water	Protection against direct sprays of water when device is tilted at an angle up to 60°. It is possible to use either a) an oscillating fixture or b) a spray nozzle with a counterbalanced shield.	Oscillating tube (a): Test duration: 10 min. Water Vol.: 0.07 l/min per hole.

Level	Protection against	Effective against	Details
		Test a) is conducted for 5 min., and then repeated with the specimen rotated horizontally by 90° for the second 5-min. test. Test b) is conducted (with shield in place) for 5 min. minimum.	Spray nozzle (b): Test duration: 1 min. per m2 for at least 5 min. Water volume: 10 litres/min. Pressure: 50–150 kPa.
4	Splashing of water	Protection from sprays and splashing of water in all directions. It is possible to use either a) an oscillating fixture, or b) a spray nozzle with no shield. Test a) is conducted for 10 minutes. Test b) is conducted for 5 min. minimum (without shield).	Oscillating tube (a): Test duration: 10 min. Spray nozzle (b): same as IPX3 spray nozzle with the shield removed.
5	Water jets	Protection from low-pressure water projected from a nozzle (6.3 mm diameter opening) against the enclosure from any direction.	Test duration: 1 min. per m2 for at least 3 min. Water volume: 12.5 litres/min. Pressure: 30 kPa at distance of 3 m.
6	Powerful water jets	Protection from water projected in powerful jets from a nozzle (12.5 mm diameter opening) in any direction.	Test duration: 1 min. per m2 for at least 3 min. Water volume: 100 litres/min Pressure: 100 kPa at distance of 3 m.
6K	Powerful water jets with increased pressure	Water projected in powerful jets (6.3 mm nozzle) against the enclosure from any direction, under elevated pressure, shall have no harmful effects. Found in DIN 40050, and not IEC 60529.	Test duration: at least 3 min. Water volume: 75 litres/min. Pressure: 1000 kPa at distance of 3 m.
7	Immersion, up to 1 m depth	Ingress of water in harmful quantity shall not be possible when the enclosure is immersed in water under defined conditions of pressure and time (up to 1 m of submersion).	Test duration: 30 min. (ref IEC 60529, table 8). Tested with the lowest point of the enclosure 1000 mm below the water surface, or the highest point 150 mm below the surface, whichever is deeper.
8	Immersion, 1 m or more depth	Protected from immersion in water with a depth of more than 1 m. The equipment is suitable for continuous immersion in water under conditions that shall be specified by the manufacturer. However, with certain types of equipment, the classification can	Test duration: Agreement with Manufacturer Depth specified by

Level	Protection against	Effective against	Details
		mean that water can enter as long as it is not producing harmful effects. The test depth and duration is expected to be greater than the requirements for IPx7, and other environmental effects may be added, such as temperature cycling before immersion.	manufacturer, generally up to 3 m.
9K	Powerful high temperature water jets	Protected against close-range high pressure, high temperature spray downs. Smaller specimens rotate slowly on a turntable, from 4 specific angles. Larger specimens are mounted upright, no turntable required, and are tested freehand for at least 3 minutes at distance of 0.15–0.2 m. There are specific requirements for the nozzle used for the testing. This test is identified as IPx9 in IEC 60529.	Test duration: 30 seconds in each of 4 angles (2 min. total) Water volume: 14–16 litres/min. Pressure: 8–10 MPa at distance of 0.10–0.15 m Water temperature: 80°C

Combining both digits together results in information on the protection provided against the entry of foreign solid objects and against the entry of moisture. As of today, IP67 and IP68 are the highest level of protection claimed by some manufacturers of mobile phones, smartphones and tablets (Table 4).

Table 4: Examples of relevant IP ratings for mobile phones, smartphones and tablets (Cordella et al. 2020)

IP codes	First Digit - SOLIDS	Second Digit – MOISTURE
IP67	Protected from total dust ingress.	Protected from immersion between 15 centimetres and 1 meter in depth.
IP68	Protected from total dust ingress.	Protected from long-term immersion up to a specified pressure.

It is noteworthy that devices do not have to pass every test leading up to the highest rating they achieve. This means that in some cases a device rated with IP67 may not have been tested against dust protection levels 1-5, or water protection levels 1-6.

- IEC 60068-2-31:2008 - Environmental testing - Part 2-31: Tests - Test Ec: Rough handling shocks, primarily for equipment-type specimens (drop and topple, free fall, repeated free fall and bounce tests). This norm deals with a test procedure for simulating the effects of rough handling shocks, primarily in equipment-type specimens, the effects of knocks, jolts and falls which may be received during repair work or rough handling in operational use. The following table provides a short summary of the test (IEC 60068-2-31:2008):

Table 5: Scope and Test procedure of IEC 60068

Working Group	Objectives
Scope	The IEC 60068 2-31 standard deals with shock tests, as they may occur during use or repair scenarios. The standard does not specify which kinds of devices can be tested other than that they must be prone to experience such shocks (falls, dumps and the like) during their useful life.
Tests	The standard includes three types of tests:

	• Drop and topple • Free fall • Repeated free fall **Drop and topple** In this test, the device is dropped from a tilted position. The starting position should either form a specific angle with the impact area or set a minimal distance from it. The device shall undergo a fall once per edge (to be limited to four if the device had more). The impact surface shall be, if not indicated otherwise by the specific use of the device, a steel plate over concrete. **Free fall** This test deals with a limited set of free falls from specific heights that the device has to endure. Two free falls are to be performed for every position. Those positions are not specified in any degree in the standard. The fall height is set to be dependent on the mass of the device. There is no specification on the device to be used as a tester, rather some parameters are given that the testing device has to fulfil. **Repeated free fall** This test deals with repeated free falls that a device endures. In this case, the standard gives a specific definition of the kind of tester to be used (including drawings of the required shape of the drum and the materials of the impact area). The number of falls is to be set to 50, 100, 200, 500 or 1000. The fall height is also specified as well as the spinning speed of the testing drum. Once the test is completed, the device has to be checked visually and the electronic and mechanic properties should be verified.

4.1.8. Main interface standards

The specification and standardisation of interfaces, in particular of USB, is relevant in context of harmonising chargers for mobile devices (see 5.4). Relevant standards include:

- IEC 62680-1-1:2015, Universal Serial Bus interfaces for data and power – Part 1-1: Common components – USB Battery Charging Specification, Revision 1.2.
- IEC 62680-1-2:2018, Universal serial bus interfaces for data and power – Part 1-2: Common components – USB Power Delivery specification.
- IEC 62680-1-3:2018, Universal serial bus interfaces for data and power – Part 1-3: Universal Serial Bus interfaces – Common components – USB Type-C™ Cable and Connector Specification.
- IEC 62680-2-1:2015, Universal serial bus interfaces for data and power – Part 2-1: Universal Serial Bus Specification, Revision 2.0.
- IEC 62684:2018, Interoperability specifications of common external power supply (EPS) for use with data-enabled mobile phones.
- ITU Recommendation L.1000 (07/19): Universal power adapter and charger solution for mobile terminals and other hand-held ICT devices

The target solution recommended in L.1000 still leaves some options as follows:

- A highly recommended option of detachable cable with a USB Std-A connector on the charger side to a USB Micro-B or a USB type-C plug connector or a detachable cable with USB type C connectors at both end.
- A non-recommended option, depending on market demand, of captive cable terminating in a USB connector (Micro-B type or type C).

- A plug adapter may be used as option for connecting from a USB type C receptacle/plug to any specific connector. A plug adapter can also be the cable itself. In that case the USB-C voltage and current management protocol may not be used.
- A rated charging current in the range 750 mA (preferably 1000 mA) to 3000 mA.
- No-load power consumption of the power adapter below 0.03 W.

4.1.9. Main standards and testing methods on a broader range of material efficiency aspects

- ITU-T L.1020 (01/2018): Circular economy: Guide for operators and suppliers on approaches to migrate towards circular ICT goods and networks
- ITU-T L.1022 (10/2019): Circular economy: Definitions and concepts for material efficiency for information and communication technology

4.1.10. Main standards and testing methods on recycling and substance analytics

- ITU-T L.1100 (02/2012): Procedure for recycling rare metals in information and communication technology goods
- ITU-T L.1101 (03/2014): Measurement methods to characterize rare metals in information and communication technology goods
- ITU-T L.1102 (07/2016): Use of printed labels for communicating information on rare metals in information and communication technology goods

4.1.11. Main standards and testing methods on life cycle assessments and environmental impact evaluation or environmental rating

- ETSI ES 203 199 V1.3.1 (2015-02) - Environmental Engineering (EE); Methodology for environmental Life Cycle Assessment (LCA) of Information and Communication Technology (ICT) goods, networks and services
- ITU-T L.1015 (01/2019): Criteria for evaluation of the environmental impact of mobile phones
- ITU L.Sup32 (10/2016): Supplement for eco-specifications and rating criteria for mobile phones eco-rating programmes
- 1680.1-2018 - IEEE Standard for Environmental and Social Responsibility Assessment of Computers and Displays
- ETSI TR 103 679 (2019-05): Environmental Engineering (EE); Explore the challenges of developing product group-specific Product Environmental Footprint Category Rules for Smart Phones
- EC Product Environmental Footprint (PEF) method[26]

ETSI ES 203 199 has been developed to complement ISO 14040 and ISO 14044 [2] for the environmental assessment of the life cycle impact of ICT goods, networks and services. Some of the requirements put forward in ETSI ES 203 199 are considered as challenging due to life cycle assessment (LCA) tool limitations, a lack of data, limitations in data granularity, etc. It is thus recognized that compliance to all requirements may not be possible. This statement in the introduction was made in 2015, and LCA has progressed since then, but even today full compliance is at least extremely challenging. This standard makes another important point: "Comparisons of results from environmental assessments of ICT goods, networks and services, assessments which have been performed by different organizations are beyond the scope of the present document, as such comparisons would require that the assumptions and context of each study are exactly equivalent." This

[26] https://eplca.jrc.ec.europa.eu/permalink/PEF_method.pdf

problem can be greatly reduced using PEF, as many of the assumptions which are possible with other methods have been "regulated". However, it remains true that even with PEF, a comparison between products is only allowed if there is a PEFCR.
Supplement ITU L.Sup32 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. L.Sup32 cross-references to UL 110 (see 4.3.1). L.Sup32 does not specify requirements to be met, but suggests aspects to be addressed and covered by any eco-rating of mobile phones:

- compliance with [ITU-T L.1000] (charger, USB cable)
- firmware/software updates and maintenance releases
- personal data transfers to a new phone
- manufacturer-provided information on reduced energy phone usage (advise consumers on how to minimize battery discharge)
- external power supply average efficiency and no-load power
- material restrictions, including homogenous material limit, as already defined in EU legislation (RoHS, REACh, Battery Directive)
- low halogen electronics (IEC 61249-2-21)
- Product volume ratio
- Dissimilar packaging material
- Plastics packaging marking
- No printed complete user manual
- Phone disassembly for recycling and proper end-of-life disposal
- Repair of the mobile phone

Some of these aspects are novel and not found in other measures, such as the product volume ratio to incentivise more efficient logistics due to reduced package sizes.

ETSI TR 103 679 is an important analysis of the current status of LCAs for smartphones. The European Commission initiated the development of PEFs (Product Environmental Footprint) for a range of products, but not yet for products in scope of this study. A pre-condition for comparing PEF assessments is the existence of Product Environmental Footprint Category Rules (PEFCRs), which have not been developed for smartphones yet. ETSI TR 103 679 provides some guidance for such PEFCR. However, at least 2 PEFCRs have been developed for related sectors that could be interesting to the extent of the smartphones product group: Data storage and Uninterruptible Power Supplies.

ETSI TR 103 679 includes a comparison of published carbon footprint data for smartphones. All of the compiled examples (13 models) indicate that the materials acquisition and manufacturing phase ("upstream") dominates the greenhouse gas emissions in all cases, but otherwise results are stated not to be comparable.
Authors of ETSI TR 103 679 compared current practice for published full LCAs, which can be considered the state-of-art in industry, with the guidance for PEF Category Rules (PEFCR) and existing Product Category Rules for smartphones. The analysis of full LCAs is shown in Table 6. The colour coding indicates what is in scope, partly / occasionally in scope, and out of scope. Compared to the PEFCR Guidance current modelling practice is stated to be slightly less complete. The main differences are related to what is covered in (commercial) databases, transports between supply chain tiers, and partly distribution and storage.

