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Preparatory study to support the revision of GPP criteria for computers and monitors and the possible inclusion of smartphones

Draft report

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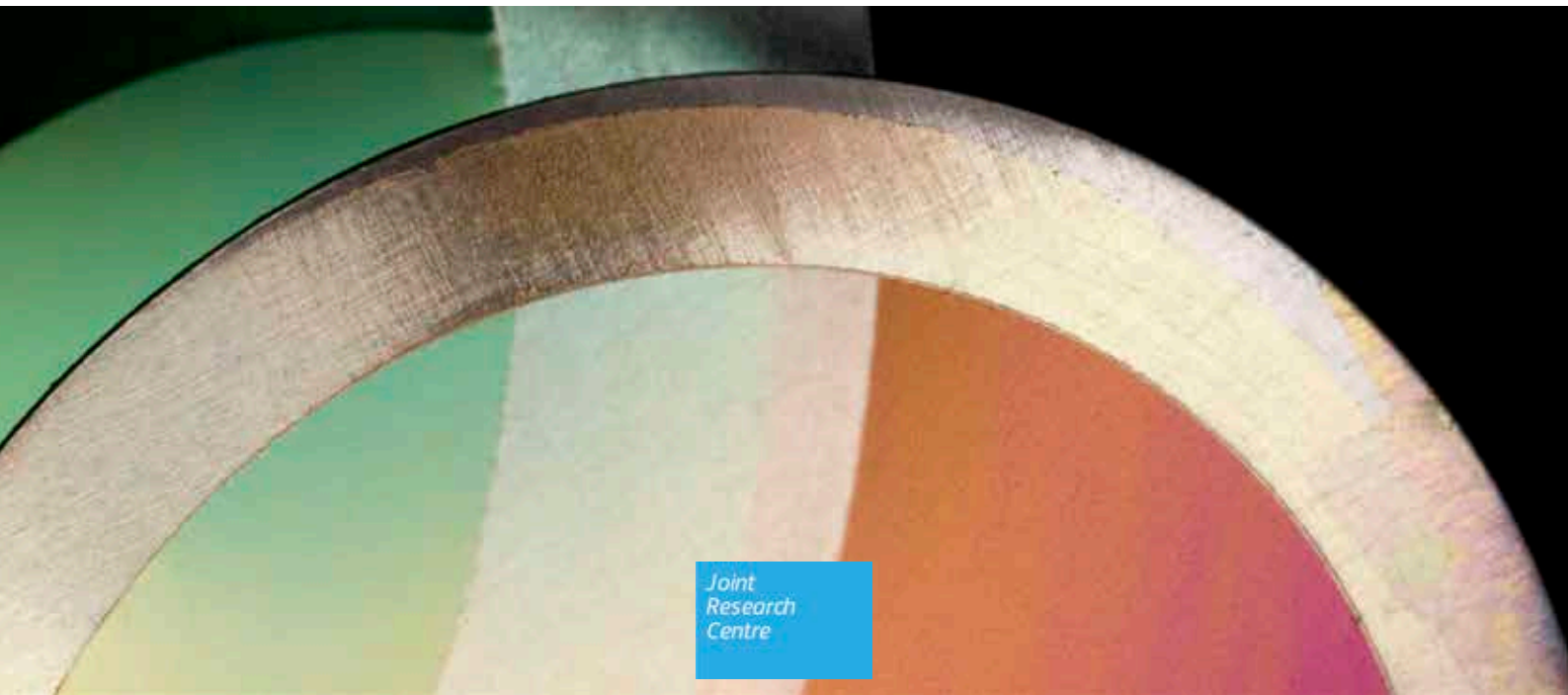

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1. Background, scope and goal of the study

The scope of the work includes the revision of the GPP criteria for the product group computers and monitors (criteria document[1] as of 21.10.2016).

This report gathers the necessary background information for the revision and presents it in a structured form. Market and technological trends are presented. Implementation of the current GPP criteria has been analysed and discussed. Finally a technical analysis of the existing criteria, legal provisions and voluntary approaches by industry are analysed to support the criteria revision in the following areas:

- Energy,
- Hazardous substances,
- Product lifetime extension and
- End-of-life management.

The evidence gathered will be crosschecked with sector-experienced stakeholders to find the best way to develop the criteria in order to deliver optimum environmental improvements while complying with Public Procurement law and safeguarding the Single Market.

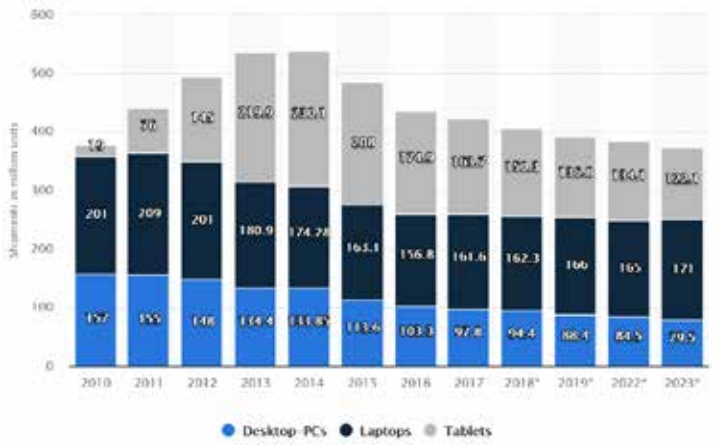
Product groups falling under the scope of this study are stationary computers, display devices, and portable computers with its subgroups as defined in the GPP criteria document. With this revision it is also analysed the possibility to extend the applicability of some criteria to smartphones, and to have common EU GPP criteria for stationary and mobile ICT products and services.

[1] See current criteria under http://ec.europa.eu/environment/gpp/pdf/EU_GPP_criteria_for_computers_and_monitors.pdf

2. Market Analysis

2.1. Computers and monitors

The market sectors of desktops and notebook computers represent, in spite of regressive sales numbers, still large volume markets. In 2018, worldwide shipments were approximately 94 million units of desktop computers (PCs) and 162 million units of notebook computers. For several years, global shipments of desktop PCs and tablets have reached a declining plateau whereas notebooks have been sold in slightly increasing numbers. Figure 1 shows the decline in worldwide shipments of desktop PC units since 2010 up to 2018. The chart also shows a projection of future market trends until 2023. Within this time horizon, it is expected, that shipments of PCs and tablets will continue to shrink slightly but in general stabilise on a high level[2]. Nevertheless, the personal computing equipment of all types remains to be a mass commodity featuring large turnover markets, both in terms of shipped units and installed base (private and commercial applications).



Source: (Statista 2019a)

Figure 1: Shipment forecast of tablets, laptops and desktop PCs worldwide from 2010 to 2023

Recent market developments in the PC sector over the past two years exhibit increasing unit sales for the top three OEM of PCs (Lenovo, HP, and Dell) whereas other brands still exhibit declining shipments (Figure 2). The market consultancy firm 'International Data Corporation' (IDC) reports for the second quarter of 2018 a market grow of 2.7% for traditional PCs (desktop, notebook, and workstation), owing to device renewals in the commercial space (IDC 2018)[3]. Market analysts and observers infer as a general conclusion of market trends, that the demand for PCs in business applications remains strong whereas private applications of PCs decline, owing to the demand shift towards portable and mobile applications, such as notebook computers and smartphones.

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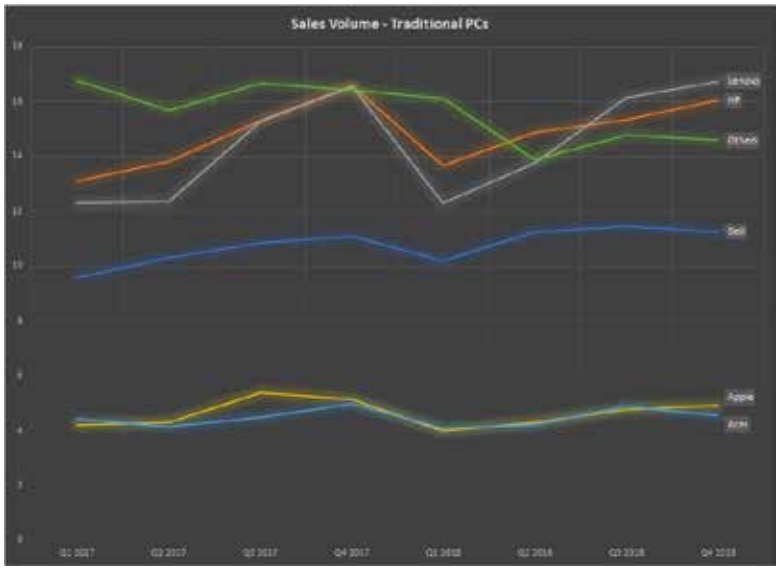
[2] Bott, E. (2019): As the PC market continues to shrink slowly, guess which OEMs are still thriving? zdnet.com. available online: https://www.zdnet.com/article/as-the-pc-market-continues-to-shrink-slowly-guess-which-oems-are-still-thriving/

[3] IDC (2018): Traditional PC Market Grows 2.7% in the Second Quarter of 2018, Strongest Rate Since Q1 2012, According to IDC. available online: https://www.idc.com/getdoc.jsp?containerId=prUS44118818



Source: Bott (2019), data based on IDC Worldwide Personal Computing Device Tracker (2019)

Figure 2: Collective market share of OEM manufacturers of PCs (unit sales)

The expected increase in shipments of notebook computers to 171 million devices in 2023 is probably less due to standard devices but rather due to the growing market of so-called ultra-mobiles, which are midsize lightweight computing devices. There is a certain overlap in statistical accounting between notebooks, tablets and convertibles. Such ultra-mobile computers are quite similar to tablet computers with additional display lid and offer functions primarily focussed on web content and social media consumption as well as data processing to a certain degree. On the other hand, smartphones and upcoming foldable smartphones are partly substituting for tablets and notebooks. In a five-year forecast until 2022, the market consultancy firm IDC expects a 2.4% decline in shipments of PCs and a 6.2% decline in shipments of tablets (Table 1) (IDC, 2018).

Table 1: Forecast for shipments of personal computing devices, 2018-2022 (in millions)

Product Category	2018 Shipments*	2018 Share*	2022 Shipments*	2022 Share*	2018-2022 CAGR*
Desktop PCs and Datacenter Workstations	95.4	23.4%	86.6	22.4%	-2.4%
Notebook computers and Mobile Workstations	160.9	39.4%	161.7	41.9%	0.0%
Detachable Tablets	23.9	5.9%	35.0	9.1%	9.8%
Slate Tablets	128.0	31.4%	102.9	26.6%	-6.2%
Grand Total	**408.3**	**100.0%**	**386.2**	**100.0%**	**-1.8%**
Traditional PC	256.3	62.8%	248.4	64.3%	-0.9%
Traditional PC + Detachable	280.2	68.6%	283.4	73.4%	0.1%
Total Tablet (Slate + Detachable)	152.0	37.2%	137.9	35.7%	-3.4%

Source: IDC (2018)

The regressive market trends for PCs and notebooks, observed since 2012, are mostly explained by shifting demands on the consumer markets. Consumers have readily adopted smartphones for applications that previously had been provided by larger computer types. On the other hand, business applications of PCs and notebooks remain stronger than in the consumer market although saturation effects are also been observed in the commercial market. IDC expects little grow potential during the forecast period until 2022.

Farther reaching projections of market trends per product types are difficult to justify, given the uncertainty regrding the future of technological innovations in the semiconductor industry (see below). The analysis by Viegand Maagøe and VITO (2017)[4] shows estimated historical sales and stock data of personal computers within the EU market based on PRODCOM data 2012-2014. Based on that database, the future trend for the computing devices market in the EU is extrapolated until 2030 (Table 2) (ibid).

Table 2: Estimated past shipments of various computing products 2009-2014 and projected future development until 2030

Product categories	2012	2013	2014	2015	2020	2025	2030
	million units/year						
Notebook	50.66	47.21	46.79	42.40	41.66	41.55	41.74
Desktop computer	19.13	15.77	14.84	12.74	12.05	13.47	13.60
Integrated desktop	0.77	0.63	0.59	0.51	0.48	0.54	0.54
Thin client	1.35	1.35	1.43	1.31	1.37	1.37	1.37
Integrated thin client	0.13	0.13	0.14	0.13	0.14	0.14	0.14
Tablet/slate	28.46	44.74	45.21	40.79	38.38	38.47	38.56
Portable all-in-one	0.21	0.19	0.19	0.17	0.17	0.17	0.17
Workstation	0.71	0.75	0.80	0.79	0.79	0.82	0.85
Small-scale server	0.17	0.18	0.19	0.20	0.21	0.22	0.23
Total computers	101.59	110.95	110.19	99.05	95.24	96.73	97.20

Source: Viegand Maagøe and VITO (2017)

For reasons explained below, any market forecast beyond 2025 approximately appears highly questionable. From today`s perspective it is hard to predict how semiconductor technology develops after that point in time. Megatrends such as pervasive digitisation of economy, production and private life make computing devices increasingly indispensable. However, the statistical accounting of traditional product categories is likely to become more and more difficult due to increasing diversification of computer tapes and blurring boundaries between computer categories and their functional characterisation.

[4] Viegand Maagøe and VITO (2017): Preparatory study on the Review of Regulation 617/2013 (Lot 3) Computers and Computer Servers, Task 2 report

2.2. Thin Clients and Zero Clients

The terminology used to specify different types of computer terminals on the market is rather fuzzy; in particular there are large overlaps in devices that are advertised as 'zero clients' or 'thin clients' respectively. Thin clients (TC) and zero clients (ZC) are dedicated as substitutes for Personal Computers (PCs) at client side (the users` work place) in professional application areas, such as companies and public administrations. In comparison to PCs, both device types consist of abriched computers whose hardware resources are much reduced in comparison to normal desktop PCs. Such devices contain less powerful CPUs (central processing units), RAM and data storage components or even none of these (as for ZC). Computing is partly (as for TC) or fully (as for ZC) executed by a server to witch the TC/ZC are connected via LAN (local area network). As a rule, the server, which can be a workstation PC, a small scale server or a data centre, operates many (tens to hundreds) of TC/ZC. Such devices provide approximately the same range of ICT functions (such as office computing, Internet access) as PCs but utilise ICT hardware more efficiently because the server`s hardware resources are shared by many users.

From the user's perspective, there is little difference between ZC/TC and PC in terms of functionality. However, there is a large difference regarding the hardware configuration for both types of ICT. PCs provide computing function in a one-to-one ratio, that is, one working place requires a fully equipped PC that has a service life of six years on average. While the average PC weighs 10 to 15 kg on average, one ZC/TC device weighs not more than 2 to 3 kg and offers a potentially longer service life (up to nine years). Moreover, the average power consumption of one ZC/TC desktop device during the use phase is much lower than that of a desktop PC. However, the use of ZC/TCs devices necessitates additional ICT infrastructure in the background in order to provide computing functions. Notably, data network infrastructure (local area network (LAN), servers and file-servers, as well as auxiliary equipment (e.g. uninterruptable power supply, air-conditioned server rooms) are required to run ZC/TCs[5] clients. A typical application case may encompass one hundred ZC/TCs clients that are connected to one server via LAN. Thus, one ZC/TC working place requires additional LAN-server network infrastructure that is shared by a larger number of working places. The amount of LAN and server capacity required depends on the number of ZC/TC working places. These numbers vary largely, depending on the size of the organisation using them. The size of ZC/TC networks may range from a small home network (connecting a handful of clients) and networks of large organisations with thousands of ZC/TC working places connected to a server centre. Therefore, this study uses generic assumptions regarding hardware configurations of PCs and ZC/TCs systems. It is assumed that the average size of ZC/TCs systems, running office applications, represents the typical application case of a SME with 100 clients that are connected to a LAN server.

Table 3 shows an example of possible hardware specifications for PCs and zero clients and thin clients that may offer user functionality at comparable level.

[5] Most office PCs are connected to a LAN and server infrastructure as well. However, the function of these machines is not wholly dependent on this background system whereas ZC/TCs are.

Table 3: Overview of hardware specifications of PCs and Zero clients and Thin Clients

Personal Desktop Computers (PC)	Zero clients or thin clients (ZC/TC)
Function: one computer work place per PC	Function: one virtual desktop work place per client device
100 PCs (à 15 kg) = 1500 kg hardware (+ LAN) (+ Server/Fileserver)	100 ZC/TC (à 2,5 kg) = 250 kg hardware + Local area network (LAN); Server/Fileserver + Uninterruptable power supply (UPS), Air-condition
100 Desktop monitors	100 Desktop monitors
6 years lifetime per device	9 years lifetime per device

Source: Own compilation

The total number of thin clients and zero clients existing in the EU28 could not be determined within the framework of this study. However, proprietary market reports are available elsewhere.

2.3. Innovation trends in computer hardware

The semiconductor industry continues, for the time being at least, to be pursuant of its self-imposed International Technology Roadmap for Semiconductors, established almost four decades ago. Since the 1965, an innovation trajectory called 'Moores Law' has guided the semiconductor industry. Is suggests that the number of transistors that can be manufactured per unit area for integrated circuits (ICs) doubles about every two years. Increasing performance of active semiconductor components (in particular CMOS[6]–ICs (integrated circuit), in particular processors (CPU), graphics processors (GPU) and system memory (DRAM)), which represent the key components of computers, has been the driving force behind the market growth in the computer industry in the past.

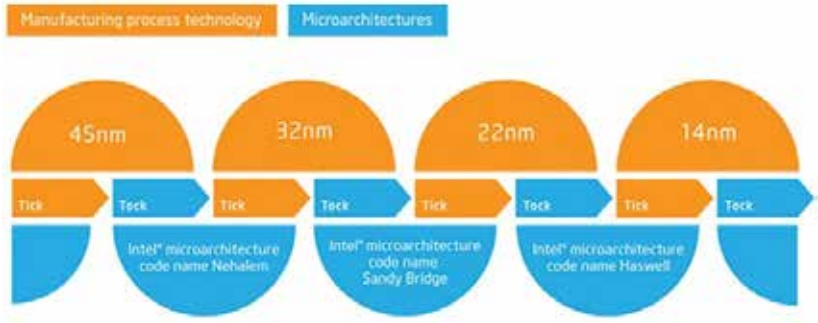
This success has been achieved by continuous miniaturization of the structure sizes on semiconductor chips, resulting in exponential growth in transistor density on CMOS–ICs. In addition, semiconductor-based mass storage devices (solid state drives, SSDs) have become increasingly popular on the market in recent years. Unlike the previous generation of mass storage (hard disk drives (HDDs), SSDs no longer contain any moving parts but consist solely of semiconductor components. This fact increases not only the performance of computers but also improves the cost-performance ratio.

The following outlines the trajectory of innovations for active and passive computer components.

[6] CMOS: Complementary metal–oxide–semiconductor

Integrated circuits (Logic ICs)

The above mentioned trajectory of innovations according to 'Moore's Law' was based on the progressing capability of semiconductor manufacturers to miniaturise transistors on integrated CMOS chips. CPU manufacturer Intel, who coined the term 'Moore's law', has followed this roadmap for many years. Up to now, CPU manufacturer Intel has followed a product development roadmap described as the so-called 'tick-tock' cycle (Figure 3) (Intel, undated)[7].



Source: Intel (undated)

Figure 3: Intel's past innovation cycles in CMOS manufacturing

Each 'tick' cycle stood for the periodic conversion of the semiconductor production ('fab') to further downsizing of semiconductor structures (die shrink) in a given design of CPU microarchitecture on the waver (die). At each miniaturisation step, the production equipment (lithography) must be modified technologically. The typical increase in transistor density following the die shrink enables higher performance and higher energy efficiency. In the subsequent 'tock' cycle, a new microarchitecture is developed that exploits the new possibilities of manufacturing process technologies. In this cycle, an attempt is made to optimize the functional density, performance and energy efficiency of the respective processor generation. At the same time, new design concepts for semiconductor manufacturing are introduced, such as 3D tri-gate transistors (Intel) and FinFETs (AMD). That innovations trajectory kept pace with Moore's roadmap for many years.

However, the situation in the semiconductor industry has changed considerably in recent years. Already now, integrated device manufacturers (IDMs) like Intel are lagging behind the Moore's law-determined innovation roadmap. Due to increasing technological and economic challenges, the further miniaturisation in semiconductor structures is slowed. Throughout the industry, the introduction intervals per silicon fab process have slowed from 2-year intervals to 3-year intervals. The reason is a third phase (optimization phase) introduced by Intel to consolidate the microarchitecture (see Figure 4) (Heath, 2016)[8]. It is expected that in future, the introduction intervals of new technology generations become even longer than 3 years.

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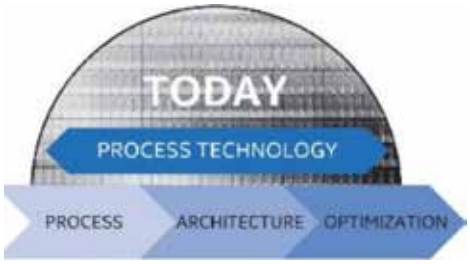
[7] Intel (undated): The Tick-Tock Model Through the Years. Available online: http://www.intel.com/content/www/us/en/silicon-innovations/intel-tick-tock-model-general.html

[8] Heath, N. (2016): Intel slows the rate of major chip upgrades as Moore's Law falters, zdnet.com, available online: https://www.zdnet.com/article/intel-slows-the-rate-of-major-chip-upgrades-as-moores-law-falters



Source: Intel (2019)

Figure 4: Intel's present innovation cycles in CMOS manufacturing

For the time being and few years ahead of time, the process technology innovation is expected to proceed with shrinking semiconductor structures of computer CPUs, however more slowly than expected. The current state of the art (node) in semiconductor manufacturing dominating the PC market is still 14 nanometers, i.e. the structure width of the transistors (half-pitch) is 14 nm. Intel introduced 14 nm CPUs to in 2014 under the codename 'Broadwell'. This node was initially intended for high-end applications. In the meantime, the current 'tock cycle' contains a further development of the processor architecture. Broadwell CPUs and its 14 nm successors ('Skylake' and 'Kaby Lake') have filtered down to mainstream applications (PCs and notebooks). The next 'tick cycle' (step down from 14 nm to 10 nm, is overdue. The first samples of Intel's 9th-generation CPUs in 10 nm node (codename 'Cannon Lake') were shipped in 2018 but volume production has been delayed. As of the second qurarter of 2019, Intel announced that 'Cannon Lake' CPUs will be released in a consumer-ready state by 2019. Further delay until 2020 for the ramp-up of mainstream 10 nm CPUs in the pending 'tock cycle' is possible. By now, the 10 nm processors have not yet completely replaced the older 14 nm technology. Intel is expected to continue to introduce new 14 nm CPUs, including a 'Comet Lake-H' with up to ten cores for gaming notebooks and mobile workstations. Meanwhile, AMD (the other large integrated device manufacturer for CPUs) announced the market roll out of its 'Ryzen 3000' processors series, based on a 12 nm node.

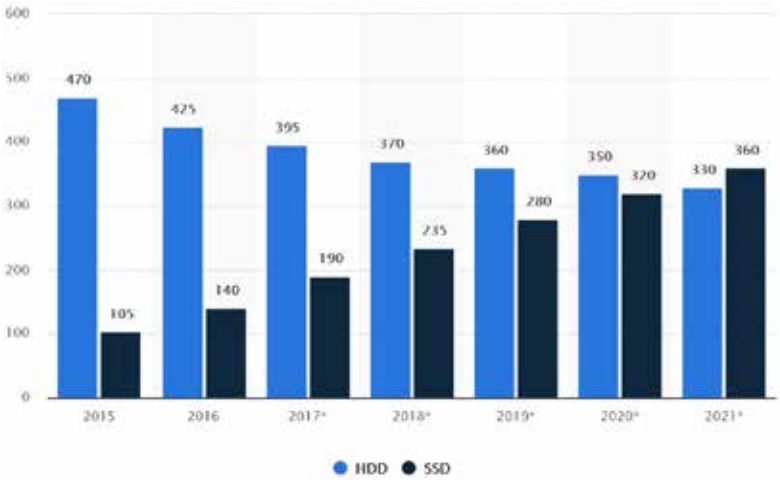
Future innovations (next 'tick cycle') in the semiconductor manufacturing process include EUV lithography (Extreme Ultraviolet Lithography), which is currently under development for semi-conductor production in dimensions below 10 nm. AMDs new generation of Ryzen processors with 'zen 2' microarchitecture will contain chip lets that are based on a 7 nm technology. AMD announces the market introduction of 'zen 2' CPUs for the second half of 2019. Commoditised CPUs manufactured in the 7 nm process node is expected to begin sometimes around 2022 (Intel`s codename 'Meteor Lake'). From today's perspective, there might be two more 'tick cycles' in a 5 nm node and 3 nm node before silicon based semiconductor technology is expected to hit its physical limit. Further miniaturisation of digital devices is thought to be impossible because at very small dimensions quantum effects become dominant. However, this forcast is highly uncertain. Approaching the end of the Moore's law-determined innovation roadmap means that miniaturisation in CMOS based IC-chips is about to reach its terminus in few years from now. From today's perspective, it is unclear how the development of computer technology will continue beyond this point.

As Moore's law will cease to play the role of a driver for performance growth in ICT, cost reduction will no longer fuel the market success of computers at the same rate as in the past. The semiconductor industry has taken benefit of the economy of scale principle in manufacturing. However, the fab processes used for silicon IC manufacturing (such as EUV) becomes more costly for dimensions below 10 nm. Additionally, the markets in the sectors of PC computers, notebooks, and smartphones are already saturated.

Non-volatile data storage

Hard disk drives (HDDs) and solid-state drives (SSDs) are the data storage technologies that are commonly used for computers nowadays. Both types exist in form of internal as well as external data storage that means device integrated storage as well as detachable storage devices. HDDs are the older storage technology consisting of rotating mechanical components with a magnetic coating that functions as data storage. HDDs are the more mature technology and excel in terms of cost efficiency (Euro per GByte storage capacity). SSDs in contrast, are a relatively recent technology consisting of interconnected flash memory chips based on solid state semiconductors. Thus far, SSDs are more expensive per GByte storage capacity than HDDs. Nevertheless, the market trend points clearly towards substitution of HDDs by SSDs because the latter are faster in read-write operations, smaller and mechanically more robust.

Figure 5 shows the estimated shipments of computers with HDDs and computers with SSDs from 2015 to 2018 (Statista, 2019)[9]. It is expected, that SSDs will become the dominating mass storage technology in computers by 2020 at the latest. SSD prices are likely to drop further due to economy of scale effects.



Source: Statista (2019)

Figure 5: Shipments of hard- and solid-state disk drives (HDD/SSD) (in millions) worldwide in computers from 2015 to 2018 and projections for 2019-2021

In 2016, Intel and Micron have launched a completely new solid-state data storage technology called 'Optane' based on a 20nm fab process (IEEE Computer Society 2016). This silicon based technology consists of non-volatile memory cells arranged in a three-dimensional grid. According to Intel, 3D XPoint memory is designed to achieve read and write speed in excess of 20 Gbps. Such a read-write speed has previously been achieved only by volatile memory technologies (RAM), which cannot permanently store data. Optane, in contrast, joins the specific advantages of RAM (high speed) and non-volatile data storage and can therefore be used for both purposes. This eliminates a typical design concept of computers thus far, namely the difference between volatile and non-volatile data storage components. Intel's Optane modules in the form of DDR4 DIMM memory bars are electronically and physically compatible with in existing computer architecture.