Table 6: Analysis of current Full LCA modelling of smartphones (ETSI TR 103 679, colour coding by Fraunhofer IZM)

Life Cycle Stage	Current Full LCA modelling practice for smartphones
Raw Material Acquisition	Included
Transport	Included if in database
Pre-processing: Material forming	Included if in database
Transport	Included if in database
Pre-processing: Subcomponent production	Included
Transport	Included if in database

Life Cycle Stage	Current Full LCA modelling practice for smartphones
Pre-processing: Component production	Included
Transport	Included with primary data for some parts
Pre-processing: Product Part Production	Included
Transport	Included for some parts
Final Assembly	Included
Distribution and Storage: Transport	Included
Distribution and Storage: Storage room	Not included
Distribution and Storage: Transport	Not included
Marketing	Not included
Transport	Included
Use stage	Included as scenario by all manufacturers
Transport	Included as scenario
End-of-life treatment	Included as scenario

With respect to data quality, ETSI TR 103 679 states as current full LCA modelling practice the use of primary data in part for component production, product part production, transports to distribution and storage, primary data to allocate final assembly (i.e., actual BOM data used), primary data for modelling the use phase based on a test scenario, and the occasional use of primary disassembly data to guide modelling of end-of-life processes. With this level of primary data usage, requirements of the PEFCR Guidance are exceeded, which states "Primary data should be used if the process contribute to more than 80 % of the most important midpoint categories." It has to be noted that, according to PEF, company specific data (primary data) should be used for a) all most relevant processes[27] under operational control and b) any other processes for which this requirement is explicitly requested in the PEFCR.

4.2. Mandates issued by the European Commission to the European Standardisation Organisations (ESOs)

The first EU Circular Economy Action Plan (2015) called for a request to European Standardisation Organisations to develop standards on material efficiency for setting future Ecodesign requirements on durability, reparability and recyclability of products. In the same year, the European Commission issued Mandate 543[28] on a standardisation request to the European Standardisation Organisations as regards ecodesign requirements on material efficiency aspects for energy-related products in support of the implementation of Directive 2009/125/EC of the European Parliament and of the Council. The main purpose of the mandate is to develop generic standards, which cover ecodesign requirements related to material efficiency aspects (such as recyclability, recoverability and reusability, durability, reversible disassembly and end of life extraction time) for any product group listed in the Article 16 of the Directive itself.

In response to the Mandate, the CEN/CENELEC JTC10 "Energy-related products – Material Efficiency Aspects for Ecodesign" was created. The CEN/CENELEC JTC10 aims to develop general standards on material efficiency aspects for Energy-related Products, which can be used to support the policy making process. The following seven working groups were formed:

[27] Most relevant processes are those that contribute cumulatively to 80% of each impact.

[28] https://ec.europa.eu/growth/tools-databases/mandates/index.cfm?fuseaction=search.detail&id=564

Table 7: CEN/CLC/JTC 10 Working Groups

Working Group	Objectives
CEN/CLC/JTC 10/WG 1	To develop Technical Reports regarding the definitions related to material efficiency and the use of generic material efficiency standards when writing energy related product specific standardization deliverables.
CEN/CLC/JTC 10/WG 2	To develop standard on the general method for the assessment of the durability of energy related products and of the upgradability of energy related products.
CEN/CLC/JTC 10/WG 3	To develop standards on the general method for the assessment of the ability to repair energy related products and of the ability to re-use energy related products.
CEN/CLC/JTC 10/WG 4	To develop a standard on the general method for the assessment of the ability to re-manufacture energy related products.
CEN/CLC/JTC 10/WG 5	To develop standard on methods for assessing the recyclability and recoverability of energy related products as well as to develop standards regarding the general method for assessing the proportion of re-used and recycled components in an energy related product.
CEN/CLC/JTC 10/WG 6	To develop standards specifying the general method to declare the use of critical raw materials in energy related products and specifying the methods for providing information relating to material efficiency aspects of energy related products.
CEN/CLC/JTC 10/WG 7	Chairman's Advisory Group

The related European Norms (ENs) and Technical Reports (TRs) were published in the years 2019-2020 and are listed in the following table.

Table 8: CEN/CLC/JTC 10 standards

Reference	Title
EN 45552:2020	General method for the assessment of the durability of energy-related products
EN 45554:2020	General methods for the assessment of the ability to repair, reuse and upgrade energy-related products
EN 45555:2019	General methods for assessing the recyclability and recoverability of energy-related products
EN 45556:2019	General method for assessing the proportion of reused components in energy-related products
EN 45557:2020	General method for assessing the proportion of recycled material content in energy-related products
EN 45558:2019	General method to declare the use of critical raw materials in energy-related products
EN 45559:2019	Methods for providing information relating to material efficiency aspects of energy-related products
EN 45553:2020	General method for the assessment of the ability to re-manufacture energy-related products
TR 45550	Definitions related to material efficiency
TR 45551	Guide on how to use generic material efficiency standards when writing energy related product specific standardization deliverables.

However, these standards only define generic approaches, which need to be adapted for specific product groups individually. Only EN 45556:2019 mentions explicitly, that the standard might be applied directly to product assessments, in absence of product-specific standards.

4.3. Third country and third party test standards

4.3.1. UL 110: Standard for Sustainability for Mobile Phones

The UL 110 Standard for Sustainability for Mobile Phones (2017) established multiple sustainability criteria for mobile phones, covering the mobile phone, accessories shipped in the box with the mobile phone, and packaging. The criteria in the standard were developed based on the life cycle stages of mobile phones (product criteria) and corporate sustainability performance factors (corporate criteria). The EPEAT requirements for Mobile Phones are based on this standard. The main sustainability factors considered in the standard are summarised in the following table:

Table 9: Overview of the UL 110 Standard for Sustainability for Mobile Phones

Reference	Title
Materials	- Compliance with the European Union REACH Regulation - Reduction of European Union REACH Candidate SVHC substances - Substitutions assessment - Requesting and receiving substance inventory - Post-consumer recycled and biobased plastic content - Compliance with the European Union RoHS Directive - Restrictions of substances
Energy use	- Mobile phone battery charging system efficiency
End of life management and extension of useful life	- Take-back program - Primary recyclers third party certified - Rechargeable battery removability/replacement - Ease of disassembling mobile phone - Feature to erase user data from mobile phone - Repair and refurbishment - Availability of replacement parts - Notification regarding and the identification of materials and components requiring selective treatment
Packaging	- Use of fibre based packaging materials - Separability and labelling of plastics in packaging - Use of post-consumer recycled plastic packaging - Expanded polystyrene packaging (EPS) restriction - Recycled content in fibre packaging - Environmentally preferable virgin fibre-based packaging and printed content - Restriction of chlorine in packaging materials - Heavy metal restrictions in packaging - Improve packaging efficiency
Corporate practices	- Corporate sustainability (CS) reporting - Corporate sustainability (CS) reporting in the supply chain - Third party assurance of corporate sustainability (CS) reporting
Life Cycle Assessment	- Conducting a life cycle assessment - Product LCA third-party verification or making LCA publicly available
Manufacturing and operations	- Supplier responsibility - Manufacturing facilities environmental management systems (EMS) - 3TG minerals - Reduce fluorinated gas emissions resulting from flat panel display manufacturing
Innovation	- Innovation

4.3.2. US Department of Defense Test Method Standard MIL-STD-810

In the last years, it became popular among smartphone brands to claim compliance with military standards. The MIL-STD-810[29] is a United States Military Standard. The latest version is MIL-STD-810H, dated January 31, 2019, superseding MIL-STD-810G w/Change 1, dated April 15, 2014. It consists of three main parts: General program guidelines, laboratory test methods and world climatic regions. Part 2 contains 29 different test methods that range from less (e.g. rain, sand and dust, etc.) to more extreme conditions (e.g. pyro shocks, acidic atmosphere, etc.). While the document explicitly states that the standard can be tailored for commercial applications, it does not provide clear rules for its application. In fact, the MIL-STD-810 is a flexible standard that allows companies to tailor test methods to fit the specific application. This means that it might be enough for a company to pass at least one of the 29 tests in order to be able to label its product MIL-STD-810. Some third party organizations are already offering this independent verification (e.g. TUV[30]). This flexibility of the standard could make the label misleading. For this reason, consumers who require rugged products should verify which test methods and parameter limits were selected. As an example, the comparison of two phones labelled MIL-STD-810 shows the difference of the testing depth.

Table 10: Compliance with MIL-STD-810 – comparison of different smartphone models

Title	LG Q60, LG K12 Prime, LG X6 2019, LG K50, LG K12 Max[31]	Galaxy X Cover Pro[32]
Low Pressure (Altitude)		2
High Temperature	2	4
Low Temperature	2	2
Temperature Shock	1	1
Rain		2
Humidity	1	1
Salt Fog		1
Sand and Dust		2
Immersion		1
Vibration	1	1
Shock	1	1
Temperature, Humidity, Vibration, and Altitude		1
Icing/Freezing Rain		1
Ballistic Shock		1
Total tests	**8**	**21**

More detailed results of the LG tests (incl. test conditions) for models LG Q60, LG K12 Prime, LG X6 2019, LG K50, LG K12 Max are shown in below table[33]:

[29] http://everyspec.com/MIL-STD/MIL-STD-0800-0899/MIL-STD-810H_55998/

[30] https://www.tuvsud.com/en/services/testing/shock-and-vibration-testing

[31] https://www.lg.com/co/celulares/ESL102896-MIL-rev-1-(MH42-43).pdf

[32] https://insights.samsung.com/2020/01/13/10-ways-the-galaxy-xcover-pro-will-make-your-team-field-ready/

[33] https://www.lg.com/co/celulares/ESL102896-MIL-rev-1-(MH42-43).pdf

Table 11: Test results according to MIL-STD-810G for LG devices

MIL-STD-810G Test Method	Test Name	Test Conditions	Test Status
Method 501.5 High Temperature	Procedure I - Storage (High Temp)	Storage : with the EUT not operating, continuously 24 hours at 63°C	Compliant
Method 501.5 High Temperature	Procedure II - Operation (High Temp)	Operation : with the EUT operating, continuously 24 hours at 43°C	Compliant
Method 502.5 Low Temperature	Procedure I - Storage (Low Temp)	Storage : with the EUT not operating, continuously 24 hours at -33°C	Compliant
Method 502.5 Low Temperature	Procedure II - Operation (Low Temp)	Operation : with the EUT operating, continuously 24 hours at -21°C	Compliant
Method 503.5 Temperature Shock	Procedure I-C - Temperature Shock - Multi Shocks	Chamber temperature extreme set at -21 to 43 °C (a period of 8 hours, total of 3 cycles)	Compliant
Method 507.5 Humidity	Humidity – Procedure I, Natural Cycles (Cycle B3- 16 days per table 507.5-II, Figure 507.5-6)	Maintained for 24 hours, 16 cycles (Humidity 45 ~ 55 %, Temperature 21 ~ 25°C)	Compliant
Method 514.6 Vibration	Procedure I - Vibration – Category 4, Restrained Cargo (Wheeled), Table 514.6C-VI and Figures 514.6C-3	Vibration test in total of 3 hours(3-axis each 1 hour / 5 ~ 500Hz)	Compliant
Method 516.6 Shock	Procedure IV - Transit Drop	Drop test at 48 inches in 10 direction with each of 5 cell phones, total drops 50	Compliant

Some of the tests defined under MIL-STD-810 might qualify in adapted versions to specify durability requirements of devices.

4.4. Tests performed by consumer organisations

Under the umbrella of ICRT (International Consumer Research and Testing), many consumer organisations from all over the world tests smartphones together by following specific testing programmes and exchanging testing results. Usually, the devices are purchased anonymously and neither samples nor pre-series models are selected for the test. Besides basic features (voice quality, network sensitivity, computing power, location, etc.), display and camera performance and handling, important smartphone tests also cover battery life and durability.

Table 12: Durability tests performed by consumer organisations for smartphones

Test Type	Description
Battery test (running time)	This test is performed with the help of an industrial robot. Each device is run once at maximum screen brightness and once with a brightness of 300 candelas per square meter until the battery is empty and the cell phone switches off. An example of a test performed by the German consumer organisation Stiftung Warentest looks as follows: • Play a YouTube video over WiFi for 7.5 min. every hour • Navigate for 1.25 minutes via GPS • Make calls for 2.5 minutes • Take five photos • Receive two notifications • The rest of the time the device remains in standby (WiFi and GPS on, Bluetooth off)
Battery test (charging time)	The charging time of the battery and the quick charge function (battery capacity after 15 minutes of charging) are evaluated.
Rain test	The devices are switched on and connected to a network. A measurement according to EN60529-2000-09 is performed. A raining appliance is used to provide an even rain distribution according to Ipx1 (7.2 l/h). The phones are placed horizontally on a rotary table and are irrigated for 5 min. The functions are assessed immediately and then one, two and three days after the test.

Test Type	Description
Diving test (Water resistance submersion)	Only devices that are certified to be water-protected (at least IPX7) according to EN 60529 are tested. The testing laboratories follow the information provision of the manufacturer. Devices are submerged into a water tube at the stated maximum depth for 30 min. to verify the waterproofness. The correct functioning is assessed immediately, after one day, after 2 days and after 3 days.
Shock resistance tumble test	The durability against mechanical shocks (e.g. accidental drops) is tested with a tumbling barrel to simulate an 80 cm fall against a stone surface, as described in IEC 60068 2-31. Devices are switched on, set in operational mode (e.g. call), put into a tumbling drum for 50 and 100 drops and checked regularly.
Scratch resistance test	Scratch hardness tests based on ISO 1518 are performed to test how scratch-resistant the display and camera window are. The scratch resistance of the phones' displays and their bodies is examined using a hardness test pencil (e.g. ERICHSEN, Model 318 S). A rating for the display is generated depending on the maximum load that does not lead to permanent scratches on the device under test.
Fold mechanism test	In the case of foldable or foldable cell phones, consumer organisations use an industrial robot to check whether the fold mechanism shows signs of wear after 30,000 folds.

Since 2020, the scratch resistance test of the housing was abandoned by several consumer organisations, since most of the devices passed the test. Furthermore, the visual tests on accuracy and solidity of the housing, contacts and connections are also performed less often, mainly because connectors were harmonised and consumer organisations were not able to open the devices anymore.

When it comes to testing of tablets by consumer organisations, the most relevant tests for the purpose of this study are related to batteries. An example is provided in the following table.

Table 13: Durability tests performed by consumer organisations for tablets (source: Stiftung Warentest)

Test Type	Description
Battery test (running time)	The battery life is checked starting with a fully charged battery and using different brightness modes: • Display brightness when playing a video • Maximum display brightness when surfing via WiFi
Battery test (charging time)	Battery charging times according to the charging current measurement and the quick charge function. Evaluation of the active power consumption of the power supply and the device in standby.
Scratch resistance test	Scratch hardness tests based on ISO 1518 are performed to test how scratch-resistant the display and housing are. It is also evaluated whether there are sharp edges and burrs.
Drop test	The stability is tested through falls from three positions on a carpet from a height of 50 centimetres.
Rain or diving test	Only devices that are certified to be water-protected according to EN 60529 are tested.

4.5. Eco-Label and third party ratings, third party guidelines

4.5.1. Blue Angel

4.5.1.1. Mobile Phones (DE-UZ 106)

Criteria for the award of the Blue Angel ecolabel to mobile phones have been setup in Germany. The latest version of the criteria is dated July 2017. Currently there is no phone to which the label is awarded.

Table 14: Blue Angel criteria Mobile Phones (DE-UZ 106)

Requirement	Specification (in brief)
State-of-Charge Indicator	indicating the current state of battery charge during use and charging; show in a clear manner that the charging has been completed
External Power Supply	provide a distribution channel for the mobile phone through which the mobile phone is marketed without an external power supply
Replaceability of the Battery	replaceable by the user
Battery Capacity	shall be measured in accordance with paragraph 7.3.1 „Discharge performance at 20 °C (rated capacity)" of EN 61960
Battery Marking	marked in accordance with EN 61960 providing at least the following information: nominal capacity (N), nominal voltage, type designation, date of manufacture
Durability of the Battery	after 500 full charge cycles min. 90% remaining capacity of the nominal capacity
Battery Safety	EN 62133-2 "Secondary cells and batteries containing alkaline or other non-acid electrolytes – Safety requirements for portable sealed secondary cells, and for batteries made from them, for use in portable applications – Part 2: Lithium systems"
Warranty	minimum 2 years (except for batteries: 1 year @ 90% remaining capacity), for free
Availability of Spare Parts and Repair	3 years spare parts ("those parts which, typically, may fail or break down within the scope of the ordinary use of a product, especially batteries, displays and front glasses") availability at reasonable price; designed to enable qualified specialist workshops to replace such spare parts with reasonable effort; product documents shall provide information on spare parts supply and repair services
Software Updates	function to allow the user to update the operating system; security updates for the operating system for at least 4 years from the time that production ceases
Data Deletion	completely and securely delete all personal data without the help of pay software shall be feasible; alternatively: encode personal data and allowing a secure deletion of the key; factory reset; product documents shall include detailed instructions
Take Back and Recycling	operate its own take-back scheme to direct all collected devices to reuse or professional recycling
Recyclable Design	removal of the battery in max. 5 seconds
Plastics used in Housings and Housing Parts	no SVHCs; no carcinogenic / mutagenic / reprotoxic substances; no halogenated polymers in housings; no

Requirement	Specification (in brief)
	halogenated organic FRs; no carcinogenic / hazardous to water FRs
Biocidal Silver	on touchable surfaces: not permitted
Electromagnetic Radiation	near ear: max. 0.5 W/kg; near body: max. 1.0 W/kg; allow phone calls without holding phone close to ear or mouth
Social Corporate Responsibility	Compliance with "OECD Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas"; list components containing conflict minerals and suppliers, supply chain scheme
Working Conditions	ILO-Standards
Operating Instructions	include specified user information relating to environment and health

4.5.1.2. Digital cordless phones (DE-UZ 131)

Criteria for the award of the Blue Angel ecolabel to digital cordless phones have been setup in Germany. The latest version of the criteria is dated January 2020. Currently there are no phones yet to which the label in its most recent version is awarded, but there are 8 phone models (all manufactured by Vtech Telecommunication Ltd., Hongkong) to which the Blue Angel in the April 2014 version, which is still valid until December 2020, is awarded.

As the Blue Angel criteria for digital cordless phones prioritises to reduce exposure to electromagnetic radiation and power consumption there is only one criterion which is the same as for mobile phones, which are the requirements for plastics.

Table 15: Blue Angel criteria Digital Cordless Phones (DE-UZ 131)

Requirement	Specification (in brief)
Power consumption	base station: < 1.0 W without the handset on the base station as well as with the charged handset on the base station (trickle charge); < 1.5 W in case base station has a display charging cradle: < 0.6 W with charged handset (trickle charge); < 1.0 W for charging cradle with WLAN; with or without WLAN < 0.3 W when handset is not on the charging cradle
User-adjustable range limitation	reduce the transmission power in at least three steps, i.e. the user must be able to set a minimum of four different ranges (transmission power levels)
Automatic adaptation of transmission power	adjust transmission power to the connection quality
Cut-off of transmission signals in standby mode	factory settings: in standby mode (no active voice or data connection) the radio signals of the base station and handsets (or handset) are completely cut off
Further exposure reduction	at least one of the following: Hands-free mode or use of corded headsets or use of cordless headsets (maximum transmission power: 1 mW)
Handset display	must show the duration of the call, actual range limitation, current transmission power level during a call
Specific absorption rate (SAR)	Handset: max. 0.10 watts per kg.
Plastics used in Housings and Housing Parts (*)	no SVHCs; no carcinogenic / mutagenic / reprotoxic substances; no halogenated polymers in housings; no halogenated organic FRs; no carcinogenic / hazardous to water FRs

Requirement	Specification (in brief)
Rechargeable batteries	Replaceable without the aid of any special tools; Batteries need to be those available commercially in standard forms, or made available by the manufacturer as original spare parts for at least 6 years after marketing of the product has ceased, or available commercially as compatible spare parts in the form of "replica rechargeable batteries" (lithium ion rechargeable batteries)
Provision of spare parts and replacement devices	guarantee the provision of spare parts (i.e., parts which, typically, may break down within the scope of the ordinary use of a product) or replacement devices for at least 2 years from the time that marketing of the product ceases
Sales packaging	made out of paper or cardboard, using recycled fibres accounting for at least 70 % by mass
Operating instructions	include specified user information relating to environment and health, in particular how to reduce exposure to electromagnetic fields

(*) : same requirement as for mobile phones, DE-UZ 106

4.5.1.3. Resource and Energy-Efficient Software Products (DE-UZ 215)

The Blue Angel for "Resource and Energy-Efficient Software Products" provides special guidance to purchasers and users of software in the area of ICT[34]. Currently, criteria are defined for application software that is primarily run on desktop systems. The Basic Award Criteria refer to application software that has a user interface and can be run on one of the reference systems defined in Annex D of the requirements document. It is foreseen to expand the scope to other architectures, such as client server systems and mobile apps.

Table 16: Blue Angel criteria Resource and Energy-efficient Software Products (DE-UZ 215)

Requirement	Specification (in brief)
Potential hardware operating life	The software must not contribute to the early replacement of existing hardware with more powerful hardware because the existing hardware no longer meets the performance requirements of the software. Software updates must not result in the need for a hardware update.
Backward compatibility	It must be possible to run the software product on a reference system from a calendar year that is at least five years before the time of application.
Uninstallability	It must be possible to completely remove the software product from the computer system after the end of its operating life without leaving any unnecessary traces of data.
Continuity of the software product	Security updates must be provided free of charge, updates offering additional functionalities are excluded from this rule. The applicant undertakes to supply security updates for the labelled product for at least 5 years after the end of sale.

[34] https://produktinfo.blauer-engel.de/uploads/criteriafile/en/DE-UZ%20215-eng%20Criteria.pdf

4.5.2. TCO

TCO Certified is an international third party sustainability certification scheme for IT products.

TCO is a type-1 label certifying that products fulfil requirements along its life cycle:

- Manufacturing (social responsible manufacturing, environmental management system)
- Use phase (climate, ergonomics, health and safety, extended product life and emissions)
- End of life (reduction of hazardous content and chemicals, design for recycling)

The latest version of criteria for smartphones and tablets are the TCO Certified – Generation 8, Smartphones / Tablets – edition 2 – 2019.

The last generation of TCO Certified ("Generation 8") was released in December 2018. The criteria include comprehensive management system, product performance and safety aspects. Main product related environmental aspects are listed in Table 17. The criteria are very similar for smartphones and tablets with slight differences in the definition of "critical replaceable components" and the weight limits for plastics criteria.

Table 17: TCO criteria for smartphones and tablets (selection)

Criteria	Specification (in brief)	
	smartphones	tablets
non-mandatory		
Replaceable components	Critical parts (=battery, display panel / display assembly, charger) replaceable without the use of heat or other tools than those intended to turn, slotted (ISO 2380), cross-recessed (Phillips® and Pozidriv®, ISO 8764) or hexalobular recess heads (Torx®, ISO 10664)	… (= battery, display panel / display assembly, external/internal PSU) …
PCR plastics	Percentage by weight of total weight of all product parts made out of plastic (exemptions apply)	
Battery replaceability	Without tools	
mandatory		
Energy efficiency	External power supply: level VI (International Efficiency Protocol)	
Product warranty	Minimum 1 year	
Service manual	Free online instructions how to replace at least all critical replaceable components	
Availability of all critical replaceable components	Available for anyone to purchase or may be replaced by a service network for repair and maintenance	
Standardized connectors	USB Type-C connector that is backward compatible with USB 2.0 (or USB Type-A Male to USB Type-C female adapter)	
Product durability	MIL-STD-810G w/CHANGE 1 or IEC 60068-2: Drop Test (45 cm), high temperature, low temperature	
Data removal	Media sanitization software, pre-installed or free download	
Battery longevity	Minimum 300 charging cycles with at least 60% of the initial capacity (IEC 61960)	
Battery replaceability	Replaceable by the end-user and/or technician	

Criteria	Specification (in brief)	
	smartphones	tablets
Halogens	Parts > 5 g made mainly of plastics must not contain flame retardants or plasticizers with halogenated substances or intentionally added halogens as part of the polymer (exempted: PCB laminates, electronic components, cable insulation)	… > 25 g …
Non-halogenated flame retardants	Those contained in parts > 5 g and are made mainly of plastics must appear on the public TCO Certified Accepted Substance List[35] (exempted: PCB laminates, electronic components, cable insulation)	… > 25 g …
Plasticizers	Those used in product housing and cable insulations must appear on the public TCO Certified Accepted Substance List	
Coding of plastics	Parts made mainly of plastics > 5 g must be coded (ISO 11469, ISO 1043-1, -2, -3, -4); exempted PCB laminates	… > 25 g …

At the moment there are no smartphones awarded and registered as TCO Certified. In 2013 Samsung's Galaxy S4 smartphone was the first TCO labelled model[36]. In the tablet category 5 models are awarded the TCO Certified Tablets (Table 18).

Table 18: TCO Certified Tablets (as of May 26, 2020)

Brand	Sales name	Certified on	Valid until
DELL	Latitude 7210 2-in-1 TCO Certified	2020-03-09	2022-03-09
Lenovo	Lenovo 10e Chromebook Tablet	2020-03-02	2022-03-02
DELL	Latitude 7200 2-in-1	2019-03-28	2021-03-28
DELL	Latitude 5290 2-in-1	2017-11-22	2020-11-22
DELL	Latitude 7285	2017-04-26	2020-12-03

4.5.3. Green Public Procurement (EU)

The European Commission has developed comprehensive guidance for green public procurement (GPP) and it encourages Member States to develop National Action Plans for GPP. The guidance also covers mobile phones. Many Member States have gone beyond the EU guidance and have specific legislation and regulation in place to include environmental and social sustainability criteria (Transform Together 2018).