[9] Statista (2019): Shipments of hard and solid state disk (HDD/SSD) drives worldwide from 2015 to 2021 (in millions), edited by Arne Holst

It appears possible that, in a few years from now, PCs and notebooks will no longer contain separate mass storage devices such as hard disk drives (HDD) or solid state drives (SSD). This keeps the runtime data of the operating system also in the off state without consuming energy for refresh cycles as is the case with RAM-ICs up to now. However, 3D Xpoint technology can exploit its full potential only if the memory addressing is completely reorganized. This requires a completely new hardware architecture (e.g. CPU) as well as newly designed operating systems and application software (Labs 2016). Hence, Optane technology paves the way for a more integrated computer design concept in future.

Future prospects

The innovation roadmap according to Moore's law has given integrated device manufacturers (IDM), such as Intel and AMD control over the pace of technological innovation in semiconductor manufacturing and allowed them to set the pace for the computer industry as a whole. System integrators (computer manufacturers) on the other hand, have created a constant demand for new generations of ICs as they operate in a highly competitive market environment. This has caused a fast moving succession of computer generations with ever growing performance at decreasing costs. However, the rapid succession of new generations of processors also means that system integrators were hardly able to optimize existing computer systems before the next generation of ICs came onto the market (ITRS, 2015)[10]. One of the consequences of the rapid succession of new IC generations, in addition to the progressive obsolescence of computer hardware, is the insufficient upward compatibility of the computer systems on offer.

The end of the Moor's law determined innovation roadmap is likely to be a game changer. One of the expected consequences is stronger diversification of computer types. In future, universal purpose computers (such as Desktop PCs and notebooks) might become less dominant as they could be replaced in part by more customised computing systems with narrower application purposes. Well-known examples of such narrow-purpose computers are thin-client computers. Such devices are designed for purpose and do not possess much reserve in terms of CPU power or system memory. Therefore, within a given application spectrum, these devices are fit for purpose and more resource efficient than universal purpose computers.However, there will be a possible trade-off with regard to energy and resource efficiency in case the user will need additional devices for each further functions.

Computer manufacturers (i.e. system integrators) are increasingly able to design and manufacture application specific integrated circuits (ASIC) in form of a single chip (so-called System on Chip, SOC) or a single package (System in Package, SIP). This makes them more and more independent from the IDMs` innovation roadmaps. SOC integrate multiple functionalities on one die. This is more efficient and cost-effective than mounting several separate ICs (e.g. microprocessor, graphics processor, several types of memory, USB, etc.) on a single printed circuit board. This innovation trend goes hand in hand with the market success of design-dominated mobile ICT terminals such as tablets, e-book readers and smartphones. This allows today's system integrators to set the pace of innovation for the electronics industry much more than previous PC vendors (Arden et al. 2012)[11]. The System on Chip (SOC) and System in Package (SIP) architectures are therefore regarded as future drivers of development and will continue to drive the diversification of ICT device types (ibid.) (see Figure 6).

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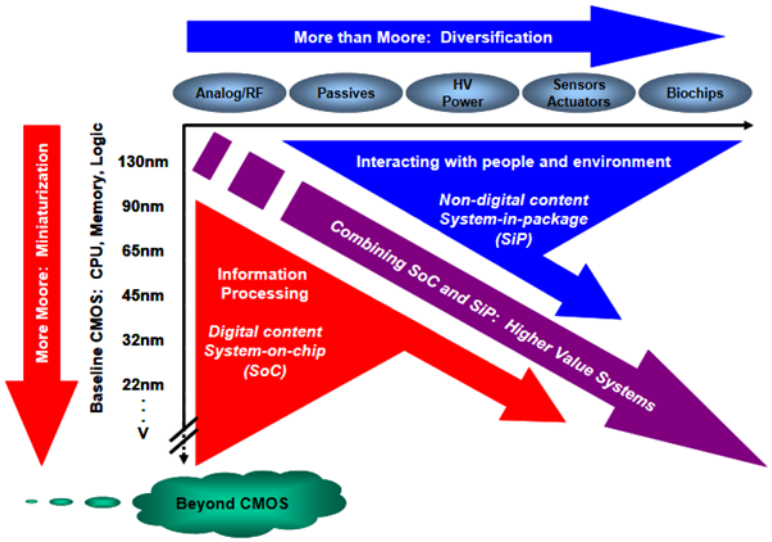
[10] ITRS (2015): International Technology Roadmap for Semiconductors - ITRS 2.0. International Technology Roadmap for Semiconductors available online: http://www.itrs2.net

[11] Arden, W., Brillouët, M., Cogez, P., Graef, M., Huizing, B. & Mahnkopf, R. (2012): “More-than-Moore. White Paper (International Technology Roadmap for Semiconductors)



Source: Arden et al. 2012

Figure 6: Trends in system integration of digital functions according to the International Technology Roadmap for Semiconductors

2.4. Rugged devices

A subset of professional used ICT products falls into the market niche of so-called rugged devices, including notebooks, tablets and smartphones. Such mobile or portable rugged devices are to be distinguished from embedded industrial purpose computers that are integrated in industrial machines and installations. The latter type is usually not considered 'rugged' although they may come with comparable physical or functional properties.

The meaning of the term 'rugged' is not standardised. Generally spoken, it refers to the promise that such devices exhibit above-average physical robustness in order to be used under harsh environmental conditions or heavy-duty application purposes. Rugged devices are typically advertised as being hardwearing in their mechanical design, dust and water tight, shockproof, temperature tolerant under hot and cold surroundings and having scratch resistant surfaces. Some rugged devices contain larger than normal batteries in order to store reserve power for extended off-grid operating time. Rugged devices, as a rule, are marketed as outdoor and sports equipment, professional equipment for construction workers, field utilities technicians and industrial manufacturing engineers. Moreover, agriculture and farming are application areas where rugged devices are advertised for.

The market niche of rugged devices is somewhat blurry due to the lack of internationally agreed definitions and testing procedures about what 'rugged' actually means [12]. Professional purpose rugged devices should at least be tested according to the US military test standard MIL-STD-810G, which requires devices to pass drop tests and withstand exposure to dust, moisture and mould. Some private purpose devices for outdoor application are considered semi-rugged.

[12] Blickenstorfer, C.H. (2019): Rugged Notebook Computers. RuggedPCReview. Available online: http://www.ruggedpcreview.com/2_notebooks.html

Such devices are specified according to the international enclosure ratings IP66, IP65, IP55 up to IP54, which are standardised by the international standard EN 60529 (European IEC 60529:1989). The IP rating consists of a letter code IP followed by 2 digits where the first digit stands for the level of protection that the enclosure provides against solid particles (dust), the second digit describes the degree of protection of the equipment inside the enclosure against liquids (water). Dust protection (first digit) ranges on a scale from 0 to 6, where 0 refers to low dust proof enclosure and 6 is high. Digit two ranges from 0 to 8, the higher the number the better a device is protected against water and moisture.

In terms of their physical embodiment, rugged devices typically consist of commoditised ICT components that are contained in a sturdy casing. The latter may consist of plastic (such as ABS) or metals (usually aluminium). Typically, the design of rugged devices features a somewhat bulky appearance due to thicker casing and larger internal batteries. Some low-budget semi-rugged devices on the consumer market segment appear to merely mimic ruggedness by means of playful design rather than providing increased sturdiness and functional performance. In regard to their service lifetime, semi-rugged devices could turn out to be less long lasting than normal notebooks and smartphones in spite of the sturdy design. Casings of dust and waterproof devices are often sealed or glued and this goes usually at the expense of reparability as there is no or little access to the device`s interior. Thus, the possibility for repair and hardware upgrade is typically limited (notwithstanding exceptions available on the market).

The semi-rugged notebooks market is expected to grow modestly by 1% in 2019 in terms of revenue. The major driver of grow are semi-rugged notebooks in the end-consumer market segment. In contrast, fully rugged notebooks for business applications seem to be a plateau market niche, with little potential for grow except of possible replacements with less expensive semi-rugged notebooks. The market consultant Technavio predicts for the period 2019-2023 a Compound Annual Growth Rate (CAGR) of more than 7% on the global rugged devices market[13]. This corresponds to a growing market size by over USD 2.27 billion during this period.

2.5. Trends in computer monitors

According to the Computer Monitor Buying Guide 2019[14], professional-grade monitors for example tend to have more monitor **stand adjustments** than consumer variants which include height, tilt, swivel, and pivot (ergonomic customizability). **Ultrawide 21:9 monitors** deliver all the benefits of a dual monitor setup, whereas **curved screens** improve wide viewing angles. Screen sizes of 21 to 24 inches are the most popular monitor size with 1080-pixel resolution being predominant. Larger 24-inch models have **Quad High Definition (QHD)** or 4K specifications. Monitors in the range of 25 to 29 inches tend to have QHD or greater resolutions, and are popular among creative professionals. In this segment, many so called in-plane switching (IPS) screens are represented for their high degree of color accuracy. Finally, there are ultrawide monitors of 29 to 34 inches and curved ultrawide monitors.

[13] Technavio (2018): Global Rugged Devices Market 2019-2023. Press release. Available online: https://www.technavio.com/report/global-rugged-devices-market-industry-analysis?utm_source=t9&utm_medium=bw_wk49&utm_campaign=businesswire

[14] See https://www.neweggbusiness.com/smartbuyer/buying-guides/computer-monitor-buying-guide-2/

According to 'The Best Computer Monitors of 2018' of PC Mag Australia[15], popular panel types used in desktop displays are Twisted Nematic (TN), Vertical Alignment (VA), Patterned Vertical Alignment (PVA), Super PVA (S-PVA), Multi-Domain Vertical Alignment (MVA), and **In-Plane Switching (IPS)**. Whereas TN technology offers superior motion-handling performance, IPS monitors offer very good color quality and wide viewing angles. VA monitors also offer robust colors, but viewing-angle performance, while better than on a typical TN panel, is not quite as sharp as from an IPS panel. Nowadays LED-backlit monitors are ubiquitous, offering a brighter image compared to the previous cold-cathode fluorescent lamp (CCFL) technology for backlighting; further, LED-backlit monitors are smaller, require less power, and they allow for extremely thin cabinet designs. The next wave of monitors will feature Organic Light Emitting Diode (OLED) technology that promises ultra-high contrast ratios, true blacks, and a super-fast pixel response. According to PC Mag Australia, high-end 32-inch-and-up professional-grade displays use **indium gallium zinc oxide (IGZO)** or **Advanced High-performance In-Plane Switching (AH-IPS)** panel technology and cater to graphics professionals who require a high degree of color and grayscale accuracy. Further, still being uncommon, but with the advent of Windows 10, **touch-screen desktop displays** have gained some traction. Upcoming are monitors that utilize **quantum dot technology** to offer superior color accuracy, increased color gamut, and higher peak brightness compared to current panel technologies. Quantum dot technology based on cadmium needs an exemption under the RoHS Directive 2011/65/EU (see section 4.4.2.1).

2.6. Smartphones

This section about the market analysis of smartphones is all extracted from the JRC report *Guidance for the Assessment of Material Efficiency: Application to smartphones – draft version 2 – May 2019*[16].

Market sales

Smartphones came onto the consumer market in the late 90s but only gained mainstream popularity with the introduction of Apple's iPhone in 2007 (Statista, 2018a)[17]. Smartphones have rapidly overtaken basic mobile phones and feature phones (Figure 7), as well as other small electronics as digital cameras, GPS, MP3 players, calculators, voice recorders. Every two out of three mobile phones that were shipped globally in 2014 were smartphones: the introduction of smartphones on the market has changed the behaviour of both consumers and businesses (Watson et al. 2017)[18].

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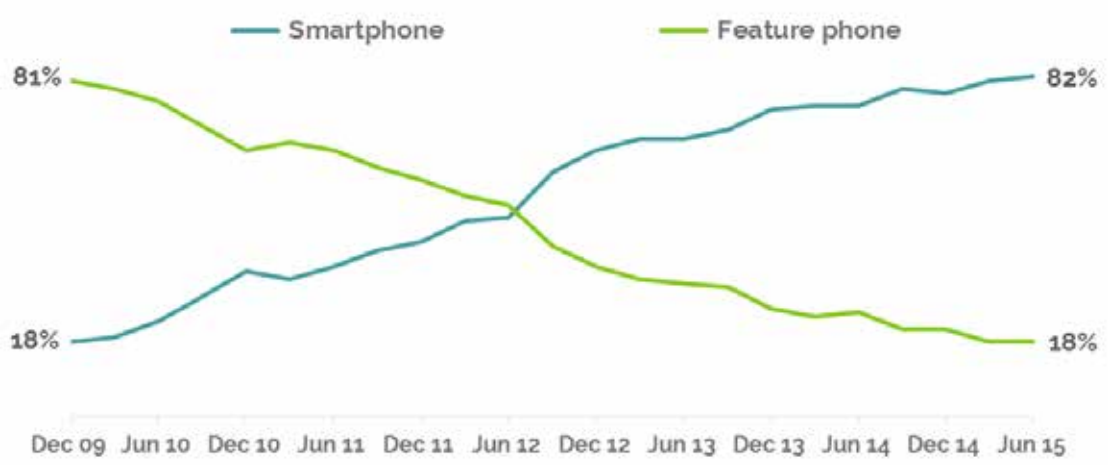
[15] See https://au.pcmag.com/monitors/10471/the-best-computer-monitors

[16] Available at https://susproc.jrc.ec.europa.eu/E4C/documents.html

[17] Statista (2018a) Smartphones industry: Statistics & Facts, https://www.statista.com/topics/840/smartphones/ (accessed on 12 February 2018)

[18] Watson D, Charlotte Gylling A, Tojo N, Throne-Holst H, Bauer B, Milios L (2017) Circular Business Models in the Mobile Phone Industry, Nordic Council of Ministers 2017, http://dx.doi.org/10.6027/TN2017-560



Source: Farmer (2015)[19]

Figure 7: Smartphone and feature phone ownership in the UK

The smartphone industry has been steadily developing and growing, both in market size, as well as in models and suppliers. Almost 1.5 billion smartphones were sold to end users in 2016, an increase from less than 300 million units in 2010 (Statista 2018b)[20].

The smartphone market has been reported to stop is growth in 2016. Smartphone sales between 2015 and 2016 dropped by 2% in US, Great Britain, Germany, France, Italy, Spain, China, Australia, and Japan. As the smartphone industry matures, fewer consumers are moving between brands and market growth has increasingly relied on replacing existing devices (Kantar World Panel 2017)[21]. No market data has been found to confirm this trend also for 2017-2018. Smartphone shipments worldwide are projected to add up to 1.71 billion in 2020 (Statista, 2018a)[22], a tenfold increase from 2009 although an asymptotic limit appears approached (Figure 8).

Sales of smartphones in Western Europe increased from 115.4 million units in 2013 to 125.6 million units in 2017 (+9%). Sales reached a peak of 135 million units in 2015, after which they decreased by 3-4% (Statista 2018c)[23].

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[19] Farmer A (2015) SIM-only on the march as consumers hold on to handsets for longer, 19th August 2015, https://yougov.co.uk/news/2015/08/19/sim-only-march-consumers-hold-handsets-longer/ (Accessed on 9 February 2018)

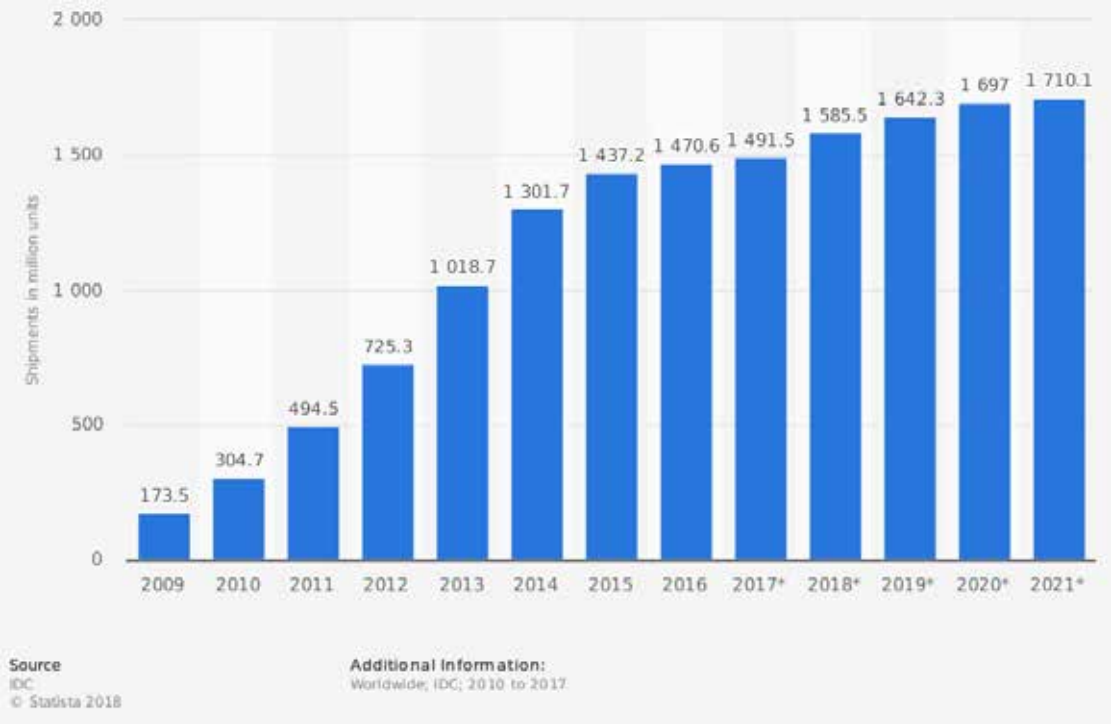
[20] Statista (2018b) Smartphone user penetration as percentage of total global population from 2014 to 2021, https://www.statista.com/statistics/203734/global-smartphone-penetration-per-capita-since-2005/ (accessed on 12 February 2018)

[21] Kantar World Panel (2017) AN INCREDIBLE DECADE FOR THE SMARTPHONE: WHAT'S NEXT? The Future of Mobile is in Combining Devices, Content, and Services -Rev 2017-24-Feb-0925, https://www.kantarworldpanel.com/dwl.php?sn=news_downloads&id=1361 (accessed on 27 February 2019)

[22] Statista (2018a) Smartphones industry: Statistics & Facts, https://www.statista.com/topics/840/smartphones/ (accessed on 12 February 2018)

[23] Statista (2018c) Smartphone unit shipments in Western Europe from 2013 to 2017 (in million units), https://www.statista.com/statistics/412224/global-smartphone-shipments-western-europe/ (accessed on 12 February 2018)

Sales are instead increasing in Central and Eastern Europe, from 50.9 million units in 2013 to 85.2 million units in 2017 (+67%) (Statista 2018d)[24]. The overall picture for Europe results in an increase of shipments from 166.3 million units in 2013 to 210.8 units in 2018 (+27%). Sales in Europe represent around 15% of the global sales of smartphones (Figure 9).

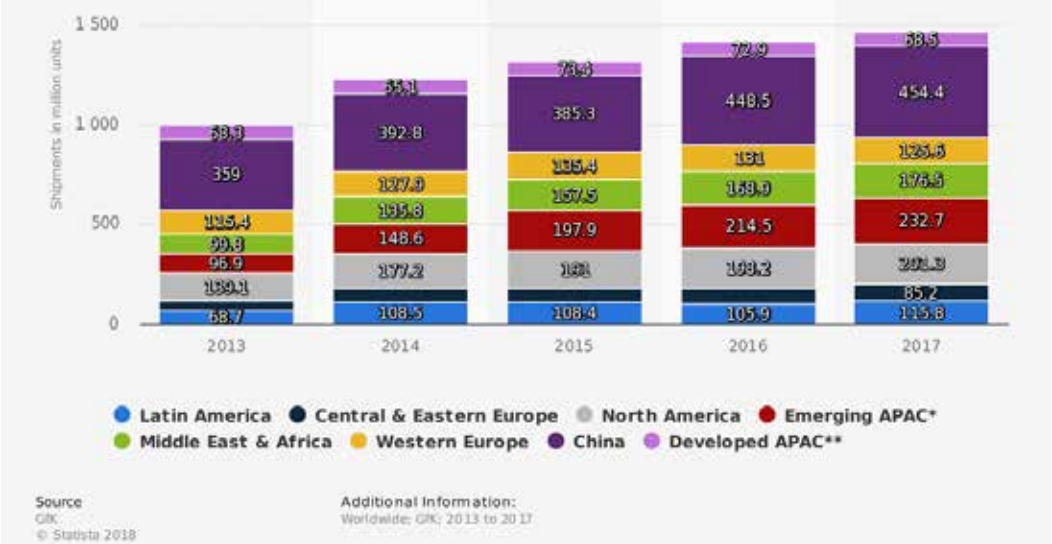


Source: Statista (2018e)[25]

Figure 8: Global smartphone shipment forecast from 2010 to 2021 (million units)

[24] Statista (2018d) Smartphone unit shipments in Central & Eastern Europe from 2013 to 2017 (in million units), https://www.statista.com/statistics/412204/global-smartphone-shipments-central-and-eastern-europe/ (accessed on 12 February 2018)

[25] Statista (2018e) Global smartphone shipments forecast from 2010 to 2022 (in million units), https://www.statista.com/statistics/263441/global-smartphone-shipments-forecast/ (accessed on 12 February 2018)



Source: Statista (2018f)[26]

Figure 9: Smartphone unit shipments worldwide from 2013 to 2017 (in million units), by region

In terms of total value, sales of smartphones in 2017 were 56 billion USD in Western Europe (Statista 2018g)[27] and 21.2 billion USD in Central and Eastern Europe (Statista 2018h)[28], which add to 77.2 billion USD. Total value of sales has increased constantly since 2013.

Values of single units in 2017 for Western Europe and for Central and Eastern Europe would correspond to 446 and 249 USD, respectively. Compared to 2013, the single unit value has decreased by 16% in Eastern Europe while it has remained almost constant in Western Europe. The European average is 366 USD, 10% less than in 2013.

Market penetration

The number of smartphone users is forecast to grow from 2.1 billion in 2016 to around 2.5 billion in 2018 (Figure 10), with smartphone penetration rates increasing as well. Over 36% of the world's population is projected to use a smartphone by 2018, up from about 10% in 2011 (Statista 2018i)[29] and 21.6% in 2014 (Statista 2018b)[30].

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[26] Statista (2018f) Smartphone unit shipments worldwide from 2013 to 2017 (in million units), by region, https://www.statista.com/statistics/412108/global-smartphone-shipments-global-region/ (accessed on 12 February 2018)

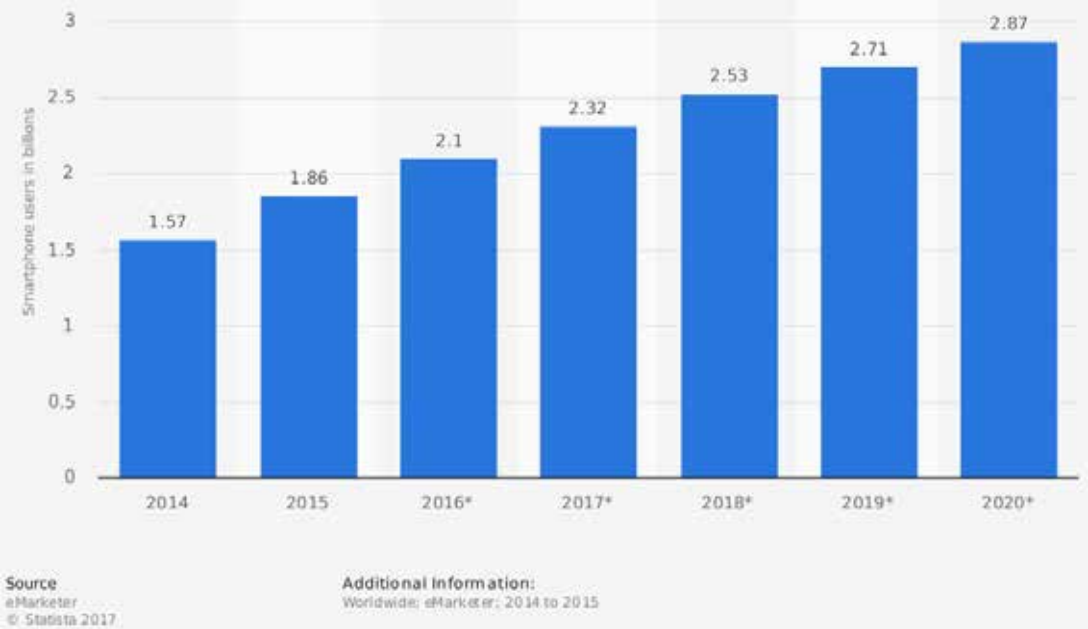
[27] Statista (2018g) Smartphone sales value in Western Europe from 2013 to 2017 (in billion U.S. dollars), https://www.statista.com/statistics/412280/global-smartphone-sales-value-western-europe/ (accessed on 12 February 2018)

[28] Statista (2018h) Smartphone sales value in Central and Eastern Europe from 2013 to 2017 (in billion U.S. dollars), https://www.statista.com/statistics/412256/global-smartphone-sales-value-central-and-eastern-europe/ (accessed on 12 February 2018)

[29] Statista (2018i) Number of smartphone users worldwide from 2014 to 2020 (in billions), https://www.statista.com/statistics/330695/number-of-smartphone-users-worldwide/ (accessed on 12 February 2018)

[30] Statista (2018b) Smartphone user penetration as percentage of total global population from 2014 to 2021, https://www.statista.com/statistics/203734/global-smartphone-penetration-per-capita-since-2005/ (accessed on 12 February 2018)

Higher penetration levels are achieved in some markets and saturation may be reached soon in developed countries (e.g. in Japan 97% of mobile subscribers have smartphones) (Benton et al. 2015)[31].



Source: Statista (2018i)

Figure 10: Number of smartphone users worldwide from 2014 to 2020 (in billions)

China, the most populous country in the world, leads the smartphone industry. The number of smartphone users in China is forecast to grow from around 563 million in 2016 to almost 675 million in 2019. Around half of the Chinese population is projected to use a smartphone by 2020 (Statista 2018i). This would correspond to about a quarter of all smartphone users in the world (Statista 2018a).

The smallest regional market for smartphones is the Middle East and Africa, where smartphone penetration will stand at an estimated 13.6% (Statista 2018b). The highest penetration rates are instead registered in Western Europe and North America. It is estimated that in 2018 about 64% of the population of those regions will own a smartphone. Market penetration has increased significantly in the last years in both regions: from 22.7% in 2011 in Western Europe, and from 51% in 2014 for North America (Statista 2018b, 2018j)[30, 32]. Smartphone penetration per capita in Central & Eastern Europe has been estimated to increase from 13.3% in 2011 to 58.2% in 2017.

Penetration rates appear significant in the most populated countries of Europe:

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[31] Benton D, Coats E, Hazell J (2015) A circular economy for smart devices: Opportunities in the US, UK and India, Green Alliance, https://www.green-alliance.org.uk/a_circular_economy_for_smart_devices.php (accessed on 27 February 2019)

[32] Statista (2018j) Smartphone user penetration as percentage of total population in Western Europe from 2011 to 2018, https://www.statista.com/statistics/203722/smartphone-penetration-per-capita-in-western-europe-since-2000/ (accessed on 12 February 2018)

- The number of smartphone users in France was estimated to reach 43.35 million in 2017. From 2015 to 2022 the number of smartphone users is expected to grow by 17.68 million users (+26%). Most individuals without a smartphone still own a regular mobile phone and only 7% of the population own no type of phones (Statista 2018k). In relative terms, the share of monthly active smartphone users is projected to increase from 59% of the total population in 2016 to 78.5% in 2022 (Statista 2018k)[33].
- The number of smartphone users in Germany was estimated to reach 55.46 million in 2017 (Statista 2018l)[34]. In relative terms, the share of monthly active smartphone users is projected to increase from 61% of the total population in 2016 to 78.5% in 2022 (Statista 2018m)[35].
- The number of smartphone users in Italy was estimated to increase from 26.8 million in 2015 to 31.5 million in 2017 (Statista 2018n)[36]. In relative terms, the share of monthly active smartphone users is projected to increase from 46% of the population in 2014 to 65% in 2021 (Statista 2018o)[37].
- The number of smartphone users in Spain was estimated to reach 30.3 million in 2017. From 2015 and 2021 the number of user is expected to grow by 7.7 million to 34.3 million users (+16%) (Statista 2018p)[38]. In relative terms, the share of monthly active smartphone users is projected to increase from 59% of the population in 2016 to 72% in 2022 (Statista 2018q)[39].
- The number of monthly active smartphone users in the United Kingdom (UK) is projected to grow steadily from 41.09 million in 2015 to 53.96 million in 2022 (Statista 2018r)[40].

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[33] Statista (2018k) Number of smartphone users in France from 2015 to 2022 (in millions), https://www.statista.com/statistics/467177/forecast-of-smartphone-users-in-france/ (accessed on 12 February 2018)

[34] Statista (2018l) Number of smartphone users in Germany from 2015 to 2022 (in millions), https://www.statista.com/statistics/467170/forecast-of-smartphone-users-in-germany/ (accessed on 12 February 2018)

[35] Statista (2018m) Forecast of the smartphone user penetration rate in Germany from 2015 to 2022, https://www.statista.com/statistics/568095/predicted-smartphone-user-penetration-rate-in-germany/ (accessed on 12 February 2018)

[36] Statista (2018n) Number of smartphone users in Italy from 2015 to 2021 (in millions), https://www.statista.com/statistics/467179/forecast-of-smartphone-users-in-italy/ (accessed on 12 February)

[37] Statista (2018o) Forecast of the smartphone user penetration rate in Italy from 2014 to 2021, https://www.statista.com/statistics/568187/predicted-smartphone-user-penetration-rate-in-italy/ (accessed on 12 February 2018)

[38] Statista (2018p) Number of smartphone users in Spain from 2015 to 2022 (in millions), https://www.statista.com/statistics/467185/forecast-of-smartphone-users-in-spain/ (accessed on 12 February 2018)

[39] Statista (2018q) Forecast of the smartphone user penetration rate in Spain from 2015 to 2022, https://www.statista.com/statistics/568268/predicted-smartphone-user-penetration-rate-in-spain/ (accessed on 12 February 2018)

[40] Statista (2018r) Forecast of smartphone user numbers in the United Kingdom (UK) from 2015 to 2022 (in million users), https://www.statista.com/statistics/553464/predicted-number-of-smartphone-users-in-the-united-kingdom-uk/ (accessed on 12 February 2018)

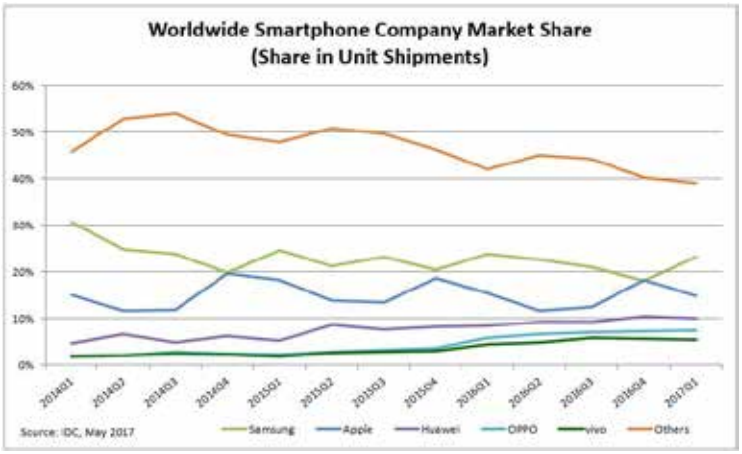
In relative terms, the share of monthly active smartphone users is projected to increase from 62% of the population in 2014 to 78% in 2022 (Statista 2018s)[41].

However, ownership differs across age groups. For example, 88% of 16-24 year olds owned smartphones in 2014 in the UK, compared to 14% of those over 65 (Benton et al. 2015).

Market shares by vendor

Until the first quarter of 2011, Nokia was the leading smartphone vendor worldwide with a 24% market share (Statista 2018a). As represented in Figure 11, the leading smartphone vendors in 2016 were Samsung and Apple, with about 20-25% and 15% of the share respectively, followed by Huawei, OPPO and Vivo (IDC, Statista 2018i)[42,29]. Other prominent smartphone vendors include Lenovo and Xiaomi (IDC, Statista 2018a)[42,17]. At the end of 2017, Apple had a worldwide market share of 19%, surpassing Samsung (Statista 2018t)[43].

China is not only home of three of the top smartphone vendors (Huawei, Lenovo and Xiaomi), but it is also the largest smartphone market in the world (Statista 2018u)[44]. Shares vary depending on the country and the year considered. For example, in the UK the most popular mobile device vendor has been Apple since 2010, which had a total market share of 49% in the first eight months of 2017. In January 2017, the total market share of the Apple iPhone 7 Plus in terms of total smartphone sales in the UK was higher than all others (Statista 2018s).



Source: IDC

Figure 11: Worldwide Smartphone Company Market Share from 2014 to first quarter of 2017 (Share in Unit Shipments)

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[41] Statista(2018s) Forecast of the smartphone user penetration rate in the United Kingdom (UK) from 2015 to 2022, https://www.statista.com/statistics/553707/predicted-smartphone-user-penetration-rate-in-the-united-kingdom-uk/ (accessed on 12 February 2018)

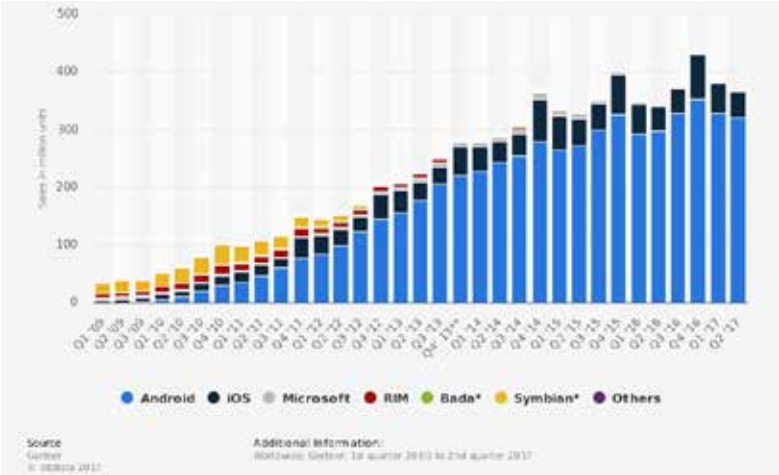
[42] IDC, Smartphone Market Share, https://www.idc.com/promo/smartphone-market-share/vendor (accessed on 13 February 2018)

[43] Statista (2018t) Smartphone shipments by vendor worldwide from 4th quarter 2009 to 4th quarter 2018 (in million units), https://www.statista.com/statistics/271490/quarterly-global-smartphone-shipments-by-vendor/ (accessed on 12 February 2018)

[44] Statista (2018u) Global smartphone shipments market share of Lenovo by quarter from 2012 to 2015, https://www.statista.com/statistics/299121/global-market-share-held-by-lenovo-smartphones/ (accessed on 12 February 2018)

Market shares by operating system

Google's Android is the clear leader among operating systems with a global market share of more than 80%. Apple's operating system iOS is its main competitor, accounting for about 15% of the share (Statista 2018a). The two operating systems amounted to 352.67 million Android units and 77.04 million iOS units being shipped in the final quarter of 2016 (Statista 2018e) (see also Figure 12, Figure 13, Figure 14). There are however differences between regional markets; in the United States for example, the market is almost equally divided between Android and iOS (Statista 2018v) [45]. Microsoft's Windows Phone is another smartphone operating system on the market. Symbian, which was used extensively on mobile phones and early generations of smartphones by leading manufacturers, such as Samsung, LG, Motorola and Nokia, was a dominant player on the market in 2009 and 2010. Due to the growing popularity of Android, which most major smartphone manufacturers adopted as their OS of choice, and Nokia's partnership with Windows Phone, which began in 2011, Symbian was pushed off the market in 2014 (Statista 2018v). It has been also reported by stakeholders involved in the development of this study that Blackberry stopped shipping products with Blackberry 10 in 2015 and switched to Android. Although the main producers of operating systems are based in the U.S., the Chinese smartphone industry may dominate the market in the future: China could control about a third of the smartphone market in 2017 (Statista 2018e).

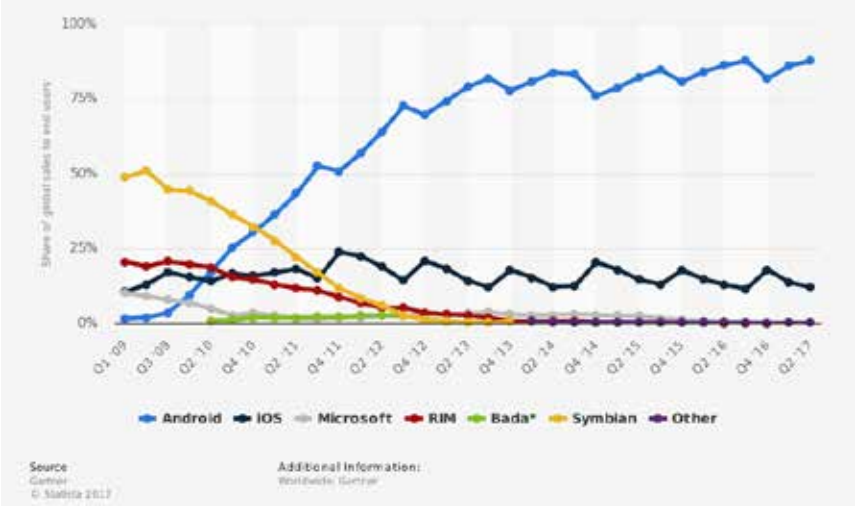


Source: Statista (2018w)[46]

Figure 12: Global smartphone sales to end users by operating system from 1st quarter 2009 to 2nd quarter 2017 (in million units)

[45] Statista (2018v) Global market share held by smartphone operating systems from 2009 to 2017, https://www.statista.com/statistics/263453/global-market-share-held-by-smartphone-operating-systems/ (accessed on 12 February 2018)

[46] Statista (2018w) Global smartphone sales to end users from 1st quarter 2009 to 2nd quarter 2018, by operating system (in million units), https://www.statista.com/statistics/266219/global-smartphone-sales-since-1st-quarter-2009-by-operating-system/ (accessed on 12 February 2018)



Source: Statista (2018z)[47]

Figure 13: Global market share held by the leading smartphone operating systems in sales to end users

Source: Statista (2018aa)[48]

Figure 14: Installed base of smartphones by operating system from 2015 to 2017 (in million units)

[47] Statista (2018z) Global mobile OS market share in sales to end users from 1st quarter 2009 to 2nd quarter 2018, https://www.statista.com/statistics/266136/global-market-share-held-by-smartphone-operating-systems/ (accessed on 12 February 2018)

[48] Statista (2018aa) Installed base of smartphones by operating system from 2015 to 2017 (in million units), https://www.statista.com/statistics/385001/smartphone-worldwide-installed-base-operating-systems/ (accessed on 12 February 2018)

3. Analysis of the application of GPP criteria for computers

3.1. Aim and methodological approach

The aim of this work package is to provide a comprehensive analysis of the application of GPP criteria for computers in Europe. This includes the analyses of the National Action Plans on Green Public Procurement (NAP GPP) and the analyses of current tenders.

Further on there will be case studies prepared indicating examples of good practice.

3.1.1. Analyses of the National Action Plans on Green Public Procurement (NAP GPP) concerning computers

Basis for the research was first and foremost a document from the European Commission on GPP with an overview from June 2018 of the NAP GPP in the European member states[49]. Unlike the most NAP GPP this document is in English which allows considering also countries with languages other than English, German, French, Spanish, or Italian.

3.1.2. Analyses of invitation to tenders (via TED) on computer equipment

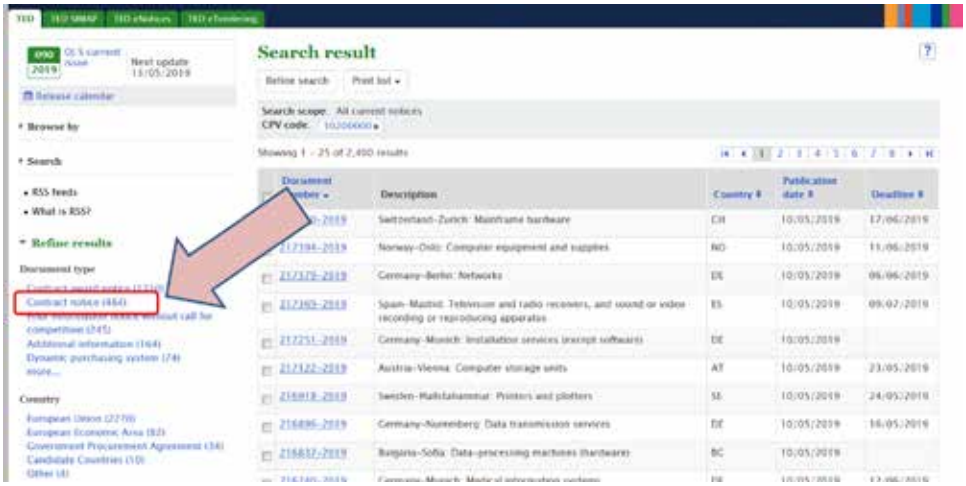
Starting point of the research of invitation to tenders on computer equipment is the website https://ted.europa.eu. The contract notices on the TED website were screened from mid-May to mid-June 2019. The subsequent screenshots illustrate the different steps:

Step 1: The research was done by business sector (CVP).

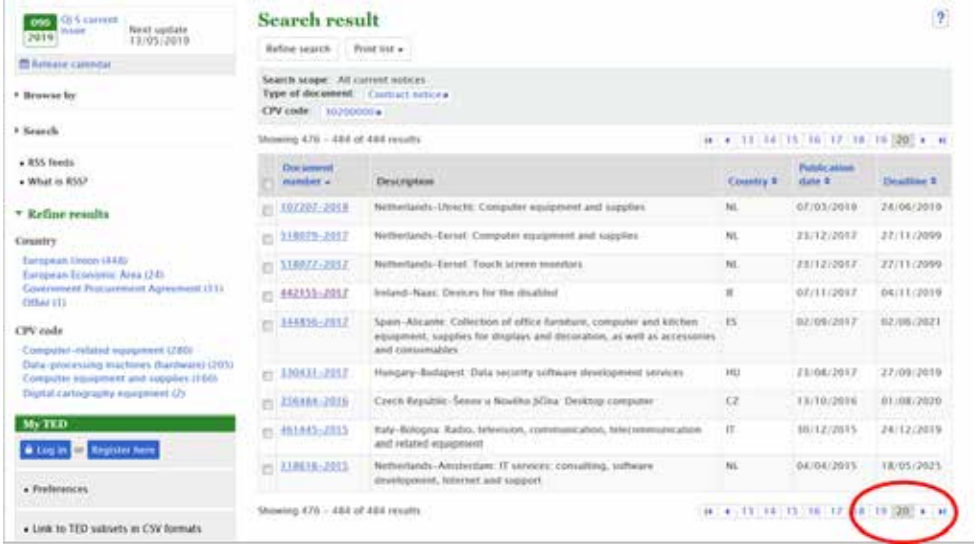
[49] Link: http://ec.europa.eu/environment/gpp/pdf/GPP_NAPs_June_2018.pdf

Step 2: The CVP 30200000 'Computer equipment and supplies' was chosen.

Step 3: Only contract notices were screened



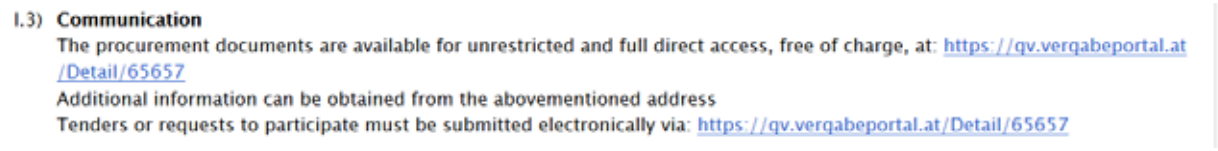
Step 4: The check of the TED notices started with the last page of the search results in order to cover results where the time limit for receipt of tenders or requests to participate was close. Only within this time limit the respective documents can be downloaded.



Step 5: Download of tender documents. The download of tender documents was restricted to the following:

- Only the languages German, English, French, Italian, and Spanish were considered. This was congruent with the countries Austria, Belgium (only French documents), France, Germany, Ireland, Italy, Spain, and United Kingdom.
- Only tenders that included product groups relevant to the study were considered, e.g. desktop-computers, integrated desktop-computers, mobile all-in-one-computers, notebook-computers, 2-in-1-notebook-computers, tablet-computers, thin-clients, workstations and small-scale-server. Additionally also computer screens and mobiles /smartphones were considered.

In the TED message in Section *I contracting entity* there is a link where the tender documents can be downloaded. Often it can be found under *I.3) Communication*, for example like this:


I.3) **Communication**
The procurement documents are available for unrestricted and full direct access, free of charge, at: https://qv.verqabeportal.at/Detail/65657
Additional information can be obtained from the abovementioned address
Tenders or requests to participate must be submitted electronically via: https://qv.verqabeportal.at/Detail/65657

Step 6: Analysis of the filed tender documents. The tender documents were searched for selected search terms that allowed identifying relevant keywords in the documents. These keywords were chosen on the bases of the GPP documents on computers in the languages English, German, French, Spanish and Italian. The Annex shows the list of the search terms and the keywords they refer to, used for the search, see section 5.3.

The number of hits was documented and selected tenders with an above-average number of hits were further analyzed. The aim of this was also to identify possible case studies with best practice.

3.2. Results

3.2.1. Analyses of the National Action Plans on Green Public Procurement (NAP GPP) concerning computers

The following six EU Member States have indicated that they do not currently have a valid NAP GPP: Estonia, Greece, Hungary, Luxembourg, Romania, and Slovenia.

Except for Poland, in all other NAP GPP ICT equipment is mentioned specifically. However the wording is different and ranges from general terms like 'IT equipment' or 'office equipment' to specific product groups like 'personal computers', 'servers' or 'mobile phones'. In the following the term 'ICT equipment' is used to cover the different wordings in case it is not necessary to use a more specific term.

Most of the countries develop their own national GPP criteria (16 out 22) for ICT equipment which are often based on the EU GPP criteria or EU GPP criteria are used as a starting point. The following countries directly recommend EU GPP criteria for ICT equipment: Croatia, Cyprus, Ireland, Latvia, Malta, Portugal, Slovakia, and Sweden. As a rule of thumb the EU GPP criteria are recommended by the other countries in case that no national criteria exist. See Annex, section 5.1 for the full overview.

GPP is not necessarily mandatory in all EU member states. The following categories were identified:

GPP is not mandatory or there was no entry in the table:

- Estonia (no entry),
- Greece (no entry),
- Ireland (at present there is no mandatory use of GPP),
- Luxmbourg (no entry),
- Poland (general recommendations, no obligation),
- Slovakia (no obligation to use GPP criteria),
- Sweden (no entry).

It is not clear if / in what way GPP is mandatory or the anchorage of GPP in the regulative framework of the respective member state is under development:

- Bulgaria (e.g. Energy Efficiency Act Guidelines, but binding force unclear),
- Cyprus (commitment for the implementation of the GPP NAP from public authorities.),
- Czech Republic (not a legal but a political obligation),
- France (the law grenelle I, §48 decribes targets and intentions of the state concerning GPP),
- Hungary (Public Procurement Act, but binding force unclear),
- Latvia (under development),
- Malta (no specific national legislation concerning GPP, but all contracting authorities are required to complete a GPP checklist prior to tender publication and each ministry has nominated a GPP Coordinator with a remit to ensure that all tenders issued by that ministry are in accord with the national GPP criteria.),
- Romania (under development),
- Portugal (general support from the government),
- Slovenia (decree on green public procurement, not available in english).

GPP is in part mandatory, e.g. for the central government bodies and/or for certain product groups (e.g. vehicles) or aspects (e.g. energy efficiency):

- Austria (general obligation for the federal level to procure sustainable products),
- Belgium (some mandatory rules on products/services and on procurement processes are worked out in the federal and (different) regional regulations),
- Croatia (central government must purchase only products, services and buildings with high energy efficiency performance),
- Denmark (state institutes have to purchase sustainable timber and have to follow the guidelines for electricity using products set out by the Danish Energy Agency; public authorities are obliged to make an environmental assessment when purchasing vehicles),
- Finland (Government decision on the promotion of environmental and energy solutions in public procurement, is binding for central government bodies),
- Germany (public procurers are basically obliged to demand an analysis of minimized LCC by tenderers, on Länder-level there exist partly further reglations e.g. the federal states Berlin, Bremen and North-Rhine Westfalia realize GPP at a higher order level),
- Italy (the introduction of at least the technical specifications and the contract clauses of the Minimum Environmental Criteria is obligatory in tender documents, regardless of their value, so also for procurements below the threshold amounts. Also the award criteria must be taken into account when a contracting authority awards the contract with

the best quality price ratio. The mentioned obligation applies to all kinds of contracting authorities.),

- Lithuania (all contracting authorities shall apply the environmental criteria when conducting public procurement of goods, services and works that are specified.),
- The Netherlands (central government is bound by a political motion of the parliament. Decentralized government are bound by covenants.),
- Spain (Barcelona: mandatory use of the environmental criteria developed by the Government + sustainable programme),
- United Kingdom (where centralised contracts are developed - in which the Government Buying Standards are embedded -, it is mandatory for Departments to use them.).

Concerning the monitoring activities related to GPP in the member states the following categories could be identified (see Annex, section 5.2 for the full overview):

- No monitoring activities at all: Ireland, Austria (activities are stopped for the moment)
- Single studies on GPP: Sweden, Spain (national level), Poland (annual report in 2016), the Netherlands, Germany, Finland, Denmark, Czech Republic (planned for 2018), Croatia, Bulgaria, and Belgium.
- Continuous monitoring: UK (regular surveys), Spain (some regions), Slovakia (annual online survey), Portugal (automatically in online procurement platform), Malta (weekly monitoring of tenders), Lithuania (annual reports), Latvia (annual review), Italy (electronic monitoring system, but no useful data), France (several tools, yearly report of ministries), Cyprus (questionnaires etc.), Belgium (Brussels region)

3.2.2. Analyses of invitation to tenders (via TED) on computer equipment

In total 100 tenders were analysed. The considered tenders show a snapshot of tenders for the time period mid may und until mid of June 2019. In this period from some countries there were more relevant contract notices and tenders published (e.g. Spain, Germany) than from others (e.g. UK, Italy). Therefore the analysed tenders are neither equally distributed between the considered EU countries nor are they representative concerning the tender objects but they reflect the specific situation in the chosen time period. The following table shows the distribution of the analysed tenders among countries.

Table 4: Distribution of analysed tenders among countries

Member State	Number of tenders considered	Share of analysed tenders
AT	5	5,0%
BE	8	8,0%
DE	31	31,0%
ES	29	29,0%
FR	15	15,0%
IT	5	5,0%
UK	7	7,0%
Total	**100**	**100,0%**

Source: Own compilation

The results of the search of the 100 tenders by search term were analysed in two ways:

- The number of hits achieved in each tender
- The number of hits achieved by each search term

The number of hits achieved in each tender

As shown in the subsequent table, in 8 % of the tenders no hits were achieved at all. In 17 % of tenders, between 1 and 3 hits showed up. With a share of 61 %, most of the tenders achieved between 4 and 8 hits. 14 % of tenders achieved 9 hits and more. The maximum number of hits in one tender was 16.

For the results differentiated by country see Annex, section 5.3.

Table 5: Number of hits for search terms in each GPP tender

Number of hits in tender	Number of tenders	Share of tenders
0	8	8,0%
1	7	7,0%
2	6	6,0%
3	4	4,0%
4	16	16,0%
5	16	16,0%
6	13	13,0%
7	6	6,0%
8	10	10,0%
9	5	5,0%
10	3	3,0%
11	3	3,0%
12	2	2,0%
13	0	0,0%
14	0	0,0%
15	0	0,0%
16	1	1,0%
17-30	0	0,0%
	100	**100,0%**

Source: Own compilation

The number of hits achieved by each search term

With 78 the most hits were achieved by the search term 'environment'. This means that 78 % of the analysed tenders included the term 'environment'. It should be noted that false-positive hits may also be included within the 78 hits as the word environment in most of the considered languages[50] refers also to an 'IT environment' (hardware, software) that might be mentioned in the tender. With 27 tenders significantly less important is the term 'sustainable'. It is noticeable that after 'environment' the terms 'replacement' (66 tenders) and 'repair' (57 tenders) rank the highest. The terms 'recycl' (38 tenders) and 'product life' (34 tenders) are less common. The terms 'spare parts' and 're-use' were found in 19 % resp. 17 % of tenders. 'Longevity' was only found in one tender.

The term 'energy' is mentioned in 50 % of the tenders. The term 'packaging' was found in 44 tenders and is therefore similarly important.

Among the search terms that refer to labels or certification systems, 'Energy Star' is the most important with 25 % of tenders, followed by 'TCO' (14 % of tenders), Ecolabel (9 %), Blue Angel (8 %), EPEAT (7 %) and 'Nordic Swan' (1 %). No hit was achieved for 'GPP'.

Search terms that refer to hazardous substances were only found in few tenders: 'hazardous substances' (12 % of tenders), REACH (6 %), flame retardants (2 %), plasticiers (1 %). No hits were achieved for the terms 'substances of very high concern' and 'SVHC'. All results are shown in the subsequent table. The results differentiated by country are shown in the Annex, section 5.4.