Table 19: Green Public Procurement Mobile Phones

Requirement	Specification (in brief)
External Power Supply	energy efficient power supply, requirements for no-load power consumption and energy efficiency for the active mode
Contract performance clauses	Replacement of individual parts of the mobile phone product package instead of the whole package. This includes the individual replacement of the mobile phone, charger, battery or sub components such as

[35] https://tcocertified.com/accepted-substance-list/

[36] https://tcocertified.com/news/samsung-galaxy-s4-first-to-achieve-sustainability-certification-for-smartphones/

	keypads and covers only when required instead of the whole package.
Availability of Spare Parts and Repair	Compatible accessories including headsets, replacement batteries and chargers for the mobile phone shall be available. This requirement is limited to 5 years.
Recyclable Design	Design for dismantling for recycling purposes, separation and recycling of case plastics, accumulators other functional units.
Information for recycling	Dismantling shall be able to be carried out using common tools and the specialised firms entrusted by the manufacturer with the reuse/recycling of waste products shall be provided with information on the dismantling of the devices.
Plastics used in Housings and Housing Parts	no SVHCs; no carcinogenic / mutagenic / reprotoxic substances; no halogenated polymers in housings; no halogenated organic FRs; no carcinogenic / hazardous to water FRs
Plastics marking	Plastic case parts (exceeding 10 grams) must be marked according to ISO 11469 or equivalent.
Materials of PCBs	No carcinogenic / mutagenic / reprotoxic substances; no beryllium oxide
Recycled content	Additional points for the use of recycled materials in the main casing
Operating Instructions	include specified user information relating to environment and health
Information to consumer	Include information on product take back; on battery/accumulator disposal. Include instructions on how to avoid power draw of adaptors when the mobile phone battery is not being charged

4.5.4. EPEAT

EPEAT is a an environmental product rating based on a range of product group specific IEEE standards (IEEE 1680 series) and in case of mobile phones UL 110 to support in particular green public procurement. The system began in 2003 with a stakeholder process convened by the U.S. Environmental Protection Agency and has grown to become a global environmental rating system for electronics. The EPEAT registry currently lists 54 mobile phones[37] by Apple, Google, LG Electronics and Samsung, including provider versions, several of them in France as the only EU country with registered devices. There are 238 active slates / tablets registered with EPEAT and currently active. Manufacturers of registered slates / tablets include Apple, Dell, Durabook, Dynabook, Fujitsu, GETAC, Google, HP, Lenovo, Microsoft, Panasonic, Samsung, and Zebra Technologies. Individual slates / tablets are registered in several EU countries: Belgium, Finland, France, Germany, Netherlands, Poland, Portugal, Spain, and Sweden.

Manufacturers register products in EPEAT based on the devices' ability to meet certain required and optional criteria that address the full product lifecycle, from design and production to energy use and recycling:

- Bronze-rated products meet all of the required criteria in their category.
- Silver-rated products meet all of the required criteria and at least 50% of the optional criteria,
- Gold-rated products meet all of the required criteria and at least 75% of the optional criteria.

[37] As of May 27, 2020

Table 20 lists and compares the EPEAT criteria for tablets and mobile phones. Only few criteria are exactly the same. Many are specified slightly different, given the different standardisation history (UL / IEEE) and the overall evolution of EPEAT criteria. Several criteria are not relevant as they refer to EU legislation in place. Many others address requirements on the corporate level and noot on the product level.

Table 20: EPEAT criteria tablets and mobile phones

Requirements	tablets	mobile phones
Required requirements	criteria #	
Conformance with European Union RoHS Directive substance restrictions	(4.1.1.1)	(9.1.1)
Compliance with the European Union REACH Regulation		(7.1.1)
Restrictions of Extractable Nickel		(9.2.1)
Elimination of intentionally added mercury in light sources	(4.1.3.1)	
Reduction of bromine and chlorine content in plastic parts >25 g	(4.1.5.1)	
Compliance with provisions of EU Battery Directive	(4.1.7.1)	
Restriction of Cadmium and Mercury in the Mobile Phone Battery Cell		(9.2.4)
Restriction of Substances in Textile and Leather		(9.2.5)
Minimum post-consumer recycled plastic, ITE-derived post-consumer recycled plastic or bio based plastic content	(4.2.1.1)	
Declaration of Post-Consumer Recycled and Biobased Plastics Content		(8.1.1)
Identification of materials and components requiring selective treatment	(4.3.1.1)	
Plastic parts compatible with recycling	(4.3.2.1)	
Plastic parts separable for recycling	(4.3.2.2)	
Service support	(4.4.1.1)	
Removal of external enclosure	(4.4.2.1)	
Spare parts // Availability of Replacement Parts	(4.4.2.3)	(11.7.1)
Battery Charger Systems		(10.1.1)
Battery replacement and information // Battery Removability/ Replacement by Qualified Repair Service Providers or Authorized Repair Providers	(4.4.2.4)	(11.3.1)
Conformance to current ENERGY STAR® program requirements	(4.5.1.1)	
External Power Supply Energy Efficiency		(10.1.3)
Lowest power mode limit	(4.5.1.2)	
Provision of product take-back services	(4.6.1.1)	(11.1.1)
Provision of a removable rechargeable battery take-back program	(4.6.2.1)	
End-of-life processing	(4.6.3.1)	
Primary Recyclers Third Party Certified		(11.2.1)
Ease of Disassembling Mobile Phone		(11.4.1)
Feature to Erase User Data from Mobile Phone		(11.5.1)
Repair and Refurbishment		(11.6.1)
Notification Regarding and the Identification of Materials and Components Requiring Selective Treatment		(11.8.1)
Elimination of intentionally added heavy metals in packaging	(4.7.1.1)	(12.8.1)
Elimination of elemental chlorine as a bleaching agent in packaging material	(4.7.1.2)	(12.7.1)
Separable packaging material	(4.7.2.1)	(12.2.1)
Plastics marked in packaging materials	(4.7.2.2)	

Requirements	tablets	mobile phones
Expanded Polystyrene Packaging (EPS) Restriction		(12.4.1)
Recycled content in wood-based fiber packaging	(4.7.3.1)	(12.5.1)
Packaging composed of recycled, and/or bio-based, and/or sustainably forested content	(4.7.3.2)	
Third party certified environmental management system (EMS) for design and manufacturing organizations	(4.9.1.1)	
Corporate environmental performance reporting by manufacturer	(4.9.2.1)	
Corporate Sustainability (CS) Reporting		(13.1.1)
Final Assembly Facilities Environmental Management System		(15.2.1)
Public disclosure regarding conflict minerals in products	(4.10.2.1)	(15.3.1)
Optional requirements		
Restrictions of the use of cadmium	(4.1.2.1)	
Restriction of the use of beryllium	(4.1.4.1)	
Restriction of phthalates in the product		(9.2.2)
Restriction of bromine and chlorine		(9.2.3)
Further reduction of bromine and chlorine content of plastic materials	(4.1.5.2)	
Avoidance or elimination of substances on EU REACH Annex XIV (authorization list)	(4.1.6.1)	
Reduction of substances on the EU REACH Candidate List of SVHCs	(4.1.6.2)	(7.2.1)
Chemical assessment and selection	(4.1.8.1)	
Substitutions assessment		(7.3.1)
IEC 62474 declarable substances	(4.1.9.1)	
Requesting substance inventory	(4.1.9.2)	(7.4.1)
Acquiring / receiving substance inventory	(4.1.9.3)	(7.4.2)
Reduce fluorinated gas emissions from flat panel display manufacturing	(4.1.10.1)	(15.4.1)
Reduce fluorinated greenhouse emissions from semiconductor production	(4.1.10.2)	
Higher post-consumer recycled, ITE-derived post-consumer recycled plastic, or bio-based content	(4.2.1.2)	
Post-consumer recycled, ITE-derived post-consumer recycled plastic	(4.2.1.3)	
Post-consumer recycled plastic and biobased plastic content in the mobile phone		(8.1.2)
Post-consumer recycled plastic and biobased plastic content in accessories		(8.1.3)
Long life rechargeable battery	(4.4.1.2)	
Publicly available service information	(4.4.2.2)	
Product upgradeability and repairability	(4.4.2.5)	
Further repair and refurbishment		(11.6.2)
Further ease of disassembling mobile phone		(11.4.2)
Removal of lithium ion batteries	(4.4.2.6)	
Battery removability/replacement instructions		(11.3.2)
Battery removability/replacement without use of tools		(11.3.3)
Energy efficiency for internal power supplies	(4.5.1.3)	
Energy efficiency for external power supplies exceeding International External Power Supply Efficiency Level VI	(4.5.1.4)	
Reduction of energy consumption of battery charging systems		(10.1.2)
Reduced maintenance mode power		(10.1.4)
Product energy consumption less than the ENERGY STAR Maximum Energy Limit	(4.5.1.5)	

Requirements	tablets	mobile phones
Packaging composed of recycled, and/or biobased, and/or sustainably forested content	(4.7.3.2)	
Use of recyclable fiber based packaging materials		(12.1.1)
Use of post-consumer recycled plastic packaging		(12.3.1)
Environmentally preferable virgin fiber-based materials in POS packaging		(12.6.1)
Offering of a bulk packaging option	(4.7.4.1)	
Improve packaging efficiency		(12.9.1)
Product life cycle assessment and public disclosure of analyses	(4.8.1.1)	
Conducting a life cycle assessment		(14.1.1)
Product LCA third-party verification or making LCA publicly available		(14.2.1)
Product specific greenhouse gas emissions—product carbon footprint	(4.8.1.2)	
Corporate carbon footprint	(4.8.2.1)	
Greenhouse gas emissions from product transport	(4.8.2.2)	
Third party certified environmental management system (EMS) for supplier manufacturing facilities	(4.9.1.2)	
Corporate environmental performance reporting by suppliers	(4.9.2.2)	
Corporate sustainability (CS) reporting in the supply chain		(13.2.1)
Third party assurance of corporate sustainability (CS) reporting		(13.3.1)
Energy management system/energy performance improvement –manufacturers	(4.9.3.1)	
Energy management system/energy performance improvement for suppliers	(4.9.3.2)	
Renewable energy use by manufacturer	(4.9.4.1)	
Renewable energy use by manufacturer suppliers	(4.9.4.2)	
Socially responsible manufacturing: Labor	(4.10.1.1)	
Socially responsible manufacturing: OHS	(4.10.1.2)	
Supplier responsibility		(15.1.1)
Supplier production facilities environmental management system		(15.2.2)
Participation in an in-region program that advances responsible sourcing of conflict minerals	(4.10.2.2)	
3TG minerals sourcing		(15.3.2)
Smelter and refiner participation in OECD-aligned third party mechanisms	(4.10.2.3)	
Participation in 3TG Mineral Responsible Sourcing Program		(15.3.3)
Innovation 1		(16.01)
Innovation 2		(16.02)

4.5.5. sustainablySMART: Solid state memory data erasure – Guidance

The Horizon 2020 funded project sustainablySMART[38] developed guidance on data erasure (Pörhönen 2018), detailing best practices for users, device and memory manufacturers, recyclers. As privacy issues might be a relevant barrier for proper

[38] https://www.sustainably-smart.eu/

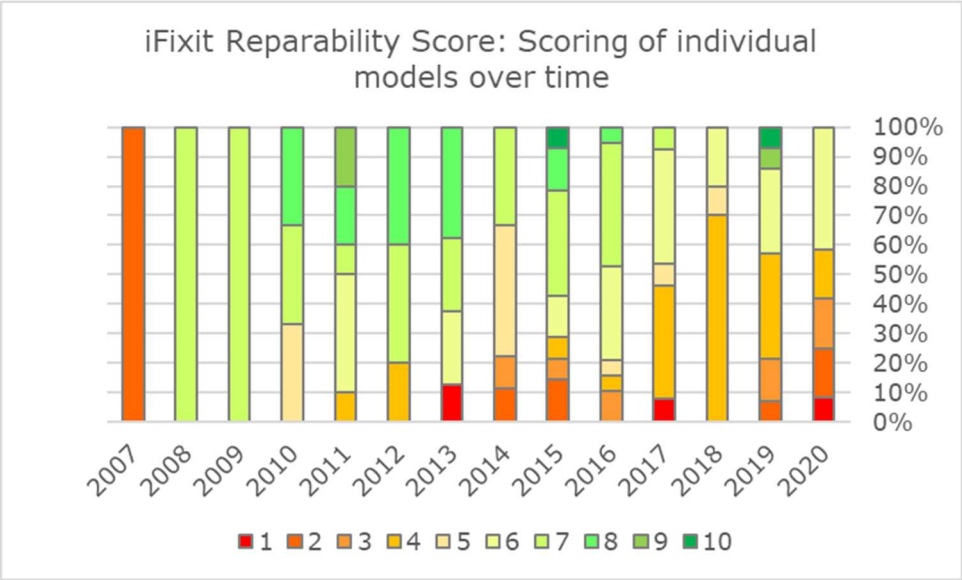
disposal and recycling of devices, confidence in data erasure can be increased by following these guidelines.