Table 6: Number of hits achieved by each search term

Search term [English; for the other languages see Annex, section 5.3]	Number of tenders that mention search term
environment	78
replacement	66
repair	57
energy	50
packaging	44
recycl	38
product life	34
sustainable	27
Energy Star	25
spare parts	19
re-use	17
TCO	14

[50] e.g. not in German as the term „Umgebung" and not "Umwelt" (=environment) is normally used in IT context.

Search term [English; for the other languages see Annex, section 5.3]	Number of tenders that mention search term
Hazardous substances	12
Ecolabel	9
Blue Angel	8
EPEAT	7
end of life	7
REACH	6
flame retardant	2
Nordic Swan	1
longevity	1
plasticizer, plastizisers	1
GPP	0
SVHC	0
substances of very high concern	0

Source: own compilation

3.3. Lessons learnt, conclusions and outlook

The fact that all - except one - current National Action Plans for Green Public Procurement (NAP GPP) specifically mention 'ICT equipment' shows that it is considered as important product group. The EU GPP criteria play an important role as they are directly recommended for GPP by 8 countries and are used as reference or starting point for the development of national GPP criteria by most other countries.

Furthermore some kind of NAP GPP monitoring activities take place in all member States except for Ireland and (temporarily) for Austria. It is not clear if they deliver valuable data. For the 11 countries that do single studies, these partly seem to be rather outdated (e.g. from 2008 / 2010). For the 9 countries that stated that they have a continuous monitoring it would have to be verified if the systems mentioned do function correctly and the mostly stated as annual monitoring activities take place and deliver valuable data.

Against the background of the analyses of the tenders by search terms the following classification can be done:

Level 0: Environmental aspects are not addressed

- Strong indicator: No hits at all in the keyword search.
- In tenders of this category no environmental aspects and criteria are mentioned at all.
- In the current research this corresponds to 8% of the tenders.

Level 1: Legal compliance / voluntary concept from offerer

- Strong indicator: 1-3 hits in the keyword search primarily on general terms like 'environment'.
- In the tender documents often only legal compliance – among others also for environmental legislation – is demanded and / or offerors are asked to submit a concept on aspects concerning the environment or sustainable development. For the latter as a rule no criteria are given in the tender document on how such a concept has to be prepared and how it will be evaluated.
- In the current research this corresponds to 17 % of the tenders.

Level 2: Defined criteria for specific aspects

- Strong indicator: 4 to 8 hits in the search with often include also search terms like 'Energy Star' or 'EPEAT'.
- In tenders of this category specific criteria for one or a few topics like energy efficiency or packaging are defined. Not necessarily all of the criteria are mandatory; in part they may also be optional.
- In the current research this corresponds to 61 % of the tenders.

Level 3: Comprehensive specifications

- Strong indicator: 9 hits and more in the specific tender and the hits cover a wide range of topics.
- Often, certification systems (e.g. ecolabels) or documents with a comprehensive set of criteria (e.g. GPP criteria papers, administrative regulations) are cited as reference and the respective criteria are mandatory.
- In the current research this corresponds to 14 % of the tenders.

Outlook: Among the 14 tenders that reach Level 3 - which corresponds to 9-16 hits in the above search – a selected number will be chosen and best practise examples and case studies will be prepared. The tenders originate from Spain (5 tenders) and Germany (9 tenders).

4. Technical analysis

The technical analysis shall serve as basis for the revision of the current GPP criteria for computers and monitors as of October 2016. The criteria focus on the most significant environmental impacts during the life cycle of the products which have been divided into four distinct categories:

- Energy consumption,
- Product lifetime extension,
- End-of life management, and
- Hazardous substances.

Data sources

First, to delimit GPP criteria from existing or upcoming legal requirements, the following new or revised EU Ecodesign and Energy label regulations covering the product groups in scope of the EU GPP criteria or related components have been analysed:

- Ecodesign Regulation for computers and computer servers (617/2013)[51]; currently under revision (ongoing); no draft regulatory documents were available at the date of analysis (mid July 2019), thus the policy recommendations of the revision study (Task 7) were taken into account, cf. https://computerregulationreview.eu/
- Ecodesign Regulation for servers (EU 424/2019)[52]
- Draft revised Ecodesign Regulation for electronic displays (XX/2019)[53]
- Adopted delegated Energy label Regulation for electronic displays (XX/2019)[54]
- Draft revised Ecodesign Regulation for external power supplies (XX/2019)
- RoHS Directive 2011/65/EU[55]
- REACH Regulation (EC) No 1907/2006[56]
- EU POPs Regulation (EC) No 850/2004[57]

Further aim of this task is to collate innovative criteria of most recent labelling schemes for the revision of the EU GPP criteria. Ideally, referring to existing labelling criteria could facilitate simplification of the verification burdens for public authorities as this may lay the foundation for potential for bidders to provide verification based on equipment holding the Type I Eco-label fulfilling the same specified requirements.

Therefore, following labelling schemes and related documents have been analysed:

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[51] https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:175:0013:0033:EN:PDF

[52] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019R0424

[53] http://ec.europa.eu/transparency/regcomitology/index.cfm?do=search.documentdetail&Dos_ID=16995&ds_id=59740&version=2&page=1

[54] See https://webgate.ec.europa.eu/regdel/#/delegatedActs/982

[55] See the consolidated version and all amendments of the Annexes at: http://ec.europa.eu/environment/waste/rohs_eee/legis_en.htm

[56] https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2007:136:0003:0280:en:PDF

[57] https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2004:158:0007:0049:EN:PDF

Table 7: Overview of analysed labelling schemes and related documents for computers and smartphones

Ecolabel (short name used in this report)	Criteria document	Number of labelled products (as of 17 July 2019)
'Blue Angel Computers'	DE-UZ 78 for Computers (as of 01/2017)[58]	0
'Blue Angel Mobile Phones'	DE-UZ 106 for Mobile Phones (as of 07/2017)[59]	0
'EPEAT Computer & Display (IEEE)'	Based on IEEE Std. 1680.1TM-2018 for computers (as of 02/2018)[60]	8337[61] (3786 Bronze, 4244 Silver, 307 Gold)
'EPEAT Mobile Phones (UL 110)'	Based on UL 110 Standard for Sustainability for Mobile Phones (Second Edition, Dated March 24, 2017 (including revisions through September 28, 2018))[62]	63[63] (0 Bronze, 11 Silver, 52 Gold)
'Nordic Ecolabelling'	Version 5.0 for rechargeable batteries and portable chargers (as of 06/2018) [64]	4 (Sweden)[65]
‚TÜV Green Product Mark Computers'	2PFG-E 2354:07.2018 for Portable Computers (as of 07/2018)	2[66]
‚TÜV Green Product Mark Mobile Phones'	2 PfG E 2073:07.2018 for Mobile Phones (as of 07/01/2018)[67]	0

[58] https://produktinfo.blauer-engel.de/uploads/criteriafile/en/DE-UZ%2078-201701-en%20Criteria.pdf

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

[60] See https://greenelectronicscouncil.org/epeat-criteria/; Criteria document accessible under https://ieeexplore.ieee.org/browse/standards/get-program/page/series?id=86

[61] According to https://epeat.sourcemap.com/?category=pcsdisplays; it has to be noted, however, that the number of product types indeed is lower due to multiple counts as the database also includes same models marketed in different countries.

[62] See https://greenelectronicscouncil.org/epeat-criteria/; Criteria document accessible under https://www.shopulstandards.com/ProductDetail.aspx?productId=ULE110_2_B_20170324(ULStandards2)

[63] According to https://epeat.sourcemap.com/?category=mobilephone; it has to be noted, however, that the number of product types indeed is lower due to multiple counts as the database also includes same models marketed in different countries.

[64] http://www.nordic-ecolabel.org/product-groups/group/DownloadDocument/?documentId=3496. The current Nordic Ecolabelling Version 7.4 as of 23 October 2013 including Desktop Computers, Integrated Desktop Computers, Notebook computers (including slate), Workstations, Thin Clients, and Small-scale Servers has not been analysed as being older than the current EU GPP criteria as of 2016

[65] According to https://www.svanen.se/en/product-types/rechargeable-battery/

[66] According to https://www.certipedia.com/search/matching_product_certificates?utf8=%E2%9C%93&locale=en&q=green+product+mark+computer

[67] https://www.tuv.com/content-media-files/master-content/services/products/1293-tuv-rheinland-green-product-mark/tuv-rheinland-2pfg-2073.pdf

Ecolabel (short name used in this report)	Criteria document	Number of labelled products (as of 17 July 2019)
'TCO Accepted Substance List'	Accepted Substance List (as of 11/2018)[68]	n.a.
'TCO Computers'	Generation 8 (as of 2018) for displays, notebooks, tablets, desktops, all-in-one PCs[69]	Latest generation: 615 displays, 87 notebooks, 1 tablet, 31 desktops, 35 AiO PCs[70]
'TCO Smartphones'	Generation 8 (as of 2019) for smartphones[71]	0
'US Energy Star Computers'	Program Requirements Version 7.1 for Computers (as of 11/2018)[72]	1233[73]

Source: Own compilation

Whereas for most ecolabels (TCO, Nordic Swan, Blue Angel, and Green Product Mark) all criteria have to be fulfilled by the product to become certified, in case of EPEAT products a different approach is applied: Bronze-rated products have to meet all of the required criteria in their category, Silver-rated products have to meet all of the required and at least 50% of the optional criteria, while Gold-rated products have to meet all of the required and at least 75% of the optional criteria. This means that for procuring EPEAT labelled products, Public Authorities would have to check in detail, if the selected product fulfils the optional criteria as required in the tender specifications or not.

Finally, the technical analysis includes feedback from stakeholders about experiences and challenges with the application of current GPP criteria for computers and monitors. During May 2019, Joint Research Centre's Directorate B - Growth & Innovation has run an EU survey based on a questionnaire on the use of the current EU GPP criteria with the possibility for stakeholders to provide feedback on possible areas of revision.

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

[69] https://tcocertified.com/certification-documents/

[70] According to https://tcocertified.com/product-finder/

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

[72] https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Computers%20Final%20Version%207.1%20Specification.pdf

[73] According to https://www.energystar.gov/productfinder/product/certified-computers/results

4.1. Energy consumption

4.1.1. Current EU GPP criteria and their application

Application of current EU GPP criteria (feedback according to stakeholder consultation)

According to the answers received the current energy consumption criteria were applied in the past mainly by referring to the provision of Energy Star certified products. While some participants highlighted the need of stricter requirements for energy consumption others are of the opinion that the efficiency thresholds introduced by the Energy Star version 7.0 for computers make product compliance with Energy Star more relevant and challenging and, according to TCO, tough to fulfil by 30 to 50% of the products on the market.

About the awarding of more efficient products, the approach used by relevant procurers is to include the energy consumption in the model for the total cost of ownership.

As note (applicable to also other labels) has been highlighted that it is important in the technical specifications to mention the exact version of Energy Star required (and not generally the latest version).

Some public authorities are aware of the expiration of the EU-US agreement on Energy Star expired and that it would require a modification of the existing criterion based on Energy Star Version 6.1.

4.1.2. Legal provisions

4.1.2.1. EU Ecodesign Regulation 617/2013 on computers and computer servers

Related to energy consumption, current EU Ecodesign regulation 617/2013 with regard to ecodesign requirements for computers and computer servers has following criteria applied:

- Maximum limits on the annual energy consumption (E_{TEC} in kWh/year), taking into account the power demand of Off-mode, Sleep-mode and Idle-State, as well as providing allowances for certain capabilities such as extended memory, additional internal storage, or a discrete television tuner, audio or graphics card. The calculation approach for the annual energy consumption is specified in the EU Ecodesign regulation.
- In addition, for the product groups desktop computers, integrated desktop computers and notebook computers, maximum limits for sleep mode, the lowest power state and off-mode apply.
- For desktop computers, integrated desktop computers, desktop thin clients, workstations and small scale servers as well as computer servers, minimum requirements on the internal power supply efficiency are set.
- Finally, for desktop computers, integrated desktop computers and notebook computers, criteria on power management enabling (such as reduced speed in low power modes, response time to ‘wake events’, pre-set time for starting display sleep mode).

The EU Ecodesign regulation and its requirements on computers and computer servers are under revision; the revision study has been finalised in July 2018. No draft regulation was available at the time of the analysis for this report (mid July 2019).

Task 7 report of the revision study[74] provides proposals for a revision of the above listed requirements. Also the possibility for the potential inclusion of active mode power demand as part of ecodesign requirements in a future regulation is discussed. Background for this is the situation that during past years power saving technologies of computer products – mainly mobile devices with the aim of extending the battery lifetime, but also available in desktop computers – has been significantly enhanced resulting in reduced idle power demand. This has created a situation where the idle mode is no longer a sufficiently good proxy for active mode as the active power demand of a typical desktop computer can be significantly higher than idle mode power demand, particularly when performing compute intensive operations like gaming and video editing. Further, current test procedures are based on a weighted average of low power modes including idle, whereas new technology developments allow very low power levels of idling. This means that real use scenarios are not reflected any more. Thus, according to the EU Ecodesign revision study, including the active mode into the requirements shall provide a much more realistic metric for the product efficiency compared to only including low power modes. So far, however, no standardized test procedure to measure active mode energy efficiency in personal computers is avaible and the active mode power demand of computers has not been addressed by any energy efficiency initiative widely applied on the main worldwide market.

4.1.2.2. EU Ecodesign Regulation 2019/424 on servers and data storage products

The most recently adopted regulation applies to servers defined as 'computing product that provides services and manages networked resources for client devices, such as desktop computers, notebook computers, desktop thin clients, internet protocol telephones, smartphones, tablets, telecommunication, automated systems or other servers primarily accessed via network connections, and not through direct unser input devices, such as a keyboard or a mouse and with the following characteristics:

- It is designed to support server operating systems (OS) and/or hypervisors, and targeted to run user-installed enterprise applications;
- It supports error-correcting code and/or buffered memory (including both buffered dual in-line memory modules and buffered on board configurations);
- All processors have access to shared system memory and are independently visible to a single OS or hypervisor.'

Regulation 2019/424 includes amendments to EU Ecodesign regulation 617/2013 to exclude computer servers from its scope in order to prevent any overlap with the same products in scope:

- Subject matter and scope of 617/2013 is limited to computers only; computer servers are taken out from the scope of 617/2013 and covered separately by regulation 2019/424. However, 'small-scale servers' are still in scope of regulation 617/2013.

According to the definitions of regulation 617/2013, small scale servers are defined as 'a type of computer that typically uses desktop computer components in a desktop form factor but is designed primarily to be a storage host for other computers and to perform functions such as providing network infrastructure services and hosting data/media, and which has the following characteristics:

[74] https://computerregulationreview.eu/sites/computerregulationreview.eu/files/Preparatory%20study%20on%20review%20computer%20regulation%20-%20Task%207%20VM%2019072018.pdf

- Is designed in pedestal tower, or other form factor similar to those of desktop computers such that all data processing, storage and network interfacing is contained within one box;
- Is designed to be operational 24 hours per day and 7 days per week;
- Is primarily designed to operate in a simultaneous multi-user environment serving several users through network client units;
- Where placed on the market with an operating system, the operating system is designed for home server or low-end server applications;
- Is not placed on the market with a discrete graphics card (dGfx) meeting any classification other than G1.

Although EU Ecodesign regulation 2019/424 does not cover product groups being in scope of the EU GPP criteria for computers and monitors, the most recent Ecodesign criteria on computer equipment could nevertheless be guiding also for the revision of the GPP criteria.

Related to energy, the EU Ecodesign regulation 2019/424 on servers and data storage products applies following criteria:

- Requirements (in two tiers) with regard to minimum PSU efficiency at 10%, 20%, 50% and 100% of the rated load level and the minimum power factor at 50% of the rated load level
- Maximum idle state power values, applying allowances for certain product types as well as extra components such as CPU performance, additional PSU, HDD or SDD, additional memory, additional buffered DDR channel and additional I/O devices.
- Minimum active state efficiency requirements.

4.1.2.3. EU Ecodesign Regulation on electronic displays (draft revised)

The draft version of the revised Ecodesign regulation on electronic displays inter alia applies to computer monitors, whereas electronic displays integrated into computers, such as tablets, laptops or 'all-in-one' desktops shall be covered by the review of Regulation 617/2013 on computers.

Related to energy consumption, the draft revised EU Ecodesign regulation on electronic displays proposes following criteria:

- Maximum limits on the Energy Efficiency Index EEI for on-mode, differing depending on the resolution (HD, UHD-4k and above as well as MicroLED displays). Two tiers are proposed to improve the energy efficiency of displays after two years. Allowances and adjustments apply to electronic displays with automatic brightness control (ABC).
- Power demand limits in different modes other than on-mode according to following table.

Table 8: Power demand limits in different modes other than on-mode as proposed in draft revised EU Ecodesign regulation on electronic displays

	Off mode	Standby mode	Networked standby mode
Maximum limits	0,30	0,50	2,00
Allowances for additional functions when present and enabled			
Status display	0,0	0,20	0,20
Deactivation using room presence detection	0,0	0,50	0,50
Touch functionality, if usable for activation	0,0	1,00	1,00
HiNA function	0,0	0,0	4,00
Total maximum power demand with all additional functions when present and enabled	0,30	2,20	7,70

Source: Draft revised EU Ecodesign regulation on electronic displays[53]

4.1.2.4. Delegated EU Energy label Regulation on electronic displays

The revised delegated regulation of 11.3.2019 with regard to energy labelling of electronic displays and repealing Commission Delegated Regulation (EU) No 1062/2010 which shall apply from 1 March 2021[75] defines 'monitor' or 'computer monitor' or 'computer display' as an 'electronic display' (i.e. a display screen and associated electronics that, as its primary function, displays visual information from wired or wireless sources) intended for one person for close viewing such as in a desk based environment.

The Energy Efficiency Index (EEI) of electronic displays shall be calculated using a specific equation. Electronic displays with automatic brightness control (ABC) shall qualify for a 10 % reduction in the measured power in on mode if certain requirements are met (for example that with ABC enabled, the measured value of the on mode power must decrease by 20 % or more when the ambient light condition, measured at the ABC sensor, is reduced from 100 lux to 12 lux). Further, the supplier shall enter into the product database the following information related to energy:

- Energy efficiency class for standard Dynamic Range (SDR) => [A/B/C/D/E/F/G]
- On mode power demand for Standard Dynamic Range (SDR) => X,X W
- Energy efficiency class (HDR) => [A/B/C/D/E/F/G] or n.a.
- On mode power demand in High Dynamic Range (HDR) mode => X,X W
- Off mode, power demand => X,X W
- Standby mode power demand => X,X W
- Networked standby mode power demand => X,X W
- Automatic Brightness Control (ABC) available => [YES/NO]; Must be activated as default (if YES).

[75] See https://webgate.ec.europa.eu/regdel/#/delegatedActs/982

4.1.2.5. EU Ecodesign Regulation on External Power Supplies (draft revised)

The draft version of the revised Ecodesign regulation on External Power Supplies (EPS) inter alia applies to EPS intended for use with electrical and electronic office quipment.

Related to energy consumption, draft revised EU Ecodesign regulation on External Power Supplies has proposed following criteria:

Energy efficiency requirements on the no-load condition power consumption which shall not exceed the following limits:

Table 9: Energy efficiency requirements on the no-load condition power consumption proposed in draft revised EU Ecodesign regulation on external power supplies

	AC-AC external power supplies, except low voltage and multiple voltage output external power supplies	AC-DC external power supplies, except low voltage and multiple voltage output external power supplies	Low voltage external power supplies	Multiple voltage output external power supplies
$P_O \leq 49{,}0$ W	0,210 W	0,100 W	0,100 W	0,300 W
$P_O > 49{,}0$ W	0,210 W	0,210 W	0,210 W	0,300 W

Source: Draft revised Ecodesign Regulation for external power supplies (XX/2019)

Energy efficiency requirements on the average active efficiency which shall not exceed the following limits:

Table 10: Energy efficiency requirements on the average active efficiency proposed in draft revised EU Ecodesign regulation on external power supplies

	AC-AC external power supplies, except low voltage and multiple voltage output external power supplies	AC-DC external power supplies, except low voltage and multiple voltage output external power supplies	Low voltage external power supplies	Multiple voltage output external power supplies
$P_O \leq 1{,}0$ W	$0{,}5 \cdot P_O + 0{,}160$	$0{,}5 \cdot P_O + 0{,}160$	$0{,}517 \cdot P_O + 0{,}087$	$0{,}497 \cdot P_O + 0{,}067$
1 W $< P_O \leq$ 49,0 W	$0{,}071 \cdot \ln(P_O) - 0{,}0014 \cdot P_O + 0{,}67$	$0{,}071 \cdot \ln(P_O) - 0{,}0014 \cdot P_O + 0{,}67$	$0{,}0834 \cdot \ln(P_O) - 0{,}0014 \cdot P_O + 0{,}609$	$0{,}075 \cdot \ln(P_O) + 0{,}561$
$P_O > 49{,}0$ W	0,880	0,880	0,870	0,860

Source: Draft revised Ecodesign Regulation for external power supplies (XX/2019)

4.1.3. Analysis of energy consumption requirements in EU GPP and Ecolabel schemes

Table 11: Energy performance of product

EU GPP	Technical specifications (core) Minimum Energy performance for computers The energy efficiency performance of computers shall meet the energy efficiency requirements of the latest version of the Energy Star standard. The version in force at the time of publication is 6.1 and updates can be followed at this weblink: http://www.eu-energystar.org/specifications.htm Annex III of Directive 2012/27/EU on energy efficiency, requires that computers purchased by central government shall meet the latest EU version of Energy Star.	Technical specifications (Comprehensive): Minimum Energy performance for computers The energy efficiency performance of computers shall meet the energy efficiency requirements of the latest version of the Energy Star standard. The version in force at the time of publication is 6.1 and updates can be followed at this weblink: http://www.eu-energystar.org/specifications.htm Annex III of Directive 2012/27/EU on energy efficiency, requires that computers purchased by central government shall meet the latest EU version of Energy Star.
	Technical specifications (core) Minimum Energy performance of monitors The energy efficiency performance of monitors shall meet the energy efficiency requirements of the latest version of the Energy Star standard. The version in force at the time of publication is 6.0 and updates can be followed at this weblink: http://www.eu-energystar.org/specifications.htm Annex III of Directive 2012/27/EU on energy efficiency, requires that computers purchased by central government shall meet the latest version of Energy Star.	Technical specifications (Comprehensive): Minimum Energy performance of monitors The energy efficiency performance of monitors shall meet the energy efficiency requirements of the latest version of the Energy Star standard. The version in force at the time of publication is 6.0 and updates can be followed at this weblink: http://www.eu-energystar.org/specifications.htm Annex III of Directive 2012/27/EU on energy efficiency, requires that computers purchased by central government shall meet the latest version of Energy Star.
	Award criteria (core) Improvement in the energy consumption upon the specified Energy Star standard It is recommended to use this criterion in conjunction with TS1 for desktop computers if the products specified are for graphics intensive uses. Points will be awarded If the product is more energy efficient than the E_{TEC_MAX} value for computers and the P_{ON_MAX} value for monitors. These shall be calculated in comparison with the minimum performance required under Energy Star (see Criterion TS1 and TS2). A maximum of x points [to be specified] may be awarded. Points shall be awarded in proportion to the improvement in energy efficiency in comparison to the E_{TEC_MAX} or P_{ON_MAX} value: - over 80% lower: x points - 60-79% lower: 0.8x points - 40-59% lower: 0.6x points	Award criteria (comprehensive) Improvement in the energy consumption upon the specified Energy Star standard It is recommended to use this criterion in conjunction with TS1 for desktop computers if the products specified are for graphics intensive uses. Points will be awarded If the product is more energy efficient than the E_{TEC_MAX} value for computers and the P_{ON_MAX} value for monitors. These shall be calculated in comparison with the minimum performance required under Energy Star (see Criterion TS1 and TS2). A maximum of x points [to be specified] may be awarded. Points shall be awarded in proportion to the improvement in energy efficiency in comparison to the E_{TEC_MAX} or P_{ON_MAX} value: - over 80% lower: x points - 60-79% lower: 0.8x points

	- 20-39% lower: 0.4x points - 10-19% lower: 0.2x points Alternatively, instead of using the E_{TEC_MAX} value for computers or the P_{ON_MAX} value for monitors a Life Cycle Costing calculation could be requested, whereby the offered improvement potential would lead to a relative decrease in the overall running costs of a product compared to a less energy efficient model.	- 40-59% lower: 0.6x points - 20-39% lower: 0.4x points - 10-19% lower: 0.2x points For computers with discrete graphic display units the overall points available for criterion A3 shall be awarded in the proportion 60:40. Alternatively, instead of using the E_{TEC_MAX} value for computers or the P_{ON_MAX} value for monitors a Life Cycle Costing calculation could be requested, whereby the offered improvement potential would lead to a relative decrease in the overall running costs of a product compared to a less energy efficient model.
EPEAT Computer & Display (IEEE)	Required: Conformance to current ENERGY STAR program requirements The product shall conform to the energy requirements of the U.S. ENERGY STAR specification in effect based on the type of product being declared to conform to this standard. In addition, if registering in a country where the U.S. or U.S. ENERGY STAR International Partner program requires ENERGY STAR certification, the product shall be ENERGY STAR certified in accordance with that country or region's certification requirements. If the energy requirements of the U.S. ENERGY STAR specification, the U.S. ENERGY STAR certification requirements, or U.S. ENERGY STAR International Partner certification requirements are modified, the product shall conform to the new requirements by their effective date to remain in conformance with this criterion. This criterion is dependent on the requirements, as defined above, imposed by the country or region of registration, and shall be met in all countries where the product is registered. Optional: Product energy consumption less than the Energy Star Maximum energy limit The calculated energy limit for the Representative Model within a Product Performance Category shall be less than the Maximum Energy Limit for that Product Performance Category, as per Table 9, according to the applicable U.S. ENERGY STAR Specification in effect at the time of declaration to this standard. For product families that meet multiple Product Performance Categories, the average calculated energy limit for the Representative Model for all applicable Product Performance Categories shall be less that the average Maximum Energy Limit for all applicable Product Performance Categories. For products that have ENERGY STAR modal power limits, all applicable modal power limits shall meet the percentage requirements as per this criterion. The applicable ENERGY STAR Specification and energy/power limit may differ by product type. If the energy requirements of the applicable U.S. ENERGY STAR specification are modified, the product shall meet the percentage requirements as per this criterion for the new energy limits by the effective date to remain in conformance with this criterion. Applies to: All covered products, excluding workstations. Required: Lowest Power mode limit The product shall have a Lowest Power Mode of ≤ 0.5W for display products and products containing battery cells capable of providing primary power to the product; and Lowest Power Mode of ≤ 1W for all other products, as measured in accordance with the version of IEC 62301, EN 50564 or IEC 62623 (EN 62623) that is current at the time of declaring conformance to this criterion. This criterion shall be declared the same in all countries or regions for which the product is declared to conform to this standard. The approach used to conform to this criterion may vary by country or region. Applies to: All covered products.	
Blue Angel Computers	Computers, as defined in para. 1.5.1 shall meet ENERGY STAR Program Requirements for Computers applicable to the specific type of computer, as amended at the time of application (current version: 6.1).	

TÜV Green Product Mark Computers	Energy efficiency For energy consumptions and power management, the applicant shall provide a report based on Energy Star – Computers. Follow Energy Star published standard and enforcement dates.
TCO Computers	Product & sustainability information: Sustainability Performance / Energy efficiency: Is the product in conformity with ENERGY STAR version 7.0 for computers? --- Product Performance: Energy efficiency (Notebooks, All-in-One PCs, Desktops) The energy efficiency requirements in version 6.1 of ENERGY STAR® program for computers must be fulfilled and verified through testing by a verifier approved by TCO Development or at any test facility accredited according to ISO 17025.

Source: Own compilation according to sources in Table 7

Table 12: Energy efficiency of Internal / External Power Supplies

EPEAT Computer & Display (IEEE)	Optional: Energy efficiency for internal power supplies The internal power supply(ies) used by the product shall meet 80 Plus efficiency levels greater than the minimum efficiency requirements as specified in the U.S. ENERGY STAR specification in effect at the time of declaration to this standard, and as per Table 8. Testing shall be done at 115 V or 230 V by a testing laboratory accredited to ISO 17025, using the EPRI/ecova Generalized Internal Power Supply Efficiency Test Protocol, or a test method with identical testing requirements. The manufacturer shall determine which of the three voltage/frequency level combinations the internal power supply shall be tested at based on product type (reference Additional details). See table 8. Efficiency limits: - One full 80 Plus efficiency level above the minimum efficiency level requirement as specified in the U.S. Energy Star specifications: 1 point - Two full 80 Plus efficiency level above the minimum efficiency level requirement as specified in the U.S. Energy Star specifications: 2 points If the minimum efficiency requirements of the applicable U.S. ENERGY STAR specification are modified, the product shall meet the requirements as per this criterion for the new minimum efficiency requirements by the effective date to remain in conformance with this criterion. A maximum of two optional points may be claimed for this criterion. If the product does not ship with an internal power supply or is not in scope of the referenced test protocol, the manufacturer may declare 'Not Applicable' for this criterion. Applies to: All covered products, excluding displays. --- Optional: Energy efficiency for external power supplies exceeding International External Power Supply Efficiency Level VI The external power supply shipped with the product shall have an efficiency at least 1% greater than International Efficiency Marking Protocol for External Power Supplies Level VI average efficiency levels, for the applicable external power supply product class. For example, if the Level VI average efficiency level is 88%, the threshold to earn the optional point under this criterion is 89%. Products shall be tested at 115 V/60 Hz and/or 230 V/50 Hz in accordance with U.S. DOE External Power Supplies Energy Conservation Standard Final Rule, Federal Register 79, no. 27 (February 10, 2014) testing requirements or test methods with identical testing requirements. Voltage/frequency level shall be determined based on what is appropriate within the country(ies) for which the product is declared conformant. If the product does not ship with an external power supply, the manufacturer may declare 'Not Applicable' for this criterion. Applies to: All covered products.
TÜV Green Product Mark	Energy efficiency

<table>
<tr><td>Computers</td><td>External Power Supply

For external power supply (without cooling fans) energy efficiency, the applicant shall provide a report based on International Efficiency Marking Protocol. The report shall be verified by an independent third-party. The limit is level V.</td></tr>
<tr><td>Blue Angel
Smartphones</td><td>The applicant shall provide a distribution channel for the mobile phone through which the mobile phone is marketed without an external power supply.

State-of-Charge Indicator

The mobile phone must have an integrated charge indicator indicating the current state of battery charge during use and charging. Also, the device must show in a clear manner that the charging has been completed.</td></tr>
<tr><td>TCO
Smartphones</td><td>Energy efficiency – external power supply (applicable to all external power supplies)

The external power supply must meet at least the International Efficiency Protocol requirement for level VI.</td></tr>
<tr><td>TÜV Green
Product
Mobile Phones</td><td>The applicant provides certificate(s) or an accredited test report that shows compliance to the limits of below. TÜV Rheinland reviews the content and the stated limits. Alternatively TÜV Rheinland verify the limits by a retesting a sample product according the requirements as below.

· EC Code of Conduct on Energy Efficiency of External Power Supplies, Version 5, October 29, 2013; or

· U.S. DOE 10 CFR Part 430.32(w) Final Rule, published on Feb. 10, 2014 (Level VI)

Methodology for assessing and demonstrating compliance: For external power supply energy efficiency and no-load power, the applicant shall provide a report based on the above standard. The report shall be verified by an independent third-party.

For universal connector for external power supply output, the applicant shall ensure that external power supplies with an attached DC output cable shall use a Micro-USB connector or external power suppliers with a detachable DC output cable shall use a standard female USB type a connector for charging the phone.</td></tr>
<tr><td>EPEAT
Mobile Phones
(UL 110)</td><td>Required – Battery charger systems

After June 13, 2018, the product shall meet the requirements of the Federal Energy Conservation Standards for Battery Chargers; Final rule (https://www.regulations.gov/document?D=EERE-2008-BT-STD-0005-0256).

Optional – Reduction of energy consumption of battery charging systems

The product shall receive points according to Table 10.1 for demonstrating a reduction in: After June 13, 2018, the Federal Energy Conservation Standards for Battery Chargers; Final Rule (https://www.regulations.gov/document?D=EERE-2008-BT-STD-0005-0256)

Table 10.1
Reduced Levels of Maximum 24 hour Charge and Maintenance Energy (Wh) of Battery Charging Systems

<table><tr><th>Until June 13, 2018
Reduced Levels of Maximum 24 Hour Charge and Maintenance Energy Less Than [12 x N+ 1.6 x Battery Capacity] where N = number of charger ports</th><th>After June 13, 2018
Reduced Unit Energy Consumption (UEC)</th><th>Points Awarded</th></tr><tr><td>10%</td><td>10%</td><td>5</td></tr><tr><td>20%</td><td>20%</td><td>10</td></tr><tr><td>30%</td><td>30%</td><td>15</td></tr></table>
Required – External power supply energy efficiency

The external power supply for the product shall meet the efficiency requirements of the version of the U.S.Department of Energy (DOE) Efficiency Regulations for External Power Supplies for ‘Maximum Power inNo-Load Mode (W)’ for direct EPS in effect at the time the product is declared to conform to this standard.This DOE requirement for direct EPS shall apply to products with both direct and indirect EPSs (http://www.ecfr.gov/cgi-</td></tr>
</table>

<table>
<tr>
<td></td>
<td>bin/textidx?SID=fba80ca090b28fe501e63140182934dc&mc=true&node=pt10.3.430&rgn=div5#se10.3.430_132)

Optional – Reduced maintenance mode power

The external power supply for the product shall exceed the efficiency requirement of the version of the U.S. Department of Energy (DOE) Efficiency Regulations for External Power Supplies for ‘Maximum Power in No-Load Mode (W) for direct EPS that is in effect at the time the product is declared to conform to this criterion, to achieve the points indicated in Table 10.2.

Table 10.2
No-Load Power Consumption Following DOE’s Level VI Efficiency Requirement Implementation

<table>
<tr><th>No-Load Power Consumption</th><th>Points Awarded</th></tr>
<tr><td>At least 20% below the DOE Level VI threshold (> 0.065 W and ≤ 0.08 W)</td><td>6</td></tr>
<tr><td>At least 35% below the DOE Level VI threshold (≤ 0.065 W)</td><td>10</td></tr>
</table>

This DOE requirement (http://www.regulations.gov/#!documentDetail;D=EERE-2008-BT-STD-0005-0219) for direct EPS shall apply to products with both direct and indirect EPSs</td>
</tr>
</table>

Source: Own compilation according to sources in Table 7

Table 13: Information

Blue Angel Mobile Phones	The product documents included with the devices shall include both the technical specifications and the user information relating to environment and health. They shall be either installed on the mobile phone, easily accessible on the Internet or supplied as a data medium or in printed form together with the device. The product documents shall include and manufacturer’s website shall allow easy access to the following basic user information: - Information on the significance and correct interpretation of the state-of-charge indicator - Instructions to disconnect the charger from the mains upon completion of the charging process in order to reduce no-load losses. - Instructions that charging on non-used PCs should be avoided in order to reduce power consumption during charging. - Instructions for using a proper charging unit.

The following tables provide an overview about the number of EPEAT labelled computer and smartphone products fulfilling dedicated optional criteria with regard to energy conservation.[76] It has to be noted, however, that the number of product types indeed is lower due to multiple counts as the database also includes same models marketed in different countries.

Table 14: Number of computer products with EPEAT labelling fulfilling optional criteria with regard to energy conservation

(4.5.1.3) Energy efficiency for internal power supplies	626 (HP, Apple Inc., Teknoservice S.L.)
(4.5.1.4) Energy efficiency for external power supplies exceeding International External Power Supply Efficiency Level VI	950 (HP, Apple Inc., Lenovo, Teknoservice S.L.)
(4.5.1.5) Product energy consumption less than the ENERGY STAR Maximum Energy Limit	1781 (HP, Lenovo, Apple Inc., DELL, ASUSTeK Computer Inc.; Zebratechnologies, Google, EIZO)

Source: Own compilation

Table 15: Number of mobile phone products with EPEAT labelling fulfilling optional criteria with regard to energy conservation

(10.1.2) Reduction of energy consumption of battery charging systems	10 (Samsung, LG Electronics)
(10.1.4) Reduced maintenance mode power	9 (Samsung, LG Electronics)

Source: Own compilation

[76] According to https://epeat.sourcemap.com/?category=pcsdisplays as of 17 July 2019 and https://epeat.sourcemap.com/?category=mobilephone as of September 2019

4.1.4. Voluntary approaches of front-running companies

Reducing the energy consumption and increasing energy efficiency beyond Energy Star requirements is achieved for example through

- **Retina displays**; according to Apple[77], the 11-inch iPad Pro introduced in fall 2018 is 69 percent more efficient than the ENERGY STAR standard. MacBook Air with Retina display consumes three times less power in sleep mode than the previous-generation MacBook Air.
- **Power supply design**; according to Apple, the iMac Pro consumes 40 percent less power during sleep and off mode as result of an innovation in power supply design: compared to a conventional, single-converter power supply design, the iMac Pro incorporates a high-efficiency, dual-converter power supply design. At HP[78], 100% of the business desktops use high-efficiency (ECOVA 80+) internal power supplies. For the HP EliteBook x360 1030 G3, HP Elite x2 1030 G3 Tablet and HP EliteDesk 800 G4 65W Desktop Mini, improvements include using high-efficiency external power supplies. Lenovo certifies internal power supplies to CLEAResult Plug Load Solutions' 80 Plus program for power supply efficiency to further improve product energy efficiency for their desktops, workstations and servers.

  Google's Pixel 3a and 3ª XL smartphones are designed with a power adapter with Level VI efficiency rating.[79] Samsung's smartphone Galaxy Note9 includes a high-efficient charger (charging efficiency 86% / Standby power 0.02W) as well as an Ultra Power Saving mode[80].

  Apple's iPhones 11, 11 Pro and 11 Pro Max consume 40 percent less energy than required by the U.S. Department of Energy Federal Energy Conservation Standards for Battery Chargers.[81]
- More efficient CPUs
- **Smaller form factor of desktops**: According to HP, a shift towards small form factor desktops, contributed to continued reductions in typical energy consumption of their desktops.
- **Reduced disk drive energy intensity** (as a function of capacity): According to Dell[82], in the past years, the disk drive energy intensity could be reduced significantly due to the introduction of new energy efficient spindle-based drives

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[77] See https://www.apple.com/environment/pdf/Apple_Environmental_Responsibility_Report_2019.pdf, page 18

[78] See http://www8.hp.com/h20195/v2/GetPDF.aspx/c06293935.pdf

[79] See http://services.google.com/fh/files/misc/pixel3a_productenvironmentreport.pdf and http://services.google.com/fh/files/misc/pixel3axl_productenvironmentreport.pdf

[80] See https://images.samsung.com/is/content/samsung/p5/global/mkt/pdf/SustainabilityReport2019-en.pdf

[81] See https://www.apple.com/environment/pdf/products/iphone/iPhone_11_Pro_Max_PER_sept2019.pdf, https://www.apple.com/environment/pdf/products/iphone/iPhone_11_Pro_PER_sept2019.pdf, https://www.apple.com/environment/pdf/products/iphone/iPhone_11_PER_sept2019.pdf

[82] See https://corporate.delltechnologies.com/en-us/social-impact/reporting/fy19-csr-report.htm#overlay=/content/dam/delltechnologies/assets/corporate/pdf/progress-made-real-reports/dell-fy19-csr-report.pdf

4.1.5. Summary and conclusions with regard to the revision of EU GPP criteria on energy consumption

Computers and monitors

So far, EU GPP criteria for computers as well as monitors are aligned to each the latest Energy Star requirements, however referring to exact versions in the GPP criteria document (currently, Energy Star v6.1 for computers and v6.0 for monitors).

The analysis of Ecolabel schemes with regard to energy efficiency of computers reveals that all these documents also refer directly to the Energy Star requirements. Whereas most of the labels take the 'latest' version of the Energy Star Program Requirements as basis, partly mentioning that version being in force at the time when the label criteria became effective, TCO makes direct reference to version 6.1 of the Energy Star program requirements for the energy efficiency requirements; in addition, through another information requirement, the applicant shall inform if the product is in conformity with a newer Energy Star version.

The EU GPP approach and the EPEAT label based on the IEEE standard offer different levels of requirements, i.e. comprehensive or award criteria (GPP) or optional criteria (EPEAT) in addition to the basic required criteria. Both schemes have additional criteria for improved energy efficiency beyond the minimum requirements of the Energy Star.

Further, IEEE requires a Lowest Power Mode limit (≤ 0.5W for display products and products containing battery cells capable of providing primary power to the product; and Lowest Power Mode of ≤ 1W for all other products). EU GPP and the other EU labelling schemes do not have such criteria as low power mode levels of computers are covered by EU regulations 1275/2008 and 801/2013 with regard to ecodesign requirements for standby and off mode, and networked standby, electric power consumption of electrical and electronic household and office equipment.

The IEEE standard as well as the TÜV Green Product Mark additionally have requirements for the energy efficiency of the External Power Supply, referring to the International Efficiency Marking Protocol for External Power Supplies[83] which defines different efficiency levels. Whereas for the Green Product Mark, Level V of the International Efficiency Marking Protocol is an obligatory limit for the energy efficiency of the external power supply (without cooling fans), the IEEE standard has an energy efficiency level exceeding the International External Power Supply Efficiency Level VI as optional criteria. It has to be noted, that the current Energy Star Program Requirements for Computers, version 7.1., already requires Level VI or higher performance under the International Efficiency Marking Protocol. EU GPP and the other EU labelling schemes do not have such criteria as efficiency requirements for External Power Supplies placed on the market with computers are covered by EU regulation 278/2009 with regard to ecodesign requirements for no-load condition electric power consumption and average active efficiency of external power supplies[84] (currently under revision) with current efficiency and no-load requirements being equivalent to Level V of the International Efficiency Marking Protocol.

Further, IEEE has optional criteria for the internal power supply(ies) which shall meet '80 PLUS'[85] efficiency levels greater than the minimum efficiency requirements as specified in the U.S. ENERGY STAR specification in effect. Again, EU GPP and the other EU labelling schemes do not have such criteria as energy efficiency requirements for internal power

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[83] See https://www.regulations.gov/document?D=EERE-2008-BT-STD-0005-0218

[84] See https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:093:0003:0010:EN:PDF

[85] 80 Plus is a voluntary certification program intended to promote efficient energy use in computer power supply units (PSUs), see www.80plus.org

supplies are integrated in EU regulation 617/2013 with regard to ecodesign requirements for computers and computer servers[86] (currently under revision).

As the direct reference to Energy Star is outdated due to the termination of the US – EU agreement in Feb18, another approach has to be proposed for the GPP criteria.

For example, the Energy Star criteria refer to IEC 62623:2012. Thus, one solution might be that the GPP criteria refer directly to the IEC standard instead of referring to Energy Star, developing own specific requirements. According to the summary on the IEC website[87], IEC 62623:2012 'Desktop and notebook computers - Measurement of energy consumption' covers personal computing products. It applies to desktop and notebook computers as defined in 4.1 that are marketed as final products and that are hereafter referred to as the equipment under test (EUT) or product. The standard does not set any pass/fail criteria for the EUTs. Users of the test results should define such criteria. This standard specifies:

- a test procedure to enable the measurement of the power and/or energy consumption in each of the EUT's power modes;
- formulas for calculating the typical energy consumption (TEC) for a given period (normally annual);
- a majority profile that should be used with this standard which enables conversion of average power into energy within the TEC formulas;
- a system of categorisation enabling like for like comparisons of energy consumption between EUTs and a pre-defined format for the presentation of results.

Also, the current EU Ecodesign revision processes for computers, electronic displays and external power supplies are of relevance. Ideally, the GPP criteria should be aligned to the foreseen EU Ecodesign approach. For computers, no draft regulatory documents are available so far; close exchange with DG ENER on the timing and content of the revised Ecodesign regulation (and possibly introduction of an Energy label regulation as proposed as one policy scenario in the EU Ecodesign revision study, Task 7) is recommended for the revision of the GPP criteria. For electronic displays, covering computer monitors, and external power supplies, draft regulation documents are available which shall entry into force and apply from 1 April 2020 (Ecodesign regulation for External Power Supplies) and 1 March 2021 (Ecodesign and Energy label regulations for electronic displays). For the minimum energy performance of monitors, EU GPP criteria could for example refer to a certain Energy Efficiency Index / Energy Efficiency Class as minimum requirement (TS Core and Comprehensive) and apply additional points for computer monitors with better Energy Efficiency Classes as award criteria.

According to stakeholder feedback, the awarding of more efficient products via the approach of including the energy consumption into the model for the total cost of ownership (as included in the current core and comprehensive award criteria) could be kept.

Smartphones

For smartphones, current TCO, TÜV and EPEAT ecolabel criteria have requirements on the efficiency of the external power supply unit of smartphones, however, referring to different systems: TCO labelling criteria are referring to the International Efficiency Protocol, TÜV requirements are related either to the EC Code of Conduct on Energy Efficiency of External Power Supplies or to U.S. DOE 10 CFR Part 430.32(w); EPEAT refers to U.S. DOE Efficiency

[86] See https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:175:0013:0033:EN:PDF

[87] https://www.iecee.org/dyn/www/f?p=106:49:0::::FSP_STD_ID:7271

Regulations for External Power Supplies for 'Maximum Power in No-Load Mode (W)' for direct EPS in effect at the time the product is declared to conform to the standard.

Whereas External Power Supplies (EPS) placed on the market with computers and monitors are clearly covered by EU regulation 278/2009 with regard to ecodesign requirements for no-load condition electric power consumption and average active efficiency of external power supplies[88] (currently under revision), it has to be clarified if EPS of smartphones would also fall under the scope of this regulation. Article 2 of regulation 278/2009 states that '*external power supply* means a device which meets all of the following criteria: […](g) it is intended for use with electrical and electronic household and office equipment as referred to in Article 2(1) of Regulation (EC) No 1275/2008'. Article 2(1) refers to the list of energy-using products covered by Annex I of Regulation (EC) 1275/2008 with regard to ecodesign requirements for standby and off mode electric power consumption of electrical and electronic household and office equipment, which includes 'Information technology equipment intended primarily for use in the domestic environment'. However, it is not clear if smartphones would then explicitly fall under this definition.

Thus, it is proposed to set efficiency requirements for External Power Supplies of smartphones in the framework of Green Public Procurement criteria. It is recommended to align to the TCO criteria, i.e. the external power supply should meet at least the International Efficiency Protocol requirement for level VI, which would be exceeding the legal minimum requirements if regulation 278/2009 would apply to EPS of smartphones.

Blue Angel has different criteria for EPS; the requirement with regard to providing a distribution channel for the mobile phone through which the mobile phone is marketed without an external power supply is aimed at resource efficiency by allowing users to procure a device without a new EPS but re-using an existing EPS of the previous smartphone. The requirement with regard to an integrated charge indicator indicating the current state of battery charge during use and charging and an indication if the charging has been completed aims at reducing no-load losses but also enables preserving the battery life. Both reqirements are reasonable and might be applied as comprehensive GPP criteria.

[88] See https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:093:0003:0010:EN:PDF

4.2. Product lifetime extension

4.2.1. Current EU GPP criteria and their application

Application of current EU GPP criteria (feedback stakeholder consultation)

Extending lifetime

Many proposals received in relation to facilitate repair (e.g. avoid soldering of certain parts, use of common tools, etc.). It has also been suggested to have 2nd hand products as first option for less demanding users (e.g. education). Including the provision of a service management was suggested and shifting to DaaS.

Warranty and service agreements

It was highlighted that the mandatory guarantee under B2B is 6 months. Some PPs reported to have applied 36 months warranty as requirement and that suppliers currently provide 3 years of warranty in the Nordic countries. According to some respondent the three year warranty is considered very challenging and not covered by the 30-50 % of the market. 2 years is instead considered reasonable in the EU context. It was remarked by some respondent (Ministry of Environment – Germany) that the mandatory warranty has to explicitly cover battery. Another stakeholder suggested including helpdesk support that would also include software. Extending warranty is considered as something that can be asked to offer and not to be used as award criteria. On the other side, changing to a third party for warranty/service after 2/3 years is also considered a valid option. Many SME's will be able to fulfil this, while they probably cannot respond to the initial tender.

Continued availability of spare parts

This criterion is reported to be applied in public tenders and fulfilled by written guarantee. Most of the time the tenderer do not correspond with the manufacturer, as the contract is carried out by an IT service provider. In this case the tenderer is not the organisation in charge of managing the availability of spare parts and it is suggested to ensure these aspects through the use of labelled products. The three years period is deemed reasonable by several respondents however more ambitious examples are reported in Finland (5 years).

Cost competitiveness of spare parts

It was found to be very difficult to include the cost of the spare parts in the financial model / criteria. Costs of accessories (e.g. power cable, batteries) are included in some tenders (e.g. DIGIT). It has to be considered that in some procurement routes the purchasing entities do not repair the devices themselves and buy spare parts but purchase maintenance services. 'Spare parts are included in the maintenance services and thus their cost is not relevant.' Some manufacturers suggested to remove this criterion as often large companies provide PC as a Service (PCaaS) solutions that offer PC lifecycle services including deployment, security, support and asset recovery. Total cost of ownership in this case needs to be considered (DELL).

Design for reparability

Also this criterion has been applied. TCO Generation 8 label is reported as possible verification method, ensuring a free available manual. The list of critical parts for displays is considered too strict as display panels are difficult to repair (TCO).

Ease of replacement for rechargeable batteries

Also in this case some stakeholders suggested better separating the responsibility of tenderer, service providers and manufacturers. Some stakeholders (DIGIT) commented that this was impossible to adopt as many products have the battery soldered and only to be replaced by a certified technician. Others (German Ministry of environment) have reported to have applied this criterion with success.

Rechargeable battery life and endurance

This criterion is adopted and adapted in tenders according to the respondents. Different thresholds are reported to be applied by different labels (EPEAT 2019 optional criteria is 1000 cycles, > 65% charging capacity; TCO Gen 8 notebooks criteria is 300 cycles with > 60% capacity). Simplification of the testing and verification procedure is also suggested.

Tablet and all in one notebook memory and storage

Respondents consider that this criterion restrict the market (DIGIT). It is also commented that some Operating System require less RAM (2-4 GB).

Notebook durability testing

The approach of the durability testing is generally supported. It is reported to be introduced also by ecolabels as TCO that has set the drop test limit to 45cm after discussions with the industry. Even at this level, TCO reports premium products that are not able to pass this criterion and therefore fail to certify accordingly to TCO Certified.

It is suggested to better specify how to determine if a product passes or fails the test.

Notebook computer drives

Generally this criterion is supported. It is also suggested to use internationally acknowledged standards, so keep criteria similar to AC8, durability requirement verified via MIL standard 810-G.

4.2.2. Legal provisions

4.2.2.1. EU Ecodesign Regulation 617/2013 on computers and computer servers

Current EU Ecodesign regulation 617/2013 with regard to ecodesign requirements for computers and computer servers only indirectly addresses the topic of product lifetime extension via information requirements to be provided by manufacturers: For notebook computers, manufacturers shall provide the minimum number loading cycles that the batteries can withstand as well as the measurement methodology used to determine this information.

The EU Ecodesign regulation and its requirements on computers and computer servers are under revision; the revision study has been finalised in July 2018. No draft regulation was available at the time of the analysis for this report (mid July 2019).

Task 7 report of the revision study[89] provides the following overview of proposals related to product lifetime extension:

[89] https://computerregulationreview.eu/sites/computerregulationreview.eu/files/Preparatory%20study%20on%20review%20computer%20regulation%20-%20Task%207%20VM%2019072018.pdf

Table 16: EU Ecodesign revision study for computers: Proposals (overview) of requirements with regard to product lifetime extension

Potential requirement	Product sub-group		Type of requirement	Focus area
	Mobile	Non-mobile		
External Power Supplies (EPS)	✓	✓	Information in *user manual and on packaging*	Resource savings and waste prevention
Battery lifetime	✓		Battery lifetime optimisation functionality installed and information in *user documentation*	Resource savings, product durability and waste prevention
Liquid spill protection	✓		Information in *user documentation* and *publicly available websites*	Product durability
Computer disassembly	✓	✓	Disassembly features for key components available and described in *technical documentation*	Reparability and reusability
Personal data deletion	✓	✓	Implemented data deletion functionality	

Source: Preparatory study on the Review of Regulation 617/2013 (Lot 3) Computers and Computer Servers, Task 7 report

Proposed requirements (details) related to product lifetime extension according to EU Ecodesign revision study on computers and computer servers, Task 7 report[90].