4.5.6. iFixit: Reparability Score

iFixit has developed a Reparability Score for smartphones. Points are gained based on the ease of opening the device, the types of fasteners and tools used, the complexity of replacing key components, and the upgradability and modularity of the device.

This score allows also for analysing trends in smartphone design over the years. Figure 1 depicts the score results percentages for all assessed models per release year. A trend towards less favourable reparability scoring over the years is evident. A score of 1 represents lowest reparability, a score of 10 best reparability.

Figure 1: iFixit reparability scoring results - share of smartphone models per score



As part of the Horizon 2020 project sustainablySMART, which focuses on material efficiency of smart devices[39], iFixit worked on upgrading the scoring system and create a more objective and robust methodology that can allow the assessment at part level.

4.5.7. Requirements for OEM regarding Smartphone Security (BSI)

The requirements catalogue for smartphone security is a development by the German Federal Office for Information Security (Bundesamt für Sicherheit in der Informationstechnik, BSI)[40]. It describes the required basic equipment of devices from IT security perspective and implementations for a secure operation and is aimed to manufacturers of smartphones.

Accordingly, for every kind of devices OEM have to make a statement about the maintenance with OS updates (main version). This statement must contain the duration in years post to the release and the minimum number of main versions planned. Devices must be provided with security updates for five years after release. The devices description must specify the time the support for security updates will end for that

[39] https://www.sustainably-smart.eu/

[40] https://www.bsi.bund.de/SharedDocs/Downloads/EN/BSI/requirements/Requirements-Smartphones.pdf?__blob=publicationFile&v=2

device. Security updates must be provided for download and installation within one month after public release.

4.6. Industry initiatives for environmental assessments

Several industry initiatives work on approaches to assess or even rate mobile ICT devices, which could point at feasible approaches how to improve environmental performance of products in scope of this study.

4.6.1. iNEMI Eco-Impact Estimator

The Eco-Impact Estimator is a development by iNEMI and its members to streamline Life Cycle Assessments of electronics. Access is restricted to iNEMI members. The tool is applicable to information and communication technology equipment. The Eco-Impact Estimator covers all life cycle phases. The calculated impact is limited to greenhouse gas emissions related to global warming potential.

Current developments explicitly exclude creating a standard or governmental approved tool, competitive assertions between products, components or materials, and do not target at industry-wide adoption.

4.6.2. Product Attribute to Impact Algorithm (PAIA)

The Product Attribute to Impact Algorithm (PAIA) is an approach to streamlined life cycle analysis (LCA) that aims to provide an efficient and cost-effective estimate of the carbon impact of a product class, including notebooks, desktops, LCD monitors, and televisions. The PAIA tool is used by several OEMs to comply with the LCA optional criteria of EPEAT. (tablet criteria 4.8.1.1 Product life cycle assessment and public disclosure of analyses and 4.8.1.2 Product specific greenhouse gas emissions—product carbon footprint)

The tablet tool of PAIA is intended to be used for tablets with the option to input or choose default values for screen size, screen resolution, production release year, 2-in-1 accessories, and other features. Users are also able to specify the information for PWB area, IC die area, packaging, transportation, use and EoL. (MIT Materials Systems Laboratory 2016)

The following are the key measurements of the information used for creating the tool:

- Range of products: teardown data from 25 tablets were used from 2010 and 2013
- Component data: integrated circuit data and display data (Scope 1 and 2 emissions per area) updated annually; other small electronics are modeled in terms of density based on data from 2008-2012.

4.6.3. Eco-rating

Several network operators and handset manufacturers work on establishing an eco-rating system for mobile phones, based on ITU-T L.1015 and ITU L.Sup32, and being aligned with several other activities, such as the material efficiency standards under mandate M/543, various eco-label criteria, MEErP and others. Such a comprehensive eco-rating was initiated already several years ago and several mobile network operators considered joining this rating system. Given the high relevance of network operators as providers of mobile phones (see Task 2 report) such a rating system can have a significant impact on the market. Throughout 2020 a revision of this rating system was under development, including a pilot phase with several smartphone vendors. For further details see Task 7, where Eco-rating is covered by one of the policy options (option 2).

5. SUBTASK 1.3 - EXISTING LEGISLATION

The objective of the subtask is an analysis of existing legislation with respect to environmental performance of the product.

5.1. Ecodesign Directive

Sustainable industrial policy aims in particular at developing a policy to foster environmental and energy efficient products in the internal market. The Ecodesign Directive 2009/125/EC is the cornerstone of this approach. It establishes a framework for the setting of ecodesign requirements for energy-related products with the aim of ensuring the free movement of those products within the internal market. This directive prevents disparate national legislations on the environmental performance of these products from becoming obstacles to the intra-EU trade and contributes to sustainable development by increasing energy efficiency and the level of protection of the environment, taking into account the whole life cycle cost.

Two product group specific and one horizontal implementing measures are relevant for the product group smartphones, mobile phones and tablets:

- Commission Regulation (EU) No 617/2013 of 26 June 2013 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for computers and computer servers
- Commission Regulation (EU) 2019/1782 of 1 October 2019 laying down ecodesign requirements for external power supplies pursuant to Directive 2009/125/EC of the European Parliament and of the Council and repealing Commission Regulation (EC) No 278/2009
- Commission Regulation (EU) No 801/2013 of 22 August 2013 amending Regulation (EC) No 1275/2008 with regard to ecodesign requirements for standby, off mode electric power consumption of electrical and electronic household and office equipment, and amending Regulation (EC) No 642/2009 with regard to ecodesign requirements for televisions[41]

Commission Regulation (EU) No 617/2013 includes slates and tablet computers, and is currently under revision. Products, which have more in common with smartphones than with (desktop) computers and computer servers might be covered in future by a mobile phone / smartphone / tablet regulation.

Commission Regulation (EU) No 801/2013 is not relevant for mobile handsets as such, but covers charging cradles and base stations of cordless VoIP phones, unless operated with a low voltage power supply. Cordless phones not based on internet telephony but working on a regular telecommunication network, are not covered by the standby regulation, thus do not need to meet the standby requirements, as stated in the legally not binding FAQ document on the Ecodesign Directive and its implementing measures (European Commission 2017): "a normal (cordless or corded) telephone connected to the normal public telecom network (so not VoIP) … [is] not in the scope of Regulation 1275/2008 [which has been amended by Regulation 801/2013] (nor is any other telephone placed on the market with a low voltage power supply)." Those devices, which are covered by Regulation 801/2013 typically do not feature an off mode or a standby mode as this is not appropriate for the intended use (to be stated by the supplier). Under the current regulation "the power consumption of HiNA equipment [explicitly covering VoIP telephones] …, in a condition providing networked standby into which the

[41] Consolidated version: https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:02008R1275-20170109&from=DE

equipment is switched by the power management function, or a similar function, shall not exceed 8,00 W".

Ecodesign regulations on other ICT products already include specific requirements on resource efficiency, such as the Ecodesign regulations on electronic displays and servers. The material efficiency requirements defined in these parallel product groups might be similarly relevant for mobile phones, smartphones and tablets. On the example of Commission Regulation (EU) 2019/2021 laying down ecodesign requirements for electronic displays, such criteria include

- joining, fastening or sealing techniques shall not prevent the removal, using commonly available tools, of those components, which have to be separated at end of life
- make available, on a free-access website, dismantling information; dismantling information shall include the sequence of dismantling steps, tools or technologies needed to access the targeted components
- marking of plastic components heavier than 50 g (with exemptions)
- components containing flame retardants shall additionally be marked as such
- logo, if Cadmium is contained (above a minimum threshold)
- use of halogenated flame retardants is not allowed in the enclosure and stand of electronic displays
- availability of a given list of spare parts to professional repairers (and external power supplies and remote controls also directly to end-users) for a minimum period of seven years after placing the last unit of the model on the market
- spare parts can be replaced with the use of commonly available tools and without permanent damage to the appliance
- publish procedure for ordering spare parts
- provide access to the appliance repair and maintenance information to professional repairers
- maximum delivery time of spare parts
- latest available version of the firmware and latest available security update to the firmware shall be made available for a minimum period of eight years after the placing on the market of the last unit of a certain product model

5.2. Energy Labelling Regulation

Regulation (EU) 2017/1369 sets the legal framework for energy labelling in the European Union. Energy labelling enables customers to make informed choices based on the energy consumption of energy-related products. Information on efficient and sustainable energy-related products makes a significant contribution to energy savings and to reducing energy bills, while at the same time promoting innovation and investments into the production of more energy efficient products. Improving the efficiency of energy-related products through informed customer choice and harmonising related requirements at Union level benefits also manufacturers, industry and the European Union economy overall. The Energy Labelling Regulation may complement ecodesign requirements with mandatory labelling requirements.

5.3. General Product Safety Directive

The General Product Safety Directive (GPSD) 2001/95/EC aims to ensure that only safe products are made available on the market. The GPSD applies in the absence of other EU legislation, national standards, Commission recommendations or codes of practice relating to safety of products. It also complements sector specific legislation. Specific rules exist for the safety of electrical and electronic goods. The GPSD establishes obligations to both businesses and Member States' authorities:

- Businesses should place only products that are safe on the market, inform consumers of any risks associated with the products they supply. They also have to make sure any dangerous products present on the market can be traced so they can be removed to avoid any risks to consumers.
- Member States, through their appointed national authorities, are responsible for market surveillance to check that products on the market are safe. Information about dangerous products found on the market has to be reported to the Rapid Alert System for non-food dangerous products (RAPEX).

5.4. Radio Equipment Directive and policy initiative on common chargers

The Radio Equipment Directive 2014/53/EU (RED) ensures a Single Market for radio equipment by setting essential requirements for safety and health, electromagnetic compatibility, and the efficient use of the radio spectrum. It regulates mobile phone radiation exposure limits, better known as Specific Absorption Rate (SAR). It applies to all products using the radio frequency spectrum, including smartphones, other mobile phones, cordless phones, and tablets.

The Radio Equipment Directive requires that manufacturers ensure that the radio equipment is accompanied by instructions and safety information. Such information has to include, where applicable, a clear description of accessories and components, including software, which allow the radio equipment to operate as intended.

Furthermore, the directive defines as an essential requirement, that "Radio equipment within certain categories or classes shall be so constructed that it … interworks with accessories, in particular with common chargers" (Art. 3); and in the recital mobile phones are explicitly mentioned to be addressed by this requirement.

Consequently, the Radio Equipment Directive sets the framework to harmonise power connectors of mobile devices. The European Commission authorised a study to consider an appropriate legislative approach. This study analysed the impact of a common charger solution on consumers, the industry and the environment assessed possible implementation of different policy options (Ipsos, Trinomics, Fraunhofer FOKUS, Economisti Associati 2019). This impact assessment analysed five policy options in-depth regarding their likely impacts. Three of these options concern the connectors at the device end, the other two the external power supply as such. Some technical options increase consumer convenience overall (USB Type-C only; guaranteed interoperability of EPS; interoperability plus minimum power requirements for EPS), "mainly due to the enhanced ability to charge different phones with different chargers, the increased likelihood of finding a compatible charger while away from home …, and/or reduced confusion about which charger works with what … ". Relatively minor environmental impacts "occur due to (1) the small differences in weight between different charging solutions, and (2) reductions in stand-alone charger sales". Only in case of guaranteed interoperability of EPS the study authors identified "a very small positive net impact" and minor negative environmental impacts for all other options. The impact in any case is "quite sensitive to the assumptions on the impact they have on standalone sales, these assumptions are based on limited data and should be treated cautiously." The various options also have economic impacts for consumers and industry. Decoupling sales of devices and chargers cannot be regulated under the RED and thus have been included in the impact assessment only as a potential indirect effect. The study authors conclude "the higher the decoupling rates, the greater the environmental benefits and the cost savings for consumers, as well as the convenience benefits for consumers who feel they have too many chargers taking up space in their home and/or workplace. However, the higher decoupling scenarios would also be likely to lead to a certain growth in the market for standalone chargers and, by extension, in the sales of unsafe and/or counterfeit chargers." The concept of a common charger could be extended to other mobile devices, in particular tablets and e-readers. For further details of the impact assessment and the analysed options, see Ipsos et al.