Table 17: EU Ecodesign revision study for computers: Proposals (details) of requirements with regard to product lifetime extension

Topic	Proposed Ecodesign requirement(s)	Proposed Energy label requirement(s)
External Power Supplies (EPS)	Manufacturers shall inform users in the user manual and publicly available websites on the required power supply specifications (voltage, current and rated output power) of personal computers that use an external power supply. If an external power supply is provided with the personal computer the user manual shall inform the end-users about the possibility to use the contained external power supply with other devices as well as its compatibly according to the external power supply specifications. The user manual shall also notify the type of connector(s) used as interface between the external power supply and the devices. If the external power supply is not provided, the user manual shall inform the end-users about the possibility to use an alternative suitable external power supply, its specifications and type of connector(s) required to interface the external power supply with the device.	A logo shall indicate the presence or absence of the external power supply. The logo shall be included in the energy label and visibly shown on the product information sheet of the personal computer. The same logo and information may be replicated on the packaging.
Battery	Provision of information on battery lifetime: Manufacturers shall test the batteries of mobile personal computers in	The remaining full charge capacity of the battery

[90] https://computerregulationreview.eu/sites/computerregulationreview.eu/files/Preparatory%20study%20on%20review%20computer%20regulation%20-%20Task%207%20VM%2019072018.pdf

Topic	Proposed Ecodesign requirement(s)	Proposed Energy label requirement(s)
lifetime	accordance with the most recent version of the standard EN 61960 and communicate in the user documentation the remaining full charge capacity of the battery compared to the initial charge capacity, after 300 and 500 charge/discharge cycles. Battery optimization built-in functionality: Manufacturers shall provide pre-installed software to enable a limit on the battery state of charge (SoC) when the computer is used systematically in grid operation. Such functionality shall prevent the battery to be loaded at full charge. The manufacturer shall inform the user of the existence and the benefits of using such functionality.	compared to the initial charge capacity after 500 charge/discharge cycles shall be indicated in the product information sheet and in the energy label.
Liquid spill protection	Manufacturers shall inform consumers in user documentation and publicly available websites on the liquid protection class for mobile personal computers, assessed in accordance with the most recent version of the standard EN 60529.	A logo shall indicate the liquid protection class in accordance with the most recent version of the standard IEC 60529. The logo shall be included on the label and the product information sheet of the mobile personal computers with keyboard not detached.
Computer disassembly	Manufacturers shall ensure that the joining or sealing assembly techniques do not prevent the disassembly of the product, making key components available for replacement. The key components are batteries (including stand-by button cells on motherboards, keyboard, trackpad or other pointing devices, data storage, memory, internal power supply units and display panels. Disassembly of computers shall be ensured by including in the technical documentation, available for professional repairers, the exploded diagram of the computer with the location of the key components and the sequence of disassembly operations needed to access and remove them. The diagrams shall include for each of these operations: type of operation, type and number of fastening technique(s) to be unlocked, tool(s) required, warnings if delicate disassembly operations are involved (with the risk of damage of the components), and safety requirements and risks (if any) related to the disassembly operations.	A logo shall be included in the label, the packaging, retailers' websites and product data sheets for all personal computers using battery packs. Three alternative logos should indicate: Logo 1: the batteries of the portable computer can be disassembled and replaced by the user, with or without the use of tools. Instructions on how to disassemble and replace the battery shall be provided in the product information sheet Logo 2: batteries must be replaced by assistance qualified service. The user documentation shall mention 'The battery contained in this product can only be replaced by professionals'. Instructions on how to contact the customer service shall be provided in the product information sheet. Logo 3: batteries cannot be replaced at all.
Personal data deletion	A built-in secure data deletion functionality or software shall be made available to support the deletion of data contained in data storage components (e.g. hard drives and solid state drives) in function of the risks faced and in order to grant the security of personal data and to facilitate the reuse.	

Source: Preparatory study on the Review of Regulation 617/2013 (Lot 3) Computers and Computer Servers, Task 7 report

4.2.2.2. EU Ecodesign Regulation 2019/424 on servers and data storage products

Although EU Ecodesign regulation 2019/494 does not cover product groups being in scope of the EU GPP criteria for computers and monitors, the most recent Ecodesign criteria on computer equipment could nevertheless be guiding also for the revision of the GPP criteria.

Related to product lifetime extension, the EU Ecodesign regulation 2019/424 applies following criteria to servers and online data storage products:

Table 18: EU Ecodesign Regulation 2019/424 on servers and data storage products: Requirements with regard to product lifetime extension

Disassembly for repair or reuse (extraction of key components)	Manufacturers shall ensure that joining, fastening or sealing techniques do not prevent the disassembly for repair or reuse purposed of the following components, when present: - data storage devices; - memory; - processor (CPU); - motherboard; - expansion card / graphic card; - PSU; - chassis; - batteries.
Availability of functionality for secure data deletion	A functionality for secure data deletion shall be made available for the deletion of data contained in all data storage devices of the product. Information on the secure data deletion functionality referred to in the requirements, including instructions on how to use the functionality, the techniques used and the supported secure data deletion standard(s), if any. The requirement on a functionality for secure data deletion could be implemented by means of technical solutions such as, but not limited to, a functionality implemented in firmware, typically in the Basic Input/Output System (BIOS), in software included in a self-contained bootable environment provided in a bootable compact disc, digital versatile disc or universal serial bus memory storage device included with the product, or in software installable in the supported operating systems provided with the product.
Provision of latest available version of firmware	The latest available version of the firmware shall be made available from two years after the placing on the market of the first products of a certain product model for a minimum period of eight years after the placing on the market of the last product of a certain product model, free of charge or at a fair, transparent and non-discriminatory cost. The latest available security update to the firmwares shall be made available from the time a product model is placed on the market until at least eight years after the placing on the market of the last product of a certain product model, free of charge.
Instructions on disassembly operations	The following product information on servers and online data storage products shall be made available from the time a product model is placed on the market until at least eight years after the placing on the market of the last product of a certain product model free of charge by manufacturers, their authorised representatives and importers to third parties dealing with maintenance, repair, reuse, recycling and upgrading of servers (including brokers, spare parts repairers, spare parts providers, recyclers and third party maintenance) upon registration by the interested third party on a website provided: Instructions on the disassembly operations referred to in the requirements,

	including, for each necessary operation and component: (a) the type of operation; (b) the type and number of fastening technique(s) to be unlocked; (c) the tool(s) required.

Source: EU Ecodesign Regulation 2019/424 on servers and data storage products

4.2.2.3. EU Ecodesign Regulation on electronic displays (draft revised)

The draft version of the revised Ecodesign regulation on electronic displays

inter alia applies to computer monitors, whereas electronic displays integrated into computers, such as tablets, laptops or 'all-in-one' desktops should be covered in the review of Regulation 617/2013 on computers.

Related to product lifetime extension, draft revised EU Ecodesign regulation on electronic displays has proposed following criteria:

Table 19: Draft revised EU Ecodesign Regulation on electronic displays: Requirements with regard to product lifetime extension

Availability of spare parts	(1) Manufacturers, importers or authorised representatives of electronic displays shall make available to professional repairers at least the following spare parts: internal power supply, connectors to connect external equipment (cable, antenna, USB, DVD and Blue-Ray), capacitors, batteries and accumulators, DVD/Blue-Ray module if applicable and HD/SSD module if applicable for a minimum period of seven years after placing the last unit of the model on the market; (2) Manufacturers, importers or authorised representatives of electronic displays shall make available to professional repairers and end-users at least the following spare parts: external power supply and remote control for a minimum period of seven years after placing the last unit of the model on the market; (3) Manufacturers shall ensure that these spare parts can be replaced with the use of commonly available tools and without permanent damage to the appliance; (4) The list of spare parts concerned by point 1 and the procedure for ordering them shall be publicly available on the free access website of the manufacturer, importer or authorised representative, at the latest two years after the placing on the market of the first unit of a model and until the end of the period of availability of these spare parts; and (5) The list of spare parts concerned by point 2 and the procedure for ordering them and the repair instructions shall be publicly available on the manufacturer's, the importer's or authorised representative's free access website, at the moment of the placing on the market of the first unit of a model and until the end of the period of availability of these spare parts.
Access to repair and maintenance information	After a period of two years after the placing on the market of the first unit of a model or of an equivalent model, and until the end of the period mentioned under the requirements 'Availability of spare parts', the manufacturer, importer or authorised representative shall provide access to the appliance repair and maintenance information to professional repairers in the following conditions: (1) The manufacturer's, importer's or authorised representative's website shall indicate the process for professional repairers to register for access to information; to accept such a request, manufacturers, importers or authorised representative may require the professional repairer to demonstrate that:

	(i) The professional repairer has the technical competence to repair electronic displays and complies with the applicable regulations for repairers of electrical equipment in the Member States where it operates. Reference to an official registration system as professional repairer, where such system exists in the Member States concerned, shall be accepted as proof of compliance with this point; (ii)the professional repairer is covered by insurance covering liabilities resulting from its activity, regardless of whether this is required by the Member State; (2) The manufacturers, importers or authorised representatives shall accept or refuse the registration within 5 working days from the date of request by the professional repairer; (3) Manufacturers, importers or authorised representatives may charge reasonable and proportionate fees for access to the repair and maintenance information or for receiving regular updates. A fee is reasonable if it does not discourage access by failing to take into account the extent to which the professional repairer uses the information; Once registered, a professional repairer shall have access, within one working day after requesting it, to the requested repair and maintenance information. The available repair and maintenance information shall include: –the unequivocal appliance identification; –a disassembly map or exploded view; –list of necessary repair and test equipment; –component and diagnosis information (such as minimum and maximum theoretical values for measurements); –wiring and connection diagrams; –diagnostic fault and error codes (including manufacturer-specific codes, where applicable); and –data records of reported failure incidents stored on the electronic display (where applicable).
Maximum delivery time of spare parts	(1) During the period mentioned under point (1) and point (2) of the requirement on 'Spart part availability', the manufacturer, importer or authorised representatives shall ensure the delivery of the spare parts for electronic displays within 15 working days after having received the order; (2) In the case of spare parts available only to professional repairers, this availability may be limited to professional repairers registered in accordance with the requirements on 'Access to repair and maintenance information'.
Information availability	The product manufacturer, importer or authorised representative shall make available the information set out below when placing on the market the first unit of a model or of an equivalent model. The information shall be provided free of charge to third parties dealing with professional repair and reuse of electronic displays (including third party maintenance actors, brokers and spare parts providers). 1. Availability of software and firmware updates (a) The latest available version of 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, free of charge or at a fair, transparent and non-discriminatory cost. The latest available security update to the firmware shall be made available until at least eight years after the placing on the market of the last product of a certain product model, free of charge. (b) Information on the minimum guaranteed availability of software and firmware updates, availability of spare parts and product support shall be indicated in the product information sheet as from Annex V of Commission Delegated Regulation (EU) 2019/XXX [i.e. the accompanying Energy Labelling Regulation on electronic displays]

Source: Draft revised EU Ecodesign Regulation on electronic displays

4.2.2.4. EU Energy label Regulation on electronic displays (delegated act adopted)

According to the revised delegated regulation of 11.3.2019 with regard to energy labelling of electronic displays and repealing Commission Delegated Regulation (EU) No 1062/2010 which shall apply from 1 March 2021[91], the supplier shall enter into the product database the following information related to product lifetime extension:

- Minimum guaranteed availability of software and firmware updates (until) => GG MM AAAA
- Minimum guaranteed availability of spare parts (until) => GG MM AAAA
- Minimum guaranteed product support (until) => GG MM AAAA date

[91] See https://webgate.ec.europa.eu/regdel/#/delegatedActs/982

4.2.3. Analysis of product lifetime extension requirements in EU GPP and Ecolabel schemes

Table 20: Analysis of EU GPP and ecolabel schemes: Criteria on warranties

EU GPP	Technical specifications Minimum two-year (core) / three-year (comprehensive) warranty effective from delivery of the product. Covering repair or replacement and including a service agreement with options for pick-up and return or on-site repairs. The warranty shall guarantee that the products are in conformity with the contract specifications at no additional cost. This shall cover battery defects.
	Award criteria Additional points shall be awarded to each additional year of warranty and service agreement offered that is more than the minimum technical specification. This shall be awarded Core: A maximum of x points [to be specified] may be awarded. +4 years or more: x points +3 years: 0.75x points +2 years: 0.5x points +1 year: 0.25x points --- Comprehensive: A maximum of x points [to be specified] may be awarded. +3 years or more: x points +2 years : 0.6x points +1 year: 0.3x points For portable devices 0.3x additional points shall also be awarded where during the first three years of the warranty, rechargeable battery replacement is provided free of charge in the case of a capacity loss of more than 50%. The contracting authority may wish to specify the battery life benchmarking software that shall be used to evaluate the loss of battery life.
TCO Smartphones	The brand owner must provide a product warranty for at least one year, covering all markets where the product is sold. Background: By extending product lifetime, natural resources are used more efficiently and the pollution to air and water is reduced. A precondition for an extended product lifetime is that the product is of high quality. A product warranty provides the brand owner with an economic incentive to design a durable product that lasts longer
Blue Angel Mobile Phones	The applicant undertakes to offer a free minimum 2-year warranty on the mobile phone, except for the batteries. In addition, the applicant shall offer a free minimum 1-warranty on the battery which covers a remaining capacity of at least 90%, provided that the phone is properly used and charged with the manufacturer's own or another suitable charging device. The product documents shall provide details of such warranties.

Source: Own compilation according to sources in Table 7

Table 21: Analysis of EU GPP and ecolabel schemes: Criteria on availability / cost competitiveness of spare parts

EU GPP	Technical specifications (core) The tenderer shall guarantee the availability of spare parts, including as a minimum those identified in criterion TS5(b), see below, for at least three years from the date of purchase. Computers (i) HDD/SSD, (ii) Memory, (iii) Rechargeable battery, Displays (i) Screen assembly and LCD backlight (ii) Power and control circuit boards (iii) Stands (excluding those integrated with the enclosure)	Technical specifications (Comprehensive): The tenderer shall guarantee the availability of spare parts, including as a minimum those identified in criterion TS6(b), see below, for at least five years from the date of purchase. Computers (i) HDD/SSD, (ii) Memory, (iii) Rechargeable battery, (iv) Screen assembly and LCD backlight, (v) Keyboard and mouse pad, Displays (i) Screen assembly and LCD backlight (ii) Power and control circuit boards (iii) Stands (excluding those integrated with the enclosure) Compatible parts with improved capacity or performance, where relevant, shall be made available.
	Award criteria (core) The tenderer shall provide a price list for, as a minimum, the following component parts: Computers (i) HDD/SSD, (ii) Memory, (iii) Rechargeable battery, Displays (i) Screen assembly and LCD backlight (ii) Power and control circuit boards (iii) Stands (excluding those integrated with the enclosure) For the component parts listed above indicative labour costs for replacements carried out by the tenderer's authorised service providers shall be provided. Points shall be awarded according to the most cost-competitive offers. Additional component parts, if considered important to the price comparison, should be added to the list provided.	Award criteria (comprehensive) The tenderer shall provide a price list for, as a minimum, the following component parts: Computers (i) HDD/SSD, (ii) Memory, (iii) Rechargeable battery, (iv) Screen assembly and LCD backlight, (v) Keyboard and mouse pad, Displays (i) Screen assembly and LCD backlight (ii) Power and control circuit boards (iii) Stands (excluding those integrated with the enclosure) For the component parts listed above indicative labour costs for replacements carried out by the tenderer's authorised service providers shall be provided. Points shall be awarded according to the most cost-competitive offers. Additional component parts, if considered important to the price comparison, should be added to the list provided.
EPEAT Computer & Display (IEEE)	Required: Manufacturer shall declare if spare parts are available for use in the repair of the product, and if available, the length of time the spare parts are available after the end of production. If spare parts are available, the following information shall be made available to 1) non-institutional purchasers of the product; 2) institutional purchasers of the products; 3)	

	manufacturer authorized service providers; and 4) third party repair providers: - A list of the spare parts that are available by category, type, name, or part number (e.g., the manufacturer provides the link to a website, which may or may not require a login or application). - The length of time that spare parts are declared to be available after the end of production. - Where party(ies) can find information on how to obtain spare parts; or, at the manufacturer's option, compatible spare parts from a different supplier. (e.g., the manufacturer can provide the link to a website).
Blue Angel Computers	The applicant undertakes to make sure that the availability of spare parts for appliance repair is guaranteed for at least 5 years from the time that production ceases. Especially batteries/accumulators, (if any) must be available for at least 5 years following the end of production. The spare parts must be offered at reasonable cost by the manufacturer itself or a by third party. Spare parts are functionally identical or compatible and functionally improved components or modules that may be exchanged during repair in the course of the life-cycle of a computer or keyboard to replace defect parts. Other parts which normally exceed the life of the product are not to be considered as spare parts. The product documents shall include detailed information on the provision of spare parts.
TÜV Green Product Mark Computers	Upgradability / Capability Enhancement Options: The applicant shall design products to ensure that they can meet the requirement of Reparation and Warranty of spare parts. Methodology for assessing and demonstrating compliance: The brand owner shall ensure that the spare parts are available for 3 years. (Self-declaration is checked).
TCO Computers / TCO Smartphones	Product lifetime extension: Replaceable components Mandate: The brand owner must guarantee that, during the validity of the certificate, all critical replaceable components for the product type, that are listed in the clarifications (see below) of this criterion - are available for anyone to purchase or - may be replaced by a service network for repair and maintenance of the certified product on all markets where it is sold. The critical replaceable components for each product type are listed below: - Notebooks: Battery. Display Panel/Display assembly, Storage (SSD, HDD, RAM), External/internal PSU, Keyboard, System/motherboard - Desktops: CPU, GPU (PCIe), External/internal PSU, Storage (SSD, HDD, ODD, RAM), System/motherboard - All-in-One PCs: External/internal PSU, Storage (SSD, HDD, ODD, RAM), System/motherboard - Tablets: Battery, Display Panel / Display assembly, External/internal PSU - Displays: Connectivity cables, Power cables, External PSU - Smartphones: Battery, Display / Display assembly, Charger The critical replaceable components listed in the clarification need only be made available if they are part of the certified product.
Blue Angel Mobile Phones	The applicant undertakes to make sure that the availability of spare parts for device repair is guaranteed for at least 3 years from the time that production ceases. Spare parts shall be offered at reasonable prices by the manufacturer itself or a by third party. Spare parts are 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. The mobile phones shall be so designed as to enable qualified specialist workshops to replace such spare parts with reasonable effort. The product documents shall provide information on spare parts supply and repair services.
TÜV Green Product Mark Mobile Phones	The applicant shall declare that the spare parts are available for 3 years after end of production. The spare parts are: battery, external power supply, headphones, cables, LCD

	and enclosure.
EPEAT Mobile Phones (UL 110)	Required – Availability of replacement parts The manufacturer shall publicly document on their website that replacement of parts or product service is made available for a minimum of three years after end of production of the mobile phone.

Source: Own compilation according to sources in Table 7

Table 22: Analysis of EU GPP and ecolabel schemes: Criteria on design for reparability

EU GPP	Technical specifications (core) The following parts, if applicable, shall be easily accessible and replaceable by the use of universally available tools (i.e. screwdriver, spatula, plier or tweezers): Computers (i) HDD/SSD, (ii) Memory, (iii) Rechargeable battery, Displays (i) Screen assembly and LCD backlight (ii) Power and control circuit boards (iii) Stands (excluding those integrated with the enclosure) Tablets and two-in-one notebooks shall be exempt for computer parts (i) and (ii). For these products award criterion C7 shall be used to encourage better design. The tenderer shall provide clear disassembly and repair instructions (e.g. hard or electronic copy, video) to enable a non-destructive disassembly of products for the purpose of replacing key components or parts for upgrades or repairs. This shall be made available in hard copy or via the manufacturer's webpage.	Technical specifications (comprehensive): The following parts, if applicable, shall be easily accessible and replaceable using universally available tools (i.e. screwdriver, spatula, plier or tweezers): Computers (i) HDD/SSD, (ii) Memory, (iii) Rechargeable battery, (iv) Screen assembly and LCD backlight, (v) Keyboard and mouse pad, Displays (i) Screen assembly and LCD backlight (ii) Power and control circuit boards (iii) Stands (excluding those integrated with the enclosure) Tablets and two-in-one notebooks shall be exempt for computer parts (i) and (ii). Award criterion C7 shall be used to encourage better design. The tenderer shall provide clear disassembly and repair instructions (e.g. hard or electronic copy, video) to enable a non-destructive disassembly of products for the purpose of replacing key components or parts for upgrades or repairs. This shall be made available in hard copy or the manufacturer's webpage.
EPEAT Computer & Display (IEEE)	Optional: Product upgradeability and reparability The product shall include a minimum number of product upgrade or repair features available after purchase of the product. Optional points shall be awarded as defined in Table 7 of the standard document, and based upon the number of features contained in the product that are upgradeable, repairable or replaceable in the product from the following list: - The main processor(s) or system on a chip (SOC); 'main' as determined by the manufacturer - The main memory capacity of the system; 'main' as determined by the manufacturer - The mass storage capacity of the system - Wireless networking capability - Graphics capability (integrated or discrete) - The display panel or display assembly; it is acceptable for the outer glass or other external	

	transparent protective layer to be attached to the display panel - Integrated mechanical keyboards - All batteries; this feature may be claimed if the product does not include batteries - All external and internal power supplies - All fan assemblies; this feature may be claimed if the product does not include fans or other thermal solutions - At least two out of the following categories (or one, if all remaining components are absent from the product): 1) speakers, 2) camera, 3) touchpad, 4) I/O connectors and external power connection, and 5) readers (e.g., magnetic stripe, Dallas key, fingerprint, Smart card) Manufacturer shall provide purchasers with a list of the hardware features on the above list that are upgradeable, repairable or replaceable, and indicate, for each, whether it is upgradeable, repairable and/or replaceable. The upgrade, repair or replacement may be achieved by way of addressing the component, or the next level up assembly to which it is attached. See table 7, minimum number of hardware features for different product types that are either upgradeable, repairable, replaceable without soldering or de-soldering and using only commonly available tools, or features for which the manufacturer, authorized service providers or other service providers offer upgrades, repair or replacement to purchasers for 5 years after the point of sale. The upgrade, repair or replacement feature shall be achievable in the product without performing a product exchange. --- Required: External enclosure(s) shall be removable with the use of commonly available tools. Removal of external enclosures shall not cause damage that would preclude reuse or refurbishment of the product.
TCO Computers / TCO Smartphones	Product & sustainability information: Replacable components Is is possible to replace all of the critical parts listed in the ‘Replaceable components’ criteria (6.2), 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)? --- Product lifetime extension: Replaceable components Mandate: The brand owner must provide a service manual describing how to replace at least all critical replaceable components. The service manual must be available online for anyone to read, free of charge. The brand owner must guarantee that, during the validity of the certificate, all critical replaceable components for the product type, that are listed in the clarifications of this criterion; - are available for anyone to purchase or - may be replaced by a service network for repair and maintenance of the certified product on all markets where it is sold. Clarification: Replaceable parts management - The brand owner must provide a service manual including step by step instructions and component descriptions for the disassembly/assembly. External PSU, charger and AC Adapters are exempted from the disassembly instructions. - A critical replaceable component must be possible to replace with an equivalent component. However, the replacement component does not have to be identical to the original component. - Instructions on how to replace the critical components must be available online throughout the whole lifetime of the certificate. - Onboard soldered CPUs are excluded from the critical component list. The critical replaceable components for each product type are listed below: - Notebooks: Battery. Display Panel/Display assembly, Storage (SSD, HDD, RAM), External/internal PSU, Keyboard, System/motherboard

	- Desktops: CPU, GPU (PCIe), External/internal PSU, Storage (SSD, HDD, ODD, RAM), System/motherboard - All-in-One PCs: External/internal PSU, Storage (SSD, HDD, ODD, RAM), System/motherboard - Tablets: Battery, Display Panel / Display assembly, External/internal PSU - Displays: Connectivity cables, Power cables, External PSU - Smartphones: Battery, Display Panel/Display assembly, Charger The critical replaceable components listed in the clarification need only be made available if they are part of the certified product.
TÜV Green Product Mark Mobile Phones	User Guide Information: Information shall be publicly available and shall contain the following information so far as applicable: - Repairability information See also section 4.3.3, Criteria on recyclability of products, structure / joining techniques, dismantling
EPEAT Mobile Phones (UL 110)	Required – Ease of disassembling mobile phone Screws, snaps, latches, or other joining or sealing technique in the housing of the mobile phone shall be removable, detachable, or the attached parts separable with the use of standard torx, phillips, blade drivers, or non-proprietary tools, to allow access to the display assembly, primary circuit board, and battery that can provide primary power by a qualified repair service provider or authorized repair provider without causing functional damage that would preclude re-use or refurbishment of the mobile phone. Exemption: An instance where an adhesive tape is used for electromagnetic compatibility (EMC) compliance does not fall under the requirements of this criterion. --- Optional – Further ease of disassembling mobile phone Additional following points shall be awarded: a) If the product utilizes the same screw head design and size to remove every part required to remove the display assembly and primary circuit board. b) If the product utilizes the same screw head design and size to remove every part required to remove batteries --- Required – Repair and refurbishment The manufacturer shall meet one of the following options. The options selected in this criterion may be declared differently in each country or region for which the product is declared to conform to this standard. Option 1: The manufacturer shall provide the following repair and disassembly information that contains a sufficient amount of detail to perform the tasks identified in the documentation online for use by qualified repair service providers: applicable documentation required for repair or disassembly of the mobile phone, which may include one or more of the following: step-by-step disassembly instructions with required tools, exploded diagram of parts and compatibility chart or other indication of which parts apply to the mobile device (if needed); product specifications; maintenance procedures; or troubleshooting information. This documentation shall be available in one or more of the following formats: Adobe PDF, or HTML, or IEEE 1874:2013 ″oManual″. OR Option 2: The manufacturer shall commit to making field replaceable service parts, and the manuals and diagnostic tools required to replace those parts, available under fair and reasonable terms within 90 days of the product release to qualified repair service providers. The manufacturer shall select or develop and disclose a publicly available program administered by a third party (e.g. CompTIA Mobility+, CompTIA A+) to which qualified repair service providers can become qualified to repair their mobile phones. Service manuals shall be available as HTML or IEEE 1874:2013 ‘oManual’, and licensed under the Creative Commons (CC-BY 4.0 or compatible license).

	OR Option 3: One or more authorized repair providers shall be available for services including: troubleshooting, repair, and (if applicable) replacement of the product. The manufacturer shall publicly communicate a means to send or bring the product for such services. --- Optional – Further repair and refurbishment The manufacturer complies with at least 2 options of the criterion above.

Source: Own compilation according to sources in Table 7

Table 23: Analysis of EU GPP and ecolabel schemes: Criteria on battery replaceability

EU GPP	Technical specifications (core): Ease of replacement for rechargeable batteries Rechargeable batteries shall not be glued or soldered into portable products. It shall be possible for a professional user or repair service provider to replace the rechargeable battery. Instructions on how the rechargeable battery packs are to be removed shall be provided in the user instructions or via the manufacturer's webpage.	Technical specifications (comprehensive): Ease of replacement for rechargeable batteries Rechargeable batteries shall not be glued or soldered into portable products. It shall be possible for a professional user or repair service provider to replace the rechargeable battery. If the rechargeable battery has a performance of less than 800 endurance cycles when tested according to IEC EN 61960, it shall be possible to extract it from the product according to the following requirements : - For notebooks and portable all-in-one computers manually without tools; - For sub-notebooks in a maximum of three steps using a screwdriver; - For tablets and two-in-one notebooks in a maximum of four steps using a screwdriver and spudger; Instructions on how the rechargeable battery packs are to be removed shall be provided in the user instructions or via the manufacturer's webpage.
EPEAT Computer & Display (IEEE)	Required: Battery replacement and information: The battery(ies) that provide primary power to the product shall be replaceable for the duration that the product is declared to conform to the standard. The manufacturer shall disclose to the purchaser on the manufacturer's website and/or in printed form the following information: Removal of lithium-ion batteries - Statement that the product's batteries are replaceable. - How to obtain and replace the battery, irrespective of whether the product is out of warranty. This guidance may take the form of a phone number to call or URL to visit in order to obtain detailed information. It is not required for the batteries to be user-replaceable; the manufacturer-provided instructions may instead guide customers to have a battery(ies) replaced at a manufacturer-authorized service center. If the product contains a battery(ies) that is designed to be user-replaceable, the manufacturer may demonstrate how to obtain the battery(ies) by directing the user to purchase the battery from a third party, or as an off-the-shelf batteries(ies) (e.g., such as AA alkaline cell batteries). If the product does not contain batteries, the manufacturer may declare 'Not Applicable.' Verification requirements: list of lithium ion battery(ies) in the product; documentation or demonstration (e.g. video, recycler statement etc.) that the battery(ies) can be removed as per the requirement of the criterion.	

	Optional: Removal of lithium-ion batteries Lithium ion battery(ies) in the product shall be easily removable from the product without the use of external heat sources, with no tools or with commonly available tools, and without damage that would preclude reuse or refurbishment of the product. Easily removable means that one person can remove the battery, starting from the point of addressing the battery attachment, in less than three minutes following the manufacturer's instructions as per required criterion 4.3.1.1. (Identification of materials and components requiring selective treatment) If the product does not contain lithium ion batteries, the manufacturer may declare 'Not Applicable.'
Blue Angel Computers	Special requirements for notebook computers: Replaceability: The computers shall be designed to allow the easy replacement of the batteries/accumulators without the need for expert knowledge.
TÜV Green Product Mark Computers	Battery replacement and information The battery(ies) that provide primary power to the product shall be replaceable. The applicant shall disclose on the website and/or in printed form the following information: - Statement that the product's batteries are replaceable. - How to obtain and replace the battery, irrespective of whether the product is out of warranty. This guidance may take the form of a phone number to call or URL to visit in order to obtain detailed information. It is not required for the batteries to be user-replaceable; the manufacturer-provided instructions may instead guide customers to have a battery(ies) replaced at a manufacturer-authorized service center. If the product contains a battery(ies) that is designed to be user-replaceable, the manufacturer may demonstrate how to obtain the battery(ies) by directing the user to purchase the battery from a third party, or as an off-the-shelf batteries. Methodology for assessing and demonstrating compliance: a) if the battery(ies) is user replaceable, demonstration thet the batteries are replaceable (e.g. disassembly / assembly steps for replacing the battery(ies) in accordance with the requirements of this criterion; b) for batteries that are not user replaceable, documentation of manufacturer-provided instructions guiding consumers to have a battery(ies) replaced at a manufacturer-authorized service center; c) manufacturer disclosure that meets the requirements of the criterion.
TCO Computers / TCO Smartphones	Sustainability Performance Indicators: Is the main battery of the product replaceable without tools? If yes, then the following proof must be confirmed by an approved verifier: Documentation proving that the sustainability performance indicator is fulfilled. Product lifetime extension: Battery replaceability (Applicable to notebooks, smartphones and tablets) The brand owner must guarantee that the main battery is replaceable by the end-user and/or technician. Instructions on how to replace the battery must be available for anyone to read, free of charge online throughout the whole lifetime of the certificate. Submit the following to an approved verifier: ● A link to instructions on the brand owner website or a pdf of the material that will be published there during the validity of the certificate ● A completed and signed product form Submit the following together with the application to TCO Development: A copy of the verification report(s) from a verifier approved by TCO Development.
Blue Angel Mobile Phones	Replaceability of the Battery The mobile phone shall be designed so as to allow the user to replace the rechargeable battery without special expert knowledge and without damaging the telephone. The rechargeable battery (hereinafter called battery or secondary battery) means a secondary cell designed to repeatedly restore its charge state using a special purpose power supply

	(charging electronics) i.e. it can be recharged. The battery includes one or more cells coupled together by a housing, plastic film or in other suitable form. It may comprise electronic control units and is equipped with connecting terminals or a connecting cable. (Secondary) batteries are also called accumulators, secondary cells, accumulator packs, electrochemical energy storage systems or rechargeable batteries.
EPEAT Mobile Phones (UL 110)	Required – Battery removability/replacement by qualified repair service providers or authorized repair providers All rechargeable batteries that can provide primary power shall be removable and replaceable by qualified repair service providers or authorized repair providers with the use of non-proprietary tools or without the use of any tools and without functional damage that would preclude re-use or refurbishment of the mobile phone. The instructions showing how the batteries can be removed shall be made available to qualified repair service providers or authorized repair providers, upon request. The manufacturer shall provide information on how to recycle used batteries in electronic or printed format, or on the battery. The instructions showing how the batteries can be removed shall also specify who (e.g. end-users, service centers, waste treatment facilities, etc.), in the view of the manufacturer, are the appropriate parties to remove the battery. Optional – Battery removability instructions Removal of embedded rechargeable batteries that can provide primary power by qualified repair service providers and authorized repair providers shall be achievable without the use of tools for removal of the battery alone (i.e. use of tools to get to the battery is acceptable). Information on how to obtain removal instructions in accordance with 11.3.1 (see required criterion above) shall be posted on the manufacturer's website. Optional – Battery removability/replacement without use of tools All rechargeable batteries that can provide primary power shall be removable and replaceable by the user without the use of any tools and without functional damage that would preclude re-use or refurbishment of the mobile phone. Information on how to obtain the instructions specified in 11.3.1 ((see required criterion above) applicable for user removable batteries (without the use of any tools) shall be one of the following: a) Provided with the product; or b) Publicly available on the manufacturer's website.

Source: Own compilation according to sources in Table 7

Table 24: Analysis of EU GPP and ecolabel schemes: Criteria on rechargeable battery life and endurance

EU GPP	Award criteria (core) Points shall be awarded for improved endurance greater than 300 cycles (with 80% capacity retention) respectively. A maximum of x points [to be specified] may be awarded. - 1000 cycles or more: x points - 800 cycles or more : 0.75x points - 500 cycles or more: 0.5x points - Up to 499 cycles: 0.25x points The minimum battery life in hours shall be set according to the Contracting Authority's requirements.	Award criteria (comprehensive) Points shall be awarded for improved endurance greater than 500 cycles (with 80% capacity retention) respectively16. A maximum of x points [to be specified] may be awarded. - 1000 cycles or more: x points - 800 cycles or more : 0.6x points - Up to 799 cycles: 0.3x points The minimum battery life in hours shall be set according to the Contracting Authority's requirements.

	Verification: The tenderer shall provide a test report for the battery cells or packs showing compliance according to the IEC EN 61960 'endurance in cycles' test carried out at 25°C and at a rate of either 0.2 It A or 0.5 It A (accelerated test procedure). Partial charging may be used to comply as long as the software is factory-installed as the default setting and the tender requirements on battery life are met at the partial changing level complying with the cycle requirement.	Verification: The tenderer shall provide a test report for the battery cells or packs showing compliance according to the IEC EN 61960 'endurance in cycles' test carried out at 25°C and at a rate of either 0.2 It A or 0.5 It A (accelerated test procedure). Partial charging may be used to comply as long as the software is factory-installed as the default setting and the tender requirements on battery life are met at the partial changing level complying with the cycle requirement.
EPEAT Computer & Display (IEEE)	Optional: Long life recharcheable battery The product shall contain a long life rechargeable battery. A long life rechargeable battery is a battery pack, including the battery cell(s), an enclosure and control circuitry, that is capable of providing primary power, and when tested in accordance with IEC 61960, is chargeable to > 65% of its original design capacity after 1000 cycles. A battery that is tested to a shorter cycle count with a greater capacity, e.g., 80% capacity after 300 cycles, does not meet the requirements of this criterion. The IEC 61960 test parameters and definitions (for cycle, C, and ambient temperature) shall be modified as below when demonstrating that the performance of a rechargeable battery meets the requirements of this criterion: a) Charge battery from a fully discharged condition to charge completion, either: 1) At a rate of not less than 0.5C using constant current (CC) and constant voltage (CV), or CC/CV mode, as follows: i) Initial charge shall be CC, from a fully discharged state to the charge voltage limit defined by the product manufacturer to be either: i) The maximum single cell charge voltage for single cells, or ii) The maximum pack charge voltage for the battery pack. ii) Subsequent CV charge shall be no more than the voltage applicable to (a)(1) above, and shall be terminated when the current drops below a rate of C/40. 2) Using an alternate charging profile that is representative of the charging profile of the product. b) Discharge battery with a constant current of > 0.2C, to the voltage cutoff limit defined by the manufacturer to be 100% depth of discharge. c) Rest periods after charge and discharge are allowed. If the product does not contain a rechargeable lithium ion or lithium polymer battery that can provide primary power, the manufacturer may declare 'Not Applicable.'	
Blue Angel Computers	Special requirements for notebook computers: Battery / Accumulator Capacity: The battery/accumulator capacity shall be measured in accordance with standard EN 61960, as amended (current version: DIN EN 61960:2012-04), in accordance with standard paragraph 7.3.1 'Discharge performance at 20 °C (rated capacity)'. The rated capacity (C), thus determined, must at least be equal to the nominal capacity (N) indicated on the battery/accumulator and in the product documents. --- Special requirements for notebook computers: Battery / Accumulator Durability The battery/accumulator must achieve a minimum of 500 full charge cycles. A full charge cycle is to be understood as the drain of a quantity of electricity (in ampere hours) from the battery/accumulator in the amount of its nominal capacity (N) that has been stored in the battery/accumulator by one or more charging processes. The minimum number of full charge cycles achievable shall be specified in the product documents. After 500 full-charge cycles the battery/accumulator must, in addition, have in a fully charged state, a remaining capacity (QRem) of at least 80% of the nominal capacity (N).	

	QRem ≥ 80% * N Full charge cycles shall be calculated and remaining capacity shall be measured in accordance with the requirements set out in Appendix A of the Blue Angel criteria document: Determination of Battery/Accumulator Durability. --- Special requirements for notebook computers: Battery/Accumulator Status and Protection Software The applicant shall make the following software tools available for the computer: • Software for Determining the Battery/Accumulator Status: The software must allow the reading of the battery's/accumulator's 'state of health' (defined as the ratio of 'full charge capacity' to 'design capacity' according to Smart Battery System Specifications20), 'state of charge' (according to Smart Battery System Specifications) as well as the number of full charge cycles already performed from the battery/accumulator and to display these data for the user. Provided that the battery/accumulator (or battery/accumulator pack) does not have integrated electronics to record these data the computer itself must be equipped with corresponding electronics. The software must access the corresponding electronics and be capable of reading the battery/accumulator status data. The electronics must, if applicable, detect a battery/accumulator replacement and take it into account when giving the number of full charge cycles. • Battery/Accumulator Protection Software: The software shall be able to limit the battery's/accumulator's charge to a value smaller than the maximum amount of usable electricity (e.g. 80% of the full charge capacity). Doing so will extend the battery's/accumulator's life. The applicant shall - from the date of placing the computer on the market or, at least, from the date of filing the application until, at least, 6 years after production ceases - make these software tools available for free-of-charge download on its website as well as inform about these tools in the computer product documents. Provided that the computer is placed on the market with a pre-installed operating system the software tools described above-described must also be pre-installed on the computer.
Nordic Ecolabelling	Battery capacity The battery capacity must be measured in accordance with paragraph 7.3 'Discharge performance at 20°C (rated capacity)' of IEC 61960-3:2017. The rated capacity (C) thus determined must be at least as high as the nominal capacity (N) indicated on the battery and in the product documents. The test must be carried out on a minimum of three batteries, in accordance with the sample size specified in IEC 61960-3:2017. All three tested batteries/cells must meet the requirements. --- Endurance in cycles The battery or cell must be tested in accordance with paragraph 7.6 'Endurance in cycles' of IEC 61960-3:2017. The test must be carried out on a minimum of three batteries, in accordance with the sample size specified in IEC 61960-3:2017. The total number of cycles obtained when the test is completed shall be≥ 75% above the specific limit for cell types listed in cells dimensionally paragraph 7.6 of IEC 61960-3:2017. In table 2 below are listed examples of requirements for minimum number of cycles for secondary lithium cells and batteries. Parameter: Endurance in cycles at a rate of 0,2 I_tA Reference paragraph: 7.6.2 Number of cycles - cells: ≥ 700 Number of cycles - batteries: ≥ 525 In order to accelerate the test, the following alternative procedures may be carried out; 'Endurance in cycles at a rate of 0,5 ItA (accelerated test)'. The test instructions are stated in appendix 5. The tested cells/batteries must meet the requirements stated in table 3. Parameter: Endurance in cycles at a rate of 0,5 I_tA (accelerated test) Reference paragraph: 7.6.3 Number of cycles - cells: 60% C_5 Ah

	Number of cycles - batteries: 60% C_5 Ah Determination of endurance in cycles for Li-ion/LiP batteries and cells Preparation of the test 1. Determination of the rated capacity (C) in accordance with IEC 61960-3, paragraph 7.3.1 'Discharge performance at 20°C (rated capacity)' at an ambient temperature of 20°C. 2. Determination or specification of the nominal capacity (N). 3. Prior to charging, the cell or battery shall be discharged at 20 °C ± 5° C at a constant current of 0,2 ItA, down to a specified final voltage. Performance of the tests 1. Charge and discharge currents, ambient temperature and the respective periods of rest must be carried out in accordance with IEC 61960-3, paragraph 7.6.2 'Endurance in cycles at a rate of 0.2 ItA'. 2. The tests must be performed on a minimum of three batteries in accordance with the sample size specified in IEC 61960-3. Each test must include at least 3 batteries of each size and brand model. The highest capacity value specified on the cell must be used for the purposes of testing 3. All three batteries must meet the requirements listed therein. Endurance in cycles at a rate of 0,5 ItA (accelerated test procedure) In order to accelerate the test, the following alternative procedures may be carried out as an alternative to above test 'Endurance in cycles at a rate of 0.2 It A'. - Cycle number A (cell): 700 or B (batteries): 525; - Charge: Method declared by the manufacturer; - Stand in charged condition h: 0 to 1; - Discharge: 0,5 ItA to final voltage The remaining capacity measured according to step 1 to step 3 of paragraph 7.3.1 'Discharge performance at 20°C' when the test is completed shall be no less than the requirement stated in the table below. - Parameter: Endurance in cycles (accelerated) - Reference paragraph: 7.6.3 - Number of cycles - cells: 60% C_5 Ah - Number of cycles - batteries: 60% C_5 Ah Leakage During testing, no leakage may occur. The requirements concerning test laboratories and test instructions for capacity and endurance in cycles are stated in Appendix 5. - Complete test report, including information that no leakage has occurred during testing. - Documentation showing that the test laboratory fulfil the requirement stated in Appendix 5.
TCO Computers / TCO Smartphones	The published sustainability performance indicators: Number of charging cycles affects the lifespan of the battery For products with a rechargeable battery: The number of charging cycles until the battery reach 60% SoC, according to the criterion 'Battery longevity'. Product lifetime extension: Battery longevity (applicable to notebooks, tablets, smartphones) The main battery must be able to withstand a minimum of 300 charging cycles with at least 60% of the initial capacity. Submit the following to an approved verifier: • A copy of the test report(s) from a laboratory accredited according to ISO 17025.

	● A completed and signed product form (chapter 11.3). Submit the following together with the application to TCO Development: 1. A copy of a verification report from a verifier approved by TCO Development. 2. The name, the amount of charging cycles, the capacity left of initial capacity after the specified amount of cycles for all main batteries must be reported in TCO Certified Portal. Clarification: If the test report shows a different number of charging cycles and/or remaining capacity than what is required in TCO Certified, then scientific methodology may be used to prove conformity in theory at 300 cycles. All battery configurations that accompany the product must be tested by an ISO 17025 accredited test facility. The test shall be done according to IEC 61960 standard. Equivalent standards may be used provided that an approved verifier has analyzed the test method and concluded that the alternative test method is equal to or stricter than IEC 61960. When performing the battery cycles test 'endurance in cycles at a rate of 0.2 C' specified in IEC 61960, the accelerated test procedure using 0.5C can be used to speed up the testing procedure. The minimum amount of charging cycles with at least 60% of the initial capacity for the main battery will be shown on the certificate.
Blue Angel Mobile Phones	Battery Capacity The battery capacity shall be measured in accordance with paragraph 7.3.1 'Discharge performance at 20 °C (rated capacity)' of EN 61960 standard 'Secondary cells and batteries containing alkaline or other non-acid electrolytes - Secondary lithium cells and batteries for portable applications', as amended (current version: DIN EN 61960:2012-04). The rated 9/24 DE-UZ 106 Edition July 2017 capacity (C) thus determined must be at least as high as the nominal capacity (N) indicated on the battery and in the product documents. Compliance Verification: The applicant shall specify, in Annex 1, the rated capacity (C) measured and present a test report in Annex 3 to the Contract stating that at least three secondary batteries have been analysed and that all three meet the requirement. The test report shall be prepared by a testing laboratory meeting the general requirements of DIN EN ISO/IEC 17025 for the competence of testing and calibration laboratories. Test reports prepared by the applicant or the battery manufacturer will be accepted as equivalent if the latter use a testing laboratory that has been accredited for these measurements by an independent body as Supervised Manufacturer's Testing (SMT) Laboratory. --- Durability of the Battery The battery must achieve a minimum of 500 full charge cycles: full charge cycles ≥ 500 A full charge cycle is to be understood as the drain of a quantity of electricity (in ampere hours) from the battery to the amount of its nominal capacity (N) that has been stored in the battery by one or more charging processes. The minimum number of full charge cycles achievable shall be specified in the product documents. After 500 full charge cycles the battery must, in addition, have in a fully charged state, a remaining capacity (QRem) of at least 90 percent of the nominal capacity (N). $Q_{Rem} \geq 90\% * N$ Full charge cycles shall be calculated and remaining capacity shall be measured in accordance with the requirements set out in Appendix A. Compliance Verification: The applicant shall - in Annex 4 - present the report on the durability test for a minimum of three batteries tested according to Appendix A documenting the resulting numbers of achieved full charge cycles of the batteries as well as the remaining capacities recorded at the end of the tests. The test report shall be prepared by a testing laboratory meeting the general requirements of DIN EN ISO/IEC 17025 for the competence of testing and calibration laboratories. Test reports prepared by the applicant or the battery manufacturer will be accepted as equivalent if the latter use a testing laboratory that has been accredited for these measurements by an independent body as Supervised Manufacturer's Testing (SMT) Laboratory. In addition, the applicant shall, in Annex 1 to the Contract, specify the minimum number of full charge cycles achievable, highlight the relevant passages documenting this figure in the product documents and present the respective pages of the product documents in Annex 2 to the Contract.
TÜV Green	Capacity of rechargeable battery

<table>
<tr><td>Product Mark Mobile Phones</td><td>Three batteries shall be tested and meet the requirements of following test: Prior to charging, the cell or battery shall be discharged at 20 °C ± 5 °C at a constant current of 0,2 It A, down to a specified final voltage. The following endurance test shall then be carried out in ambient temperature of 20 °C ±5 °C. Charge and discharge shall be carried out in accordance with the conditions specified in either Table 3 or Table 4.

Table 2: battery cycling procedure
<table><tr><td>Cycle number</td><td>Charge</td><td>Stand in charged condition (h)</td><td>Discharge</td></tr><tr><td>1 to 300</td><td>Method declared by the manufacturer</td><td>0 to 1</td><td>0.5 It A to final voltage</td></tr></table>
The remaining capacity at the last cycle shall be not less than 60% of rated capacity.

Methodology for assessing and demonstrating compliance: The applicant shall provide a report with test data showing that the batteries meet with above requirements. The report shall be issued by an ILAC or equivalent accredited party.</td></tr>
</table>

Source: Own compilation according to sources in Table 7

Table 25: Analysis of EU GPP and ecolabel schemes: Criteria on product durability

<table>
<tr><td>EU GPP</td><td>Award criteria (comprehensive):

Notebook computer drives: Points shall be awarded where the primary data storage drive used in notebooks is tested and verified to meet at least one of the following requirements:

(i) The HDD drive shall withstand a half sine wave shock of 400 G (operating) and 900 G (non-operating) for 2 milliseconds without damage to data or operation of the drive.

(ii) The HDD drive head should retract from the disc surface in less than or equal to 300 milliseconds upon detection of the notebook having been dropped from desk height (76cm) and regardless of its orientation.

(iii) A solid state storage drive technology such as SSD or eMMC is used.

Notebook durability testing: Points shall be awarded for products that have passed durability tests carried out according to IEC 60068, US MIL810G or equivalent.

A maximum of x points [to be specified] may be awarded:

- Accidental drop (x/4 points)

- Resistance to shock (x/4 points)

- Resistance to vibration (x/4 points)

- Screen resilience (x/8 points)

- Temperature stress (x/8 points)

Functional performance requirements and test specifications are provided in Annex I of the criteria document. In-house tests with a stricter specification shall be accepted without the need to retest. The tests applicable shall be specified in the ITT in order to reflect the conditions of use defined for the product.

Tablet durability testing: Points shall be awarded for products that have passed durability tests carried out according to IEC 60068, US MIL 810G or equivalent.

A maximum of x points [to be specified] may be awarded:

- Accidental drop (x/2 points):

- Screen resilience (x/2 points):

Functional performance requirements and test specifications are provided in Annex I of the criteria document. In-house tests with a stricter specification shall be accepted without the need to retest.</td></tr>
<tr><td>TCO</td><td>Product lifetime extension: Product durability (applicable to notebooks, smartphones and tablets)</td></tr>
</table>

Computers / TCO Smartphones	The product must be tested according to the MIL-STD-810G w/CHANGE 1 or IEC 60068-2 test procedure with the modified storage / operational temperature interval and duration as well as the drop test height according to the table below. The results will be reported on the certificate. - Drop test: required level ≥ 45 cm drop height - High temperature: Storage temperature for ≥ 48h: ≥ 60°C; Operational temperature for ≥ 4h: ≥ 40°C - Low temperature: Storage temperature for ≥ 48h: ≤ -30°C; Operational temperature for ≥ 4h: ≤ -20°C Submit the following to an approved verifier: - A copy of the test report(s) from a laboratory accredited according to ISO 17025. - A completed and signed product form (chapter 11.3) Submit the following together with the application to TCO Development: - A copy of the verification report from a verifier approved by TCO Development. - The measured values must be reported in TCO Certified Portal. Assessment and verification The applicant must provide test reports showing that the model has been tested and has met the functional performance requirements for durability. Testing must be carried out by a test facility accredited according to ISO 17025 and the test report must be verified by a verifier approved by TCO Development. Existing tests for the product, carried out to the same or a stricter specification, will be accepted without the need to retest. This includes products that fulfill or Method 516.7 - Shock (procedure IV), Method 502.6 - Basic Cold (C1), Method 501.6 - Basic Hot (A2) test conditions or stricter according to MIL-STD-810G w/CHANGE 1. If the product is tested according to IEC 60068-2 test methods the following procedures shall be used: Drop test - 60068-2-31:Ec, High temperature - IEC 60068-2-2:B, Low temperature - 60068-2-1:Ab/e. The product under test shall first be baseline tested for performance at 20 ° C with a fully charged battery. All operation tests shall be started with a fully charged battery in the system. During the low temperature operational test, the product may be switched on at ≤ 0 ° C. After exposure to any of the three specified stress tests, the product should be able to: 1. Boot up and operate normally - Boot or resume should not exceed 50% greater time increase as a result of the test. - No noticeable operational faults when using standard software applications (Excel, Word etc). - No major damage to the product that does not allow for standard usage, e.g.,-opening/closing of the notebook display, usage of any critical buttons, non-functional display. 2. Not create hazards to end user - No case or display cracking or other sharp points created from failures that could injure a user. - No electrical component failures or access that could result in a user safety issue. Published durability values: Printed values on the certificate do not need to be updated as long as the difference to the worst case value is less than 1 cm for the drop test height, and 1 degree celsius for the temperature tests.

Source: Own compilation according to sources in Table 7

Table 26: Analysis of EU GPP and ecolabel schemes: Criteria on upgradeability / capacity expansion / standardised interfaces

EU GPP	Award criteria (comprehensive) Points shall be awarded for products that incorporate the following features: (i) RAM memory - Soldered RAM with a minimum capacity of 8GB, or; - The potential to replace and upgrade the RAM (socketed design). (ii) Mass storage - The potential to expand the storage by using slots supporting mass storage media, or - Additional mass storage incorporated into the keyboard (for all-in-one notebooks). The RAM memory sub-criteria are not suitable for devices designed to run their main applications from the cloud. This criterion should not be used to compare bids that offer differing solutions i.e. integrated or cloud storage.
Blue Angel Computers	Computers to be Blue Angel eco-labelled must be so designed as to ensure easy accessibility to the replaceable components and expansion interfaces (e.g. IC sockets plug-in connectors). For this purpose, it must be possible to open housing parts, chassis and battery covers easily and without expert knowledge. The computers must provide the following expansion options: - Replacement or expansion of Random Access Memory (RAM) (if any), - Replacement or expansion of the mass storage (if any). In addition, the computers must provide the following interfaces: - Existence of two or more USB 3.0 or later ports (small-scale servers may have a different type of serial port), - Connectivity to external monitors (does not apply to integrated desktop computers and small-scale servers).
TCO Computers / TCO Smartphones	Product lifetime extension / standardized connectors: The device must carry at least one USB Type-C connector that is backward compatible with USB 2.0. Clarification: If the product does not have a built-in USB Type-C connector, then a USB Type-A Male to USB Type-C female adapter must accompany the product when it is delivered to the end user. Background: By using one standardized interface (USB Type-C) for charging and data transfer, fewer cables need to be manufactured and the re-use of chargers and data cables can increase. USB Type-C is also designed to be more robust and future-proof than the existing USB Type-A and Type-B. Therefore, using USB Type-C help prevent problems with failing ports. The standard also enables features such as eGPU for notebooks that makes it possible to upgrade the GPU performance with standalone graphics cards. This means that a user will be able to keep the same product for a longer time.
TÜV Green Product Mark Computers	Interchangeability of power supplies: To enable easy reuse of used power supplies and make buying a new compatible power supply for a notebook computer simpler, the DC power supply for notebook computers shall demonstrate compliance with IEC TS 62700.
TÜV Green Product Mark Mobile Phones	Upgradability of operating system: The mobile phones shall be designed with the function of getting the operating system upgraded to the up-to-date version free of charge. The upgrade shall be aimed to continuously enhance the security of the devices and enable the updates of other software. Methodology for assessing and demonstrating compliance: The applicant shall provide declaration for the compliance with supporting proof (e.g. product manual, screenshot of website).
Blue Angel Mobile Phones	The device shall come with a free function to allow the user to update the operating system. The aim of these updates is, above all, the closing of security holes, as well as other software updates, if applicable. The applicant undertakes to offer security updates for the operating system of the mobile phone to be eco-labelled for at least 4 years from the time that production ceases.