5.5. Chemicals, Substances and Materials

5.5.1. CLP Regulation

The Classification, Labelling and Packaging (CLP) Regulation (EC) No 1272/2008 is based on the UN's Globally Harmonised System (GHS) and its purpose is to ensure a high level of protection of health and the environment, as well as the free movement of substances, mixtures and articles.

CLP is legally binding across the EU member states and directly applicable to all industrial sectors. It requires manufacturers, importers or downstream users of substances or mixtures to classify label and package their hazardous chemicals appropriately before placing them on the market. (European Chemicals Agency)

5.5.2. REACH Regulation

The Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) Regulation (EC) No 1907/2006 aims to improve the protection of human health and the environment from the risks that can be posed by chemicals. REACH establishes procedures for collecting and assessing information on the properties and hazards of substances.

REACH applies to all chemical substances, including those in articles such as electrical appliances.

The Regulation also calls for the progressive substitution of the most dangerous chemicals (referred to as "Substances of Very High Concern") when suitable alternatives have been identified. SVHCs are defined as:

1. Substances meeting the criteria for classification as carcinogenic, mutagenic or toxic for reproduction (CMR) category 1A or 1B in accordance with the CLP Regulation.

2. Substances which are persistent, bio-accumulative and toxic (PBT) or very persistent and very bio-accumulative (vPvB) according to REACH Annex XIII.

3. Substances on a case-by-case basis, which cause an equivalent level of concern as CMR or PBT/vPvB substances.

Once a substance is identified as an SVHC, it is included in the Candidate List (European Chemicals Agency 2020). ECHA regularly assesses the substances from the Candidate List to determine which ones should be included in the Authorisation List (Annex XIV). Once a substance is included in an Authorisation List (European Chemicals Agency), this can be used/produced only with authorisation under certain circumstances for defined applications.

A Restrictions List (Annex XVII) is also periodically revised. Once a substance is included in the Restrictions List, specific or general uses of such substance are prohibited.

Article 33 of REACH establishes the right of consumers to be able to obtain information from suppliers on substances in articles. Suppliers of articles are obliged to provide industrial/professional users or distributors with certain pieces of information on articles containing substances with irreversible effects on human health or the environment.

The products in scope of this study are “very complex objects” – actually mobile phones are explicitly mentioned as an example for a very complex object in ECHA’s guidance document - composed of numerous articles. “The determination of the presence and concentration of Candidate List substances in all articles joined or assembled together in

a very complex object can be demanding where the number of articles is high, in particular for importers. It is also noted that the identification and differentiation of all articles may be challenging in these cases. Depending on the case and position in the supply chain, actors may need to use either a "bottom-up" approach (i.e. from the simplest components – articles or simplest complex objects - to the very complex object) or "top-down" approach (i.e. from the very complex object to the simplest components), or a combination of both, for all articles incorporated in such an object, in order to obtain the necessary information to fulfil their obligations." (European Chemicals Agency 2017) In a given example it is made clear by ECHA, that even a printed circuit board assembly is considered a "very complex object". "The most useful way to identify the articles incorporated into a printed circuit board is to trace back in the supply chain until the point at which one or more substances or mixtures were converted to an article and/or incorporated into an article or into a complex object (e.g. coating, adhesive)." (European Chemicals Agency 2017) To our understanding this means, that also a processed semiconductor chip (later on mounted on a lead frame and encapsulated in epoxy, before being soldered to the PCB), a copper winding in a coil, and spring in a connector (mounted on the PCB) are "articles", and related REACH obligation apply.

5.5.3. RoHS Directive

The scope of the Restriction of Hazardous Substances Directive 2011/65/EU (ROHS) fully applies to phones and tablets. The legislation restricts the use of certain hazardous substances used in electrical and electronic equipment. As listed in the amended Annex II of the Commission Delegated Directive (EU) 2015/863, restricted substances are:

- Lead (0.1 % threshold for homogeneous material)
- Mercury (0.1 %)
- Cadmium (0.01 %)
- Hexavalent chromium (0.1 %)
- Polybrominated biphenyls (PBB) (0.1 %)
- Polybrominated diphenyl ethers (PBDE) (0.1 %)
- Bis(2-ethylhexyl) phthalate (DEHP) (0.1 %)
- Butyl benzyl phthalate (BBP) (0.1 %)
- Dibutyl phthalate (DBP) (0.1 %)
- Diisobutyl phthalate (DIBP) (0.1 %)

The restriction of DEHP, BBP, DBP and DIBP does not apply to cables or spare parts for the repair, the reuse, the updating of functionalities or upgrading of capacity of Electrical and Electronic Equipment (EEE) placed on the market before 22 July 2019. Numerous further exemptions are provided in Annex III and Annex IV.

Most recently a study analysed the need to extend the RoHS directive to further substances. Publication of the final report is still pending. Tetrabromobisphenol-A (TBBP-A) and Medium Chain Chlorinated Paraffins (MCCPs) are prioritized for being included in the list of restricted substances. Diantimony trioxide is recommended to be re-assessed for inclusion later on.

5.5.4. EU list of Critical Raw Materials (CRM)

The Commission's communication COM(2017) 490 indicates 27 raw materials that can be defined as "critical" because risks of supply shortage and their impacts on the economy are higher than those of most of the other raw materials[42]. Many of these raw materials are used in electronics applications (see Table 21).

[42] https://ec.europa.eu/growth/sectors/raw-materials/specific-interest/critical_en

Table 21: EU list of critical raw materials (2017)

Critical raw material	Use in mobile phones, smartphones and tablets (screening)
Antimony	Antimony-trioxide (FR synergist)
Baryte	-
Beryllium	Alloying element in e.g. springs
Bismuth	could be used in solders
Borate	-
Cobalt	Li-ion batteries, alloying element
Coking coal	-
Fluorspar	-
Gallium	GaAs RF chips
Germanium	-
Hafnium	semiconductors
Helium	in upstream processes only, not contained in final product
Indium	conductive and transparent Indium-tin-oxide on displays
Magnesium	mid-frame, display shell
Natural graphite	industrial graphite: Li-ion battery electrode
Natural rubber	-
Niobium	capacitors
Phosphate rock	-
Phosphorus	flame retardants
Scandium	-
Silicon metal	semiconductors
Tantalum	capacitors
Tungsten	vibration alarm
Vanadium	-
Platinum Group Metals	coatings, metal layers
Heavy Rare Earth Elements	LEDs, magnets
Light Rare Earth Elements	LEDs, magnets

5.5.5. Import of minerals from conflict-affected and high-risk areas

In July 2017, Directive (EU) 2017/821 on the responsible supply of tin, tungsten, tantalum and gold (3TG) from conflict-affected and high-risk areas (CAHRA) became effective in the EU with a transition period until January 2021. The Directive regulates for the European Union trade and use of conflict minerals sourced in CAHRA, such as the Democratic Republic of Congo (DRC). In principle, it follows the U.S. regulation (see 5.10.1). The Regulation establishes a Union system for supply chain due diligence for tin, tantalum and tungsten, their ores, and gold. According to the Directive, when sourcing their materials, manufacturers should make sure they understand the origin of the minerals and associated social and environmental impacts. They should make sure no human rights are violated and that the returns from the minerals are not used to finance wars (Stobbe and Berwald 2019). All four metals are used in smartphones, mobile phones and tablets: Tin in solders, tantalum in capacitors, tungsten in vibration motors and gold in coatings, contacts and wire bonds.

The regulation is designed to help break the link between conflict and the illegal exploitation of minerals and to put an end to the exploitation and abuse of local communities, including mine workers, and support local development. However, the regulation has been criticised for its limited scope as well as the delay in its implementation. The main criticism is that the regulation only directly concerns importers of raw materials, and not importers of

products with minerals in them. Furthermore, it does not include cobalt, copper and lithium, which are also considered high-risk minerals (Transform Together 2018).

5.6. The Batteries Directive

The Batteries Directive is currently under revision. It was originally adopted in 2006 and has been subject to a number of revisions since then. Last amendments were incorporated in 2013.

Directive 2006/66/EC of the European Parliament and of the Council of 6 September 2006 on batteries and accumulators and waste batteries and accumulators regulates the placing on the market of batteries and accumulators. In particular, it prohibits the placing on the market of batteries and accumulators that contain hazardous substances (e.g. lead, mercury, cadmium) above a certain threshold. Furthermore, it sets rules for the collection, treatment, recycling and disposal of waste batteries and accumulators. Its main objective is to improve the environmental performance of batteries and accumulators.

Since the Directive applies to all types of batteries and accumulators, it is relevant for the products within the scope of this study. The Directive classifies batteries in three types depending on their use: portable, industrial and automotive. For the scope of this study portable batteries are the most relevant types. By definition, a 'portable battery or accumulator' means any battery, button cell, battery pack or accumulator that:

- is sealed; and
- can be hand-carried; and
- is neither an industrial battery or accumulator nor an automotive battery or accumulator.

Article 11 of the Directive on the removal of waste batteries and accumulators states that Member States shall ensure that producers design appliances in a way that waste batteries and accumulators can be readily removed. Those products that come with incorporated batteries and accumulators need to be accompanied by instructions showing how they can be removed safely. Where appropriate, they should also inform the end-user of the type of the incorporated batteries and accumulators. However, these provisions do not apply where, for safety, performance, medical or data integrity reasons, continuity of power supply is necessary and where a permanent connection between the appliance and the battery or accumulator is required.

On a Member State level, the different countries have to ensure that:

- Manufacturers do not place batteries and accumulators on the market that do not comply with the restrictions of the directive.
- Appropriate collection systems for used batteries and accumulators are established, which enables end users a free and close return of old batteries.
- The collection rates specified in the Directive are reached and the used batteries are subsequent processed to a high-quality recycling.

The progress of the implementation of the Directive was assessed in two implementation reports in 2015 and 2017 and also in a study to support the evaluation of the Directive.

A recent report of the European Commission (European Commission 2019) concluded that the Member States have adopted the required measures and delivered positive results in terms of a better environment, the promotion of recycling and better functioning of the internal market for batteries and recycled materials. However, the evaluation also highlighted some limitations when it comes to the collection of waste batteries and the efficiency in material recovery. Furthermore, the lack of efficient ways to incorporate technological innovations and new battery usages into the Directive was stressed. As an example, lithium-based batteries fall within the scope of the Directive, but are not addressed specifically by its provisions. Furthermore, the current Directive has no target rates for recycled content (e.g. for cobalt).

According to the European Parliament (European Parliament 2020), the aim of the revision is to address certain environmental, health and social impacts that are projected to increase in the context of the growing demand for batteries namely:

- environmental and health risks from the hazardous substances used in batteries;
- the greenhouse emissions released in the battery production process;
- the use of resources for the manufacturing of batteries and the challenge of ensuring that batteries (and relevant components) are part of the circular economy for longer, and
- the responsible provision of resources for the production of batteries marketed in the EU.

The revision will be one of the first deliverables of the Green Deal. On December 10, 2020, the European Commission published a proposal for a new regulation concerning batteries and waste batteries. "Portable batteries" for devices, such as mobile phones, cordless phones, and tablets, and design related issues might be addressed by proposed requirements on

- better recycling efficiencies and recovery of materials
- strengthened obligation on removability or new obligation on replaceability of batteries

5.7. Sale of Goods

Software updates

Directive (EU) 2019/771 concerning contracts for the sale of goods covers among other aspects information requirements for security updates:

- In the case of goods with digital elements, the seller shall ensure that the consumer is informed of and supplied with updates, including security updates, that are necessary to keep those goods in conformity, for a defined period of time (Article 7 Section 3).
- In addition to complying with any subjective requirement for conformity, the goods shall be of the quantity and possess the qualities and other features, including in relation to durability, functionality, compatibility and security normal for goods of the same type and which the consumer may reasonably expect given the nature of the goods and taking into account any public statement made by or on behalf of the seller, or other persons in previous links of the chain of transactions, including the producer, particularly in advertising or on labelling. (Article 7, Section 1, d)

Guarantee

The Consumer Sales and Guarantees Directive 1999/44/EC (CSGD) aims to harmonise those parts of consumer sales contract law that concern legal guarantees and commercial guarantees. Sellers of consumer goods have to guarantee that the goods are in conformity with the contract for a minimum period of two years after the delivery of the goods, with allowance for Member States to increase this.

In Sweden the minimum guarantee for mobile phones is set at three years, in Norway, five years and in Finland it is linked to the expected lifetime. (Transform Together 2018)

5.8. Waste

5.8.1. WEEE Directive

Directive 2012/19/EU on waste electrical and electronic equipment covers the products in scope of this study under category 6. Small IT and telecommunication equipment.

The WEEE Directive explicitly cross-references the Ecodesign Directive 2009/125/EC: EU member states shall take appropriate measures so that the ecodesign requirements facilitating re-use and treatment of WEEE established in the framework of the Ecodesign Directive are applied and producers do not prevent, through specific design features or manufacturing processes, WEEE from being re-used, unless such specific design features or manufacturing processes present overriding advantages, for example, with regard to the protection of the environment and/or safety requirements (WEEE, Art. 4).

Producers have to provide information about preparation for re-use and treatment for each type of new electric and electronic equipment placed for the first time on the Union market within one year after the equipment is placed on the market. This information shall identify, as far as it is needed by centres which prepare for re-use and treatment and recycling facilities in order to comply with the provisions of this Directive, the different components and materials, as well as the location of dangerous substances and mixtures. It shall be made available to centres which prepare for re-use and treatment and recycling facilities by producers of EEE in the form of manuals or by means of electronic media. Industry set up the I4R-platform to comply with this requirement[43].

As a minimum the following substances, mixtures and components have to be removed from separately collected mobile phones, smartphones and tablets[44]:

- batteries,
- printed circuit boards of mobile phones generally, and of other devices if the surface of the printed circuit board is greater than 10 square centimetres,
- plastic containing brominated flame retardants,
- liquid crystal displays (together with their casing where appropriate) of a surface greater than 100 square centimetres.

5.8.2. Waste Framework Directive and SCIP database

SCIP is the database for information on Substances of Concern in articles as such or in complex objects (Products) established under the Waste Framework Directive (WFD) (EU) 2018/851, with ECHA being in charge of setting up this database.

Companies supplying articles containing substances of very high concern (SVHCs) on the Candidate List in a concentration above 0.1% weight by weight (w/w) on the EU market have to submit information on these articles to ECHA, as from 5 January 2021. Suppliers of articles and complex objects need to provide:

- information that allows the article to be identified;
- the name, concentration range and location of the SVHC in the article; and
- possibly other information on the safe use of the article.

[43] https://i4r-platform.eu/

[44] The WEEE directive lists some more components, but these are apparently irrelevant for the product group mobile phones, smartphones and tablets

If an article of a smartphone, mobile phone or tablet, such as a component or a part of a component (see 5.5.2), contains SVHC above the concentration threshold, suppliers of such smartphones, mobile phones or tablets therefore need to provide this data to SCIP.. There are indications that suppliers of smartphones, mobile phones and tablets need to register their products with SCIP, given that semiconductor companies identified materials in their products which may contain SVHC (NXP Semiconductors 2020; ON Semiconductor 2020). However, another major semiconductor supplier states for its products no SVHC content (Qualcomm 2020).

Table 22: Exemplary list of SVHCs potentially contained in semiconductor components

SVHC	Potential use
1-Methyl-2-pyrrolidone (NMP)	solvent for dielectric coating and passivation polymer layer materials
Diboron trioxide	raw ingredients for glass or ceramic base material[45] for glass lead frit, substrates, capacitors, resistors, caps and non-conductive epoxy adhesive
Lead monoxide	
Lead titanium trioxide	
Methylhexahydrophthalic anhydride	epoxy, die encapsulation, die underfill material
4,4'-isopropylidenediphenol ("Bisphenol A")	raw polymer ingredient for epoxy resins and substrate materials
Lead	substrates, solder materials (balls, wires, and pastes), capacitors, coils, inductors, resistors, bumped semiconductor die, die shields
2-Methyl-4'-(methylthio)-2-morpholino propiophenone	Substrates

The SCIP database ensures that the information on articles containing Candidate List substances is available throughout the whole lifecycle of products and materials, including at the waste stage. The information in the database is then made available to waste operators and consumers.

5.9. Country specific legislation

5.9.1. France

5.9.1.1. Law N°2014-344 on consumer rights (Loi Hamon)

First legal steps for product lifetime extensions were taken in the 2014 law on consumer rights (Loi Hamon) that put in place several mechanisms to extend the lifetime of consumer products:

- Experimentation during two years of displaying both the selling price and the 'cost of use' for certain products.
- Obligation to provide information on the availability of spare parts. However, if the spare parts were not available, the manufacturer was not obliged to inform the consumer of the lack of spare parts.

[45] Although this SVHC is reported by NXP and ON Semiconductors, the fact that the substance is contained in glass and/or ceramics exempts it from reporting obligations

- Extension of the rebuttable presumption to which the consumer is entitled when claiming the legal guarantee of conformity according to which the defect affecting the product existed already at the time of the sale of the good from 6 to 24 months, except for second hand goods.

5.9.1.2. Law N°2015-992 on Energy Transition for Green Growth

France's Energy Transition for Green Growth Act, enacted in August 2015, provides additional measures against planned obsolescence:

- A first definition of planned obsolescence: "Planned obsolescence is defined by each manoeuvre through which the lifetime of a good is knowingly reduced since its design stage, thereby limiting its usage time for business model reasons" (Article L 213-4-1, Code de la consommation).
- Recognition as an offence punishable by two years' imprisonment with a fine of up to €300 000 (or up to 5% of the company's average yearly turnover of the last three years.)
- Initiate voluntary experiments to display the product lifetimes.
- Development of re-using spare parts in the car repair sector. Since 01/01/2017 garages have to offer used spare parts to their customers.
- Improve the transparency of provided environmental information through better and more complete communication on specific product characteristics that are related to the environment.

5.9.1.3. Law N°2020-105: Anti-waste law for a circular economy

On 10th February 2020, France passed an anti-waste law, which contains around fifty measures providing for new obligations (e.g. creating new polluter pays sectors), new prohibitions (e.g. controlling the use of single-use plastics) and new tools (e.g. bonus/malus-type incentive systems, a reparability index, etc.)[46]. This law is the outcome of a wide stakeholder consultation (local authorities, companies, NGOs) launched in October 2017.

The most relevant measures of the law for the products within the scope of this study are summarized in the following table, by date coming into force:

Table 23: Measures provided in the 2020 anti-waste law

Coming into force	Measures
01/01/2021	• Introduction of a reparability index. The score of the reparability index ranges from 0-10 and is based on five criteria (documentation, dismantling and reassembly, availability of spare parts, relative price of spare parts, and product-specific criteria). The reparability index will be first displayed on the five "pilot" categories washing machines, TVs, smartphones, laptop computers and lawn mowers. • Facilitation of repair and promotion of the use of used spare parts. When purchasing a product, the consumer will have access to complete and reliable information whether spare parts of the product are available or not. • Mandatory information on the duration of the provision of software updates for smartphones and tablets. The manufacturers and the vendors of smartphones and tablets shall inform about the period for which software updates enable a "normal" use of the devices.

[46] https://www.ecologique-solidaire.gouv.fr/sites/default/files/en_DP%20PJL.pdf

Coming into force	Measures
01/01/2022	• Producers of appliances such as small IT and telecommunication equipment will have to make spare parts available for a period fixed by decree of the Council of State (latest by 01/01/2022) and which cannot be less than five years from the date of placing on the market the last unit of the model concerned. The decree will establish the list of categories of electrical and electronic equipment and parts concerned. Spare parts have to be shipped within 15 working days. • Extension of the legal guarantee of conformity. The law provides an extension of the legal guarantee of conformity by six months, if the appliance is subject to repair under the legal guarantee of conformity. • Enabling the use of 3D printing for repair of objects. If a spare part can be manufactured through a 3D printing process and is no longer available on the market, the manufacturer or importer must provide professional vendors or repairers with the drawings or the technical information useful for the elaboration of a 3D printed spare part. The procedure has to respect intellectual property rights and is subject to the consent of the holder of the intellectual property.
tbd	• Creation of repair funds. The extended producer responsibility (EPR) schemes will finance "repair funds" via their producer responsibility organization (PRO). The main objective will be to reduce repair cost for consumers.
2024	• Introduction of a durability index, which will take into account aspects related to reliability and robustness.

5.9.2. Italy: Consumer Code

The Consumer Code (Legislative Decree no. 206/2005) harmonizes and consolidates the laws of purchase and consumption with the aim to ensure a high level of protection to consumers and users within the European Union. It applies to unfair business-to-consumer commercial practices before, during and after a commercial transaction in relation to a product as well as any unfair commercial practices between professionals and micro-enterprises (Legislative Decree no. 206/2005 2005).

By two separate decisions published on 24 October 2018, the Italian Competition Authority (ICA) has ascertained that Apple and Samsung had put in place unfair commercial practices in violation of Articles 20, 21, 22 and 24 (pertaining to misleading and comparative advertising) of Italian Consumer Code. The decision was made in relation to the release of firmware updates for mobile phones which caused malfunctions and reduced their performance, hence leading tor faster replacement with a new devices (Greco 2018).

According to the ICA, the manufacturers have led customers to install software updates not adequately supported by their devices, without adequately informing them in advance, nor providing them an effective way to recover the full functionality of their devices. If an update is capable to worse the performances of the device, the manufacturer with due professional diligence standards has to identify the devices compatible with a certain firmware update and to evaluate the impact of the updates released on the devices already in use, taking into account the possible status of the hardware on which such update could be installed (Greco 2018).

The ICA imposed to both manufacturers fines corresponding to the maximum statutory amount defined under the applied provisions of the Italian Consumers Code: Apple

received a fine of € 10 million (€ 5 million for each of the two separate unlawful practices as ascertained by the ICA) and Samsung has been fined for € 5 million (Greco 2018).

5.9.3. Germany: Digital Policy Agenda for the Environment

The Digital Policy Agenda for the Environment of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety[47] foresees the development of a digital product passport as a measure to increase the transparency about the environmental impacts of different products. This would provide information about where the raw materials come from, the working conditions it was produced under, how much CO_2 was generated in the process and information about how to recycle it.

The agenda also calls for the lifespan of smartphones and other electronics to be drastically lengthened, with manufacturers told to provide spare parts and software updates and make it easier for customers to replace elements that often wear out, like screens and batteries.

5.9.4. Sweden: VAT on repairs

In addition, the VAT on the repair of certain products has been lowered in Sweden, where repair costs are also tax deductible to further stimulate repairs. In Belgium, VAT is set at 6% for the repair of bicycles, shoes and clothes. However, ICT products are not yet covered in these countries (Transform Together 2018).

5.9.5. The Netherlands: Public Procurement

In the Netherlands guidance on sustainable procurement is focussed in the knowledge and expertise network PIANOo, which provides guidance and criteria for sustainable procurement, including guidance on circular public procurement. There are several pilots currently running to test these guidelines in practice (Transform Together 2018).

5.9.6. Finland: Public Procurement

The Finnish Government has adopted a resolution concerning the promotion of new and sustainable environmental and energy solutions in public procurement. The resolution requires government procurement units to take environmental and energy perspectives in all public procurement decisions (Transform Together 2018).

5.10. Other relevant legislation in other European countries and third countries outside the EU-27

5.10.1. Dodd-Frank Act: Responsible sourcing of materials

Smartphones use minerals such as tantalum, tungsten, tin and gold. There is widespread concern that mining of these raw materials (also called 3TG) in conflict areas such as the Democratic Republic Congo (DRC) and adjacent countries violates human rights and harms the environment. In the U.S., Section 1502 of the Dodd–Frank Wall Street Reform and Consumer Protection Act, signed into law in 2010 in the U.S., requires certain companies to disclose the use of minerals that originated in the DRC or an adjoining country (Stobbe and Berwald 2019) .

5.10.2. Global regulation on hazardous substances

Substance restrictions similar to the RoHS directive and the REACH regulation exist in other countries as well, such as the US Toxic Substances Control Act. Such regulations require

[47] https://www.bmu.de/en/download/the-bmus-key-points-for-a-digital-policy-agenda-for-the-environment/

companies operating in or importing into these markets to restrict or altogether phase out substances classified as harmful or hazardous.

Example of chemical inventories in various countries and regions[48]:

- REACH - European Union Regulation (EC) No 1907/2006
- AICS - Australian Inventory of Chemical Substances
- DSL - Canadian Domestic Substances List
- NDSL - Canadian Non-Domestic Substances List
- KECL (Korean ECL) - Korean Existing Chemicals List
- ENCS (MITI) - Japanese Existing and New Chemical Substances
- PICCS - Philippine Inventory of Chemicals and Chemical Substances
- TSCA Inventory - US Toxic Substances Control Act
- SWISS - Giftliste 1
- SWISS - Inventory of Notified New Substances

5.10.3. United States: Energy Star

Energy Star requirements are defined for telephones (version 3.0), including cordless phones, defining thresholds for maximum average power, partial on mode, and off mode. For tablets the Energy Star requirements for computers (version 7.1) apply, including power management requirements, energy efficiency requirements for the external power supply, and a threshold on calculated Typical Energy Consumption (TEC), depending on the configuration.

5.10.4. United States: Right-to-Repair

Access to repair and the conditions under which repair services can operate are an important factor for potential lifetime extension through repair.

In the United States the Right to Repair refers to government legislation that is intended to allow consumers the ability to repair and modify their own consumer electronic devices, where otherwise the manufacturer of such devices require the consumer to use only their offered services. The efforts are based on the 2012 Automotive Right to Repair Law passed in Massachusetts in 2012, which led to a national agreement with the automotive industry[49].

Fair Repair-bills, or Right to Repair bills, have been introduced in more than 20 states in 2019. Under these bills, which are legislative proposals, States can require OEMs that already provide some kind of repair service, including under warranty, to make service documentation, diagnostics, tools, firmware and service parts available, on fair and reasonable terms, to their customers and to independent repair technicians (Svensson et al. 2018).

In some states, proposed requirements for electronics include minimum lifetimes for specific products at the state level (e.g. for LED products in California)[50] and design criteria.

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[48] https://en.wikipedia.org/wiki/Toxic_Substances_Control_Act_of_1976#Example_of_chemical_inventories_in_various_countries_and_regions

[49] https://en.wikipedia.org/wiki/Electronics_right_to_repair

[50] https://ww2.energy.ca.gov/commission/newsletter/newsletterArticle.php?newNo=92

For example, in Washington the proposed "right to repair" bill[51] includes a provision that (Svensson et al. 2018):

"Original manufacturers of digital electronic products sold on 4 or after January 1, 2019, in WA state [Washington] are prohibited from designing or manufacturing digital electronic products in such a way as to prevent reasonable diagnostic or repair functions by an independent repair provider. Preventing reasonable diagnostic or repair functions includes permanently affixing a battery in a manner that makes it difficult or impossible to remove."

In California, the AB-2110 Electronics: Right to Repair bill[52] sought to ensure that OEM of equipment or parts sold and used in the state provide the same diagnostic and repair information to an independent repair providers or owners of equipment that the OEM provides to an authorized repair providers. This information includes repair technical updates, schematic diagrams, updates, corrections to embedded software, and safety and security patches. Furthermore, equipment or service parts, including any updates to the embedded software of the equipment or parts as well as diagnostic repair tools are to be made available for purchase by the owner, the owner's authorized agent, or an independent repair provider, subject to fair and reasonable terms (California Legislature 2018)

For the time being, none of the bills has seen much progression and failed to pass into legislation.

5.10.5. Scotland: Public Procurement

The Scottish Procurement established a new suite of frameworks for the supply of ICT client devices in 2016, which included mobile phones. In the framework contract for Information and Communications Technology (ICT), client devices bidders must meet or exceed the EPEAT Gold or Silver compliance requirements (depending on the product category), as well as reduce packaging and extend the lifetime of their products. Award criteria also cover social aspects (e.g. work conditions and supply chain control) (Transform Together 2018).

5.10.6. United States: Public Procurement

In the U.S., Federal government agencies and many states, provincial, and local governments are required to buy greener electronics (including mobile phones and tablets) included in the EPEAT registry, where manufacturers register their products stating the environmental performance of their products. The Green Electronics Council audits these claims on an ongoing basis.

5.10.7. Japan: Public Procurement

In Japan, the Law on Promoting Green Purchasing sets out criteria including provisions for material efficiency and it specifically covers mobile phones (Transform Together 2018).

5.10.8. Japan: Marking of batteries

After collection, batteries are usually sorted according to their chemistries (lead acid, alkaline, NiCd, NiMH, Li-ion, etc.) before conducting to recycling treatments. Currently, sorting of batteries is mostly done manually where sorting workers identify the battery

[51] http://productstewardship.net/sites/default/files/Docs/electronics/right-to-repair-code-reviser-version-2017-12.pdf

[52] https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201720180AB2110

chemistry primarily via the labels on packaging/casing of the batteries. In case the label is missing, cell batteries will be classified as not identifiable fraction and sent to dedicated landfills, thus are lost for appropriate recycling. This is due to a lack of requirements for battery labelling (Tecchio et al. 2018).

Currently, there are three different marks required by law worldwide, which aim to highlight the presence of Ni, Cd or Pb (Figure 2). No labelling is mandatory to comprehensively identify the battery chemistry in Europe. In case of missorting of NiCd batteries into LIB, the toxic Cd metal can be released to the off-gas because the treatment of LIB does not intend to treat Cd (Tecchio et al. 2018). Consequently, to avoid environmental pollution a more expensive off-gas cleaning system must be applied.

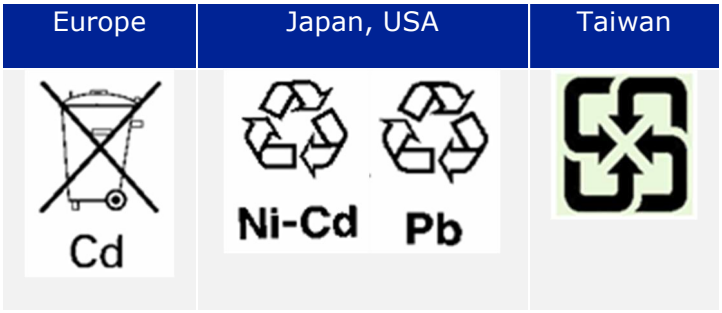

Figure 2: Current legislative battery marks (source: BAJ)

In practice, manufacturers usually apply battery marks according to their chemistries, however not in a coherent manner (see examples in Figure 3).

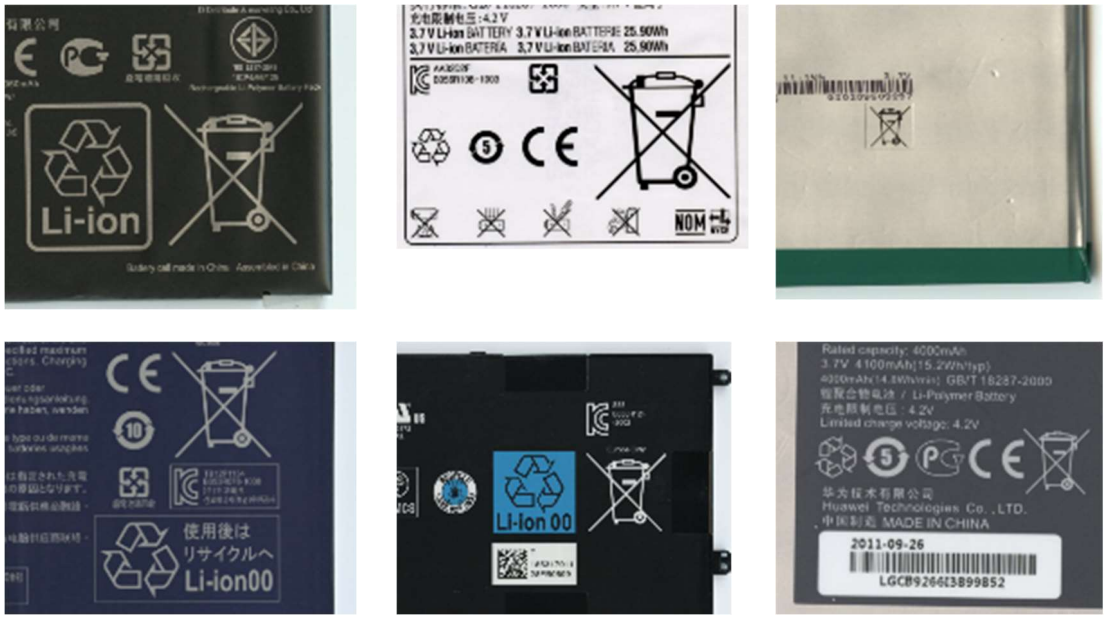

Figure 3 : Examples of battery marks in current practice

The different chemistries of LIB (LCO, NCM, LFP, etc.) are currently not indicated on battery packs or cells, leading to economic and material losses. Depending on the Li-ion chemistry, the content of cobalt varies from 0 to 15 % by weight. However, usually all Li-ion battery subtypes are co-processed, making the subsequent separation and extraction of metals more difficult and expensive. For example, in the extraction process of cobalt from high cobalt concentrates (LCO-type LIB), the iron and phosphorous from mixed processing of LFP batteries become disturbing elements and need to be removed. Such removal would increase the cost of the process. Therefore, a batch-wise treatment allows for better concentration of the target metals than a diluted mixture and is more feasible from both a technical and economical point of view. Battery recyclers point out that a more detailed

indication on the battery packs as well as on cell level would improve sorting and treatment of batteries (Tecchio et al. 2018).

In Japan, rechargeable batteries are often marked with the "Battery Recycle Mark" (Figure 4), developed by the Battery Association of Japan (BAJ)[53]. The mark was developed by BAJ in the scope of their program to make the portable secondary battery recycle mark an international standard. Currently, battery manufacturers in Japan are required to label batteries in order to facilitate sorted collection under the "Law for Promotion on effective utilization of resources" [54]. However, as there is currently no international standard for battery marking available, the BAJ promotes the internationally standardized use of one battery mark as shown in Figure 4. The logos identify four different types of battery chemistries by color and abbreviation: Ni-Cd, Ni-MH, Li-ion and Pb.

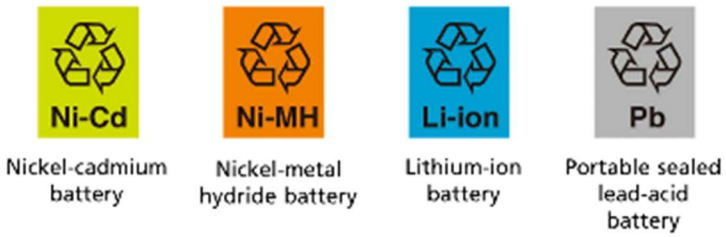

Figure 4 : Battery Recycle Mark, developed by the BAJ and promoted to be used as an international standard, which indicates the four different battery types by colour and in text.

The BAJ points out the advantages of the use of one internationally standardized battery recycle mark as follows:

- Meeting all the various marking standards globally on each battery can be challenging for manufacturers from a space and design perspective
- The production of different labels, separate production runs for each destination, and separate inventories increases costs for manufacturers
- The use of various marks on each battery leads to lower recognition by users, impeding efforts to raise the collection rate

The BAJ believes that the international use of the battery recycle mark will increase recognition, hence contributing to improved portable battery recycling globally, as well as saving costs for battery manufacturers.

The BAJ has further been requested by battery recyclers to include an additional mark to identify Li-ion batteries containing over a certain amount of tin and phosphorus. Following the request, the BAJ recommends the industry to also add a two-digit code to the logo for LIB to specify with the first digit the metal (as Co, Mn, Ni, or Fe) predominantly found (by mass) in the cathode, and whether tin or phosphorous are contained in the battery exceeding a defined threshold (Figure 5).

[53] http://www.baj.or.jp/e/

[54] Global Environment Centre Foundation: Law for promotion on effective utilization of resources, 2016, http://nett21.gec.jp/Ecotowns/

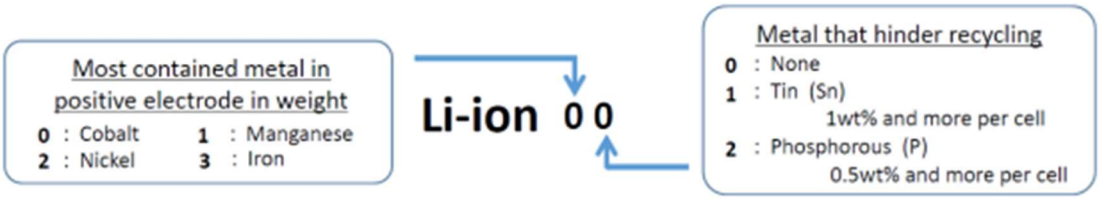

Figure 5 : The two-digit code, developed and recommended for use by BAJ, which is added to the logo for LIB to identify: the metal with the highest mass in the positive electrode (first digit); and the presence of a metal which hinders recycling (second digit).

The Battery Recycle Mark is currently applied to battery packs by several manufacturers.

Similar to the processes in Japan, the International Electrotechnical Commission (IEC) has been requested by battery recyclers to develop standard for battery marking to improve the recognition of battery chemistry. The reasons are provided as follows:

"*Many recycling processes are chemistry specific, thus undesired events can occur when a battery which is not of the appropriate chemistry enters a given recycling process. In order to ensure safe handling during sorting and recycling processes, therefore, the battery is marked so as to identify its chemistry.*" (IEC 62902:2019 2019)

The standard has been published in 2019, which defines the appearance, color, and size of the marking (Figure 6). The Mobius loop is to be included if required and not yet placed on the battery on a different position. It should be noted that the scope of the draft standard is currently limited to batteries with a volume of more than 900 cm^3 and hence does not apply to portable batteries for ICT devices. An expansion of the scope to also include portable batteries, as well as a process to create a European standard, is conceivable.

Figure 6 : Battery markings developed by IEC as published in the draft standard circulated in March 2017

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