Source: Own compilation according to sources in Table 7

Table 27: Analysis of EU GPP and ecolabel schemes: Criteria on secure data removal from products

TCO Computers / TCO Smartphones	Product lifetime extension / Secure data removal from products (applicable to notebooks, desktops, all-in-one PCs, smartphones and tablets): The brand owner must provide media sanitization software, either by: A. pre-installing it on the product before it is shipped. B. providing the software for download on their webpage, free of charge. C. providing a direct link on their own webpage to an external webpage where the software is available for download, free of charge. The media sanitization software must conform with the guidelines of N IST 800-88 Revision 1, for the level of 'Clear' in accordance with the products storage technology. Users must be able to use it at least once, free of charge. We accept 'enhanced secure erase' as an option for ATA SSDs to comply with the level of 'Clear' in NIST 800-88 Revision 1. Submit the following to an approved verifier: • For B or C a link to the media sanitization software on the brand owners website • A completed and signed product form. Submit the following together with the application to TCO Development: A copy of the verification report from a verifier approved by TCO Development.
EPEAT Computer & Display (IEEE)	Optional: Publicly available service information Instructions on how the user can remove personal data. If the instructions require destruction of the storage, instructions to replace the storage shall be provided (not applicable to display products).
Blue Angel Mobile Phones	Data deletion: To allow reuse of the device it shall be designed so as to enable the user to completely and securely delete all personal data without the help of pay software. This can be accomplished by either physically removing the memory card or the use of free manufacturer-provided software. As an alternative to removing the data, it shall also be possible to encode the personal data on the data medium by means of software provided, thus allowing a secure deletion of the key. In addition, the device shall include a software function that resets the device to its factory settings. The product documents shall include detailed instructions on how to securely delete data and how to reset the device to its factory settings. Note: It shall not be possible to restore the personal data by means of commercially available recovery software tools that are used on the intact mobile phone or, where necessary, with the help of another computer
EPEAT Mobile Phones (UL 110)	Required – Feature to erase user data from mobile phone The mobile phone shall include a software function or option that will allow the user to erase all user data from the mobile phone's internal storage.

Source: Own compilation according to sources in Table 7

Table 28: Analysis of EU GPP and ecolabel schemes: Criteria on product information and service support

EPEAT Computer & Display (IEEE)	Required: Service support Manufacturer shall inform the purchaser about how to obtain repair and replacement services for the product for a minimum of three years from the date of sale. The information shall be accessible to the purchaser without restriction of access.

	Optional: Publicly available service information: The manufacturer shall provide service and repair information for the product, excluding external components, on a publicly accessible website, as follows: - Disassembly instructions including identifying the required tools. - Exploded diagram of parts. - List of spare parts including manufacturer-approved spare parts and how to obtain them. - Maintenance procedures or guidance on where to obtain the procedures. - Troubleshooting instructions, software diagnostic tools, troubleshooting videos or other troubleshooting guidance. - Instructions on how to obtain software updates (not applicable to display products). - Instructions on how the user can remove personal data. If the instructions require destruction of the storage, instructions to replace the storage shall be provided (not applicable to display products). It is acceptable for service instructions to exclude information that, as determined by the manufacturer: a) May expose the user to risk of injury, or b) Breaches intellectual property rights, or c) Compromises user privacy or security, or d) Involves the disassembly of a battery pack or power supply If claiming any of the four exclusions above the manufacturer shall demonstrate how the product is restored to normal operating condition after being repaired. Repair may include replacement of the component(s) associated with the exclusion. This information shall be available as PDF, HTML, and/or IEEE Std 1874, IEEE Standard for Documentation Schema for Repair and Assembly of Electronic Devices. Information shall be provided, at a minimum, in the dominant language(s) local to the region(s) or country(ies) in which the product is declared to conform to this criterion.
Blue Angel Computers	Product Documents (only those information requirements related to product lifetime extension) The product documents included with the computer shall include both the technical specifications and the environment and health-related user information. These documents shall either be installed on the computer, supplied as a CD-ROM or in printed form, preferably on recycled paper, together with the device or made available on the Internet from the time of delivery for a period of at least 5 years after the end of production. The product documents shall at least provide the following user information: b) Information on the provision of spare parts according to 3.2.1 (Spare Parts Availability), c) Options for expanding the capacity according to para. 3.2.2 (Capacity Expansion), g) If the computer is a notebook computer the product documents shall additionally include information according to para. 4 (Special Requirements for Notebook Computers): - Instructions on how to remove and replace the battery/accumulator or battery/accumulator pack according to para. 4.2 (Replaceability), - Indication of nominal capacity, nominal voltage and type designation according to para. 4.4 (Battery/Accumulator Marking) as well as instructions for decoding if the battery/accumulator displays a coded date of manufacture, - Indication of the minimum achievable full charge cycles according to para. 4.5 (Battery/Accumulator Durability), - Information on the software tools for battery/accumulator status reading and for battery/accumulator protection according to para. 4.6 (Battery/Accumulator Status and Battery/Accumulator Protection Software) Compliance Verification The applicant shall declare compliance with the requirements in Annex 1 to the Contract and present the product documents in Annex 3 to the Contract.
TÜV Green Product	User Guide Information:

Mark Computers	Information shall be publicly available and shall contain the following information so far as applicable: - Reparation information - Capacity expansion options - Information that the product has been awarded the TÜV Green Product Mark, including a summary of the major features for award of the TÜV Green Product
Blue Angel Mobile Phones	The product documents included with the devices shall include both the technical specifications and the user information relating to environment and health. They shall be either installed on the mobile phone, easily accessible on the Internet or supplied as a data medium or in printed form together with the device. The product documents shall include and manufacturer's website shall allow easy access to the following basic user information: - Information on how to extend the battery life - Instructions for replacing the battery - Indication of the number of full-charge cycles achievable - Information on the warranty periods for mobile phone and battery as well as on the warranty terms - Information on the availability of spare parts and repair services - Information on software updates - Information on secure data deletion and the reset function to restore factory settings

Source: Own compilation according to sources in Table 7

The following tables provide an overview about the number of EPEAT labelled computer and smartphone products fulfilling dedicated optional criteria with regard to product longevity and lifecycle extension.[92] It has to be noted, however, that the number of product types indeed is lower due to multiple counts as the database also includes same models marketed in different countries.

Table 29: Number of computer products with EPEAT labelling fulfilling optional criteria with regard to product longevity and lifecycle extension

(4.4.1.2) Long life rechargeable battery	1404 (HP, Lenovo, Apple Inc., Zebra Technologies)
(4.4.2.2) Publicly available service information	1290 (HP, Lenovo, ASUSTeK Computer Inc., Zebra Technologies)
(4.4.2.5) Product upgradeability and repairability	4376 (HP, Lenovo, Teknoservice S.L., EIZO, ASUSTeK Computer Inc., Zebra Technologies)
(4.4.2.6) Removal of lithium ion batteries	1441 (HP, Lenovo, Apple Inc., ASUSTeK Computer Inc., Teknoservice S.L., Zebra Technologies)

Source: Own compilation

Table 30: Number of mobile phone products with EPEAT labelling fulfilling optional criteria with regard to product longevity and lifecycle extension

(11.3.2) Battery removability/replacement instructions	5 (Samsung)
(11.3.3) Battery removability/replacement without use of tools	0
(11.4.2) Further ease of disassembling mobile phone	10 (Samsung, LG Electronics)
(11.6.2) Further repair and refurbishment	10 (Samsung, LG Electronics)

Source: Own compilation

[92] According to https://epeat.sourcemap.com/?category=pcsdisplays as of 17 July 2019 and https://epeat.sourcemap.com/?category=mobilephone as of September 2019

4.2.4. Voluntary approaches of front-running companies

Durability of products

Apple for example built the iPhone XS to meet the IP68 international protection marking standard for dust and water resistance[93], which means the devices can withstand being submerged to a depth of 2 meters for up to 30 minutes. Also the device's ability to withstand mechanical stresses, such as a sudden impact with a hard surface, is tested. Further, in climate tests, the devices are tested against extreme heat and cold, dry and humid conditions, and intense sun exposure; finally, chemical sensitivity tests evaluate the ability of devices to stand up to accidental spills like coffee, soda, sunscreen, or ketchup. It is not clear, if these or similar tests are also applied to Apple's computers and monitors, or to certain smartphone models only.
Also the latest iPhone 11 is splash, water and dust resistant and was tested under controlled laboratory conditions with a rating of IP68 under IEC standard 60529 (maximum depth of 2 metres up to 30 minutes).[94]

At HP, as part of the design process, all Elite, HP Pro, Z by HP and select HP Thin Clients undergo the HP Total Test Process (TTP), a comprehensive and proven testing program consisting of a minimum of 120,000 hours of rigorous multi-tiered testing and validation procedures per computing platform. The program includes 50,000 test steps, with 240 industry-standard hardware and software products tested for compatibility. Pre-launch HP Business PCs are exposed to rigorous conditions including harsh drops and vibration, high temperatures, and enduring mechanical and functional tests that simulate rough handling over the life of the product. All HP Elite, HP Pro, HP Chromebooks, and Z by HP notebooks, convertibles and detachables, as well as desktop PCs plus select Thin Clients, undergo multiple MIL-STD-810G test procedures as a way to help demonstrate product quality and reliability. The MIL-810g standard includes tests for drop, functional shock, vibration, blowing dust, altitude, extreme temperatures (high, low, and temperature shock), humidity, sand, explosive atmosphere, as well as freeze/thaw conditions ensuring a durable and long-lasting product. All testing of the business-rugged PCs is performed by a third-party testing facility. HP has developed a technical white paper 'Testing the business ruggedness and reliability of HP Business PCs' which also includes comprehensive details of the tests performed with specific MIL-STD-810G method references and key test parameters.[95]

Dell offers so called 'Rugged PCs' which feature a durable, built-to-last chassis that has undergone extensive military-grade MIL-STD 810G testing with regard to protection against

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[93] According to https://en.wikipedia.org/wiki/IP_Code, the first digit first indicates the level of protection that the enclosure provides against access to hazardous parts where ‚6' means ‚Dust tight', i.e. complete protection against contact (dust tight); a vacuum must be applied with test duration of up to 8 hours based on air flow; the second digit indicates the level of protection that the enclosure provides against harmful ingress of water where ‚8' means protection against ‚Immersion, 1 m or more depth', i.e. The equipment is suitable for continuous immersion in water under conditions which shall be specified by the manufacturer. However, with certain types of equipment, it can mean that water can enter but only in such a manner that it produces no 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; for this test, the duration is in agreement with the manufacturer and the depth is specified by the manufacturer, generally up to 3 m.

[94] See https://www.apple.com/uk/iphone-11/specs/

[95] See http://www8.hp.com/h20195/v2/GetPDF.aspx/4AA6-0823ENW.pdf and https://www8.hp.com/h20195/v2/GetPDF.aspx/c05968416.pdf

drops, dust and liquids. Further, for example, the Latitude 7212 Rugged Extreme Tablet includes hot swappable dual batteries.[96] The model Latitude 5420 Rugged, for example, is drop tested from 3 feet (= 91 cm) for impact resistance and certified by the International Protection Marking IP-52 ingress protection.[97] Further, the model Latitude 5420 uses 'Corning Gorilla Glass 5' which has been formulated to deliver improved native damage resistance (upto 1.8X) with deep abrasion, faster chemical strengthening with high Compressive Stress and deeper depth of compression; the glass has been tested for performance when subjected to sharp contact damage, such as asphalt and other real-world surfaces.[101]

Zebra Technologies Corporation offers rugged tablets for different industry applications. Drop specifications are – depending on the model type - 3.28' drop to concrete, 5.9' drop to concrete with frame, 6' drop or 4' drop. The sealings meet – depending on the model type - the IP65 or IP54 international protection marking standard for dust and water resistance.[98] Rugged specifications such as thermall shock, drop specification, vibration, humidity, water proofing, blowing sand, or blowing dust are tested according to the standard MIL-STD-810G which is further detailed in the products specification sheets[99].

Samsung's Galaxy S10e, S10, S10+, Note9, S9, S9+, Note8, S8, S8+, S7, and S7 edge feature an IP rating of 68, i.e. withstand dust, dirt and sand, and are resistant to submersion up to a maximum depth of 1.5m underwater for up to thirty minutes.[100]

Rechargeable battery life and endurance

Dell provides, for example, for its Dell Latitude 5420 Rugged model an Owner's Manual with detailed information about the battery. According to the manual, the battery is categorized as a 'CRU (Customer Replaceable Unit)'. Dell Latitude Rugged use inter alia a battery option of 3-cell 51 Whr (Long-Life Cycle, which includes 3 year limited warranty); further, a computer controlled battery manager ('BATTMAN') is used intended for typical rechargeable batteries, inter alia with following capabilities: Monitoring self-discharge; measuring internal resistance; automatically performing repeated discharge/charge cycles to break in new batteries; keeping a log of all operations performed, which can be imported.[101]

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[96] See https://www.dellemc.com/en-us/rugged/index.htm

[97] See https://www.dell.com/en-us/work/shop/dell-laptops-and-notebooks/latitude-5420-rugged-business-laptop/spd/latitude-14-5420-laptop/xctol542014us; according to https://en.wikipedia.org/wiki/IP_Code, the first digit first indicates the level of protection that the enclosure provides against access to hazardous parts where ‚5' means ‚Dust protected', i.e. the ingress of dust is not entirely prevented, but it must not enter in sufficient quantity to interfere with the satisfactory operation of the equipment; the second digit indicates the level of protection that the enclosure provides against harmful ingress of water where ‚2' means protection against ‚Dripping water when tilted at 15°', i.e. vertically dripping water shall have no harmful effect when the enclosure is tilted at an angle of 15° from its normal position: a total of four positions are tested within two axes; for this test, the duration is 2.5 minutes for every direction of tilt (10 minutes total) and water equivalent to 3 mm rainfall per minute.

[98] See https://www.zebra.com/content/dam/zebra_new_ia/en-us/solutions-verticals/product/Tablets/brochure/tablets-brochure-en-us.pdf

[99] See for example https://www.zebra.com/content/dam/zebra_new_ia/en-us/solutions-verticals/product/Tablets/l10-series/xbook-l10/spec-sheet/xbook-l10-tablet-spec-sheet-a4-en-gb.pdf; further sheets can be downloaded under https://www.zebra.com/gb/en/products/tablets/l10-series-xbook-xslate-xpad.html

[100] See https://www.samsung.com/global/galaxy/what-is/ip68/

[101] See https://topics-cdn.dell.com/pdf/latitude-14-5420-laptop_owners-manual_en-us.pdf

Lenovo offers Battery Longevity Technology which extends notebook battery cycle life through key technologies, including: *Increased use of lithium polymer cells*; used in notebooks and tablets with embedded batteries, these cells typically provide longer life cycles than lithium ion cylindrical cells; *Longer lifespan batteries*: Many Lenovo embedded batteries are designed to last two to three times longer than standard batteries; Lenovo Services offers three-year warranty upgrades on many embedded batteries; the longer lifespan is made possible due to carefully designed cells and charge algorithms. *Dual mode charging algorithms*: These technologies are used on most notebook batteries and adjust charge voltage and current over time to prolong the battery's lifespan. The feature is implemented in the hardware and as part of the battery firmware, so it is not operating system or application dependent and works with any software load. *Field updateable battery firmware*: Customers can download a firmware update utility which allows them to apply firmware fixes to batteries in service, eliminating the need to replace batteries due to firmware problems. This program allows customers to apply fixes quickly and at no cost, even on batteries outside of the warranty.[102]

Google has incorporated power-management software to maximize battery-charging efficiency and extend battery life during use in its Pixel 3a and 3a XL smartphones[103].

Apple's iPhones 11, 11 Pro and 11 Pro Max will launch with iOS 13, which offers features to optimize battery charging and reduce the effects of battery aging.[104] Apple's iPhone XR, iPhone 8 as well as 8 Plus feature a lithium-ion polymer battery chemistry that is free of lead, cadmium, and mercury which allows for an extended lifespan, and is designed to deliver up to 500 full charge and discharge cycles before it reaches 80 percent of its original capacity.[105]

Upgradeability, capacity expansion and standardised interfaces

Apple for example uses USB-C industry standard as universal port in some of its devices.[106]

At HP, following the All-in-One HP EliteOne 1000 G1, the HP EliteOne 1000 G2 Base Desktop PC is HP's first desktop with an upgradeable PC base and display enabling customers to upgrade and reconfigure flexibly by keeping their display from the G1 series.[107] Further, for expanding personal systems HP offers the service 'Device as a Service (DaaS)' which provides customers the latest HP technology; business customers can upgrade their products to the latest and most efficient models, while avoiding the up-front costs of purchasing. In 2019, HP completed a preliminary life cycle assessment (LCA) comparing the DaaS offering for commercial PCs with traditional transactional sales offerings. Results showed a substantial reduction in environmental impacts across all categories assessed, due to the DaaS service model, which keeps PCs in use for multiple life cycles.

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[102] See https://www.lenovo.com/us/en/social_responsibility/2017.18-lenovo-sustainability-report.pdf

[103] See http://services.google.com/fh/files/misc/pixel3a_productenvironmentreport.pdf and http://services.google.com/fh/files/misc/pixel3axl_productenvironmentreport.pdf

[104] See https://www.apple.com/environment/pdf/products/iphone/iPhone_11_Pro_Max_PER_sept2019.pdf, https://www.apple.com/environment/pdf/products/iphone/iPhone_11_Pro_PER_sept2019.pdf, https://www.apple.com/environment/pdf/products/iphone/iPhone_11_PER_sept2019.pdf

[105] See https://www.apple.com/environment/pdf/products/iphone/iPhone_XR_PER_sept2018.pdf; https://www.apple.com/environment/pdf/products/iphone/iPhone_8_PER_sept2017.pdf; https://www.apple.com/environment/pdf/products/iphone/iPhone_8_Plus_PER_sept2017.pdf

[106] Cf. https://www.apple.com/thunderbolt/

[107] See http://www8.hp.com/h20195/v2/GetPDF.aspx/c06293935.pdf

HP is working with an LCA consultancy to conduct a full, ISO-compliant, peer-reviewed LCA to more fully understand the magnitude of those benefits.

Fairphone uses USB-Type C in its latest Fairphone 3 model. Also, the phone is sold without charger, cable or earphones, so that users can use the ones they have and help cut down on e-waste.[108]

Repairability

HP promotes that several HP products have received high scores from the iFixit product repair site, such as the HP Elite x2 1013 G3, an EPEAT® Gold tablet with an iFixit repairability rating of 9 out of 10 and the EliteBook 800 G5 Business Notebook series which received a 10 out of 10 iFixit repairability score.

Dell provides, for example, for its Dell Latitude 5420 Rugged model comprehensive information through the owner's manual with regard to instructions how to install or remove certain components, including a list of recommended tools and a detailed screw list with images of the screws, their number and locations in different components of the computer. Each step for either installing or removing components (in case of this model for the stylus, SIM card, memory card, handle, latch doors, battery, bottom chassis cover, keyboard, SSD carrier, SSD, memory modules, WLAN-card, WWAN-card, GPS module, coin-cell battery, PCIe Heatsink fan assembly, primary SSD rail, docking port assembly, heatsink assembly, rear I-O board, hinge covers, display assembly, LCD Bezel and Back Cover Assembly, microphone, camera, battery bay, left I/O board, smart card, speaker, system board and bottom base assembly) is illustrated with pictures and instructions.[109]

Fairphone offers various components as spare parts to its customers, for example the camera, speaker module, bottom module, top module, display, battery and back cover for the latest Fairphone 3 model.[110] These replaceable modules can be repaired by the end-user with a single screwdriver which is included in the box when purchasing the device. Fairphone offers a price list for its key components on the website, including material and repair costs as well as handling and shipping prices. The price list is used to provide the customer with a quote; the exact prices of the repairs depend on the technical diagnosis. Further, Fairphone provides an online repair tool on its website to solve repair issues by the customer itself. The spare parts, including batteries and screens, and accessories will be supplied for the next three years after purchase.

Shiftphone has composed its smartphone SHIFT6m of 13 different modules. With the enclosed Torx screwdriver, repairs or the upgrade of the camera module can be done by the user itself without loss of the warranty. The connections of the modules are plugged, not soldered or glued.[111]

Secure data removal

HP has for example a dedicated 'Hardware reuse standard' for vendors providing this service, including the following requirements[112]: If hard drives or other data bearing devices may be contained within a remarket able unit, the unit must be physically opened and the presence and number of disk drives shall be verified and documented. Each data bearing device must be overwritten using industry-standard disk-wiping software or physically

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[108] See https://shop.fairphone.com/en/?ref=header

[109] See https://topics-cdn.dell.com/pdf/latitude-14-5420-laptop_owners-manual_en-us.pdf

[110] See https://shop.fairphone.com/en/spare-parts/filter/choose-your-fairphone/fairphone-3

[111] See https://www.shiftphones.com/downloads/SHIFT-wirkungsbericht-2019-05-10.pdf

[112] See http://h20195.www2.hp.com/V2/GetDocument.aspx?docname=c05320892

destroyed. The vendor shall perform full software verification on each wiped disk to confirm that the wiping of all addressable sectors was successful. A well-defined information security management system must be maintained that supports data protection that includes the following: data security handling procedures; defined and measurable processes, risk assessment program, training program, secure transportation procedures, physical handling, storage, and final recycling/disposition protections, along with data breach investigation plans. All customer identifying labels, markings, asset tags, or documents found in or on any used EEE must be removed. Any data bearing storage devices that cannot be successfully 'sanitized' must be stored in a secure location and prepared for secure transport to an HP authorized recycling facility for destruction. The vendor shall maintain auditable records to document the disk wiping process, identifying the serial number of the host unit, date of wipe, and verification of wipe performance.

HP offers a 'Sanitization Service' where data are completely erased from old devices or the storage media are permanently destroyed in accordance with the latest recognized international industry standards.[113]

Fairphone works with a DEKRA-certified partner to erase all personal data from the phone immediately upon arrival; the data get certifiably wiped.[114]

Product lifetime extension

Apple for example offers the operation system iOS 12 released in 2018 which is optimized also for devices as far back as 2013. Out of all devices using iOS, including those released many years ago, 80 percent are using iOS 12.[115] Further, Apple offers different services[116] for enhancing the reuse of appliances, such as 'Apple Trade In' which is a simple way to exchange the old device for credit so that it can be reused by a new owner, the iPhone Upgrade Program 'AppleCare' where used devices are collected and refurbished used devices, as well as inside Apple, the Hardware Reuse Program for employees. Finally, Apple offers 'Certified Refurbished products'. The company has upset a refurbishment process that includes full testing to meet the same functional standards as new Apple products. The refurbished products are 'like new' devices with genuine Apple replacement parts (as needed) that have been thoroughly cleaned and inspected. Refurbished iOS devices will come with new battery and outer shell. Further, every device will come with all accessories, cables and operating systems. The quality commitment for the refurbished product is backed by including a standard one-year limited warranty with the option of getting additional coverage by purchasing an extended warranty. [117]

HP offers a so called 'Device Recovery Service' which includes securely retiring, collecting, and responsibly processing end-of-use devices enabling recovery and reuse of as much material as possible, giving the device a new purpose, extending its lifespan, and reducing negative environmental impact. Customers receive residual value, a certificate of data

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[113] See https://www8.hp.com/us/en/services/recoverandrenew.html

[114] See https://www.fairphone.com/en/recycle-your-phone/

[115] See https://www.apple.com/environment/pdf/Apple_Environmental_Responsibility_Report_2019.pdf, page 30

[116] See https://www.apple.com/environment/pdf/Apple_Environmental_Responsibility_Report_2019.pdf, page 32

[117] See https://www.apple.com/shop/refurbished/about

sanitization, a report detailing the environmental benefits, and peace of mind that relevant requirements and regulations governing disposal have been met.[118]

Fujitsu offers the ARROWS Tab Q736/M for corporate clients where the internal cover can be reused instead of being disposed of when refurbished. Further, Fujitsu offers different product related services which can be purchased together with the hardware and software components on a subscription basis as 'Hardware as a Service (HaaS)'. The service includes regular upgrades to follow the latest technology trends; hardware renewal takes place every three years. At the end of the period, depending on the individual agreement, the equipment can be returned which will then be data wiped to industry standards and remarketed, recycled or disposed of to WEEE directive standards. Fujitsu's 'Lifecycle Services' assist the customers during all phases of a product's lifecycle. They comprise different service levels, different offerings, and different scopes beyond the warranty to tailor ideally to individual needs. Fujitsu's 'Product Support Hardware' service supplements the warranty for Fujitsu and Partner branded hardware products and comprises the diagnosis of hardware faults and their elimination by repair or replacement. The service is delivered remotely, offsite or onsite depending on the product or selected service level and the adequate problem solution. In addition, proactive support elements are available. They are based on status information of the customers' IT that is captured and evaluated, and thus can proactively avoid system failures and downtimes. Customers may choose for example service time, onsite response time and recovery time, or HDD Retention that authorizes customers to keep ownership of an exchanged storage medium (HDD or SSD, etc.).[119]

Dell offers the service 'ProSupport Plus with SupportAssist' for PCs that automates support to prevent issues before they occur and quickly resolves them. It includes 24x7 expert hardware and software support, next-business day onsite service and coverage for accidents.[120]

Samsung offers a so called 'Business Trade-In Program' which allows customers to trade in eligible devices and receive trade-in credit towards the purchase of new qualifying Galaxy devices. A company can select their new business devices and the devices they want to trade-in; these have to comply with certain eligibility requirements. The estimated business trade-in value can be seen before the purchase is completed. After Samsung receives and verifies the condition of the devices, they apply the final business trade-in credit to the customer.[121]

LG Electronics has a Strategy to Extend Product Lifecycle: 'Long-lasting LG Smartphones'. Therefore, LG Electronics operates a 'Software Upgrade Center' where they provide steady and ongoing OS upgrades for its smartphone operating system along with systematic customer care. LGE has extended the lifecycle of the LG smartphone through strengthened after-sales service that includes operation system upgrades, security patches, software, and customer care related functions. For example, when updating old smartphone models, users can utilize the latest smartphone features such as LG Pay, camera, and AI. In addition, LGE has strengthened remote support functions through 'Smart Doctor', which diagnoses the

[118] See https://www8.hp.com/us/en/services/recoverandrenew.html and https://www8.hp.com/h20195/v2/GetPDF.aspx/4AA7-3681DEE.pdf

[119] See https://sp.ts.fujitsu.com/dmsp/Publications/public/bro-prs-at-a-glance.pdf

[120] See https://i.dell.com/sites/csdocuments/Learn_Docs/en/pc_as_a_service_brochure.pdf

[121] See https://www.samsung.com/us/business/shop/trade-in/

status of the smartphone automatically and presents solutions, and 'LG Electronics Remote Consultation', which supports remote repair services.[122]

Refurbished products

Fairphone offers 'Refurbished Products' (Fairphone 2: New Life Edition). A factory-Refurbished Product has undergone factory restoration and passed rigorous quality testing at Fairphone production facilities to ensure performance like new. Although the Refurbished Product might have minor physical marks, such as scratches or blemishes, it is guaranteed that the quality and performance will not be compromised; the refurbished product is also covered by the 2-year warranty.[123]

Samsung offers so called 'Certified Pre-Owned' smartphones: Samsung engineers take the old devices apart, inspect them, replace damaged parts, reassemble them and update the software. Each remanufactured device must pass more than 400 rigorous tests to make sure it's back to its original condition; each Samsung Certified Pre-Owned phone comes with a 12-month warranty, just like Samsung's new devices. The appliances are packaged with a brand new charger and fresh headphones.[124]

Warranties and availability of spare parts

Lenovo, for example, offers three-year standard warranties and five years of replacement parts availability on many of their top-selling commercial products. Three-year warranties are offered as the base warranty on many top-selling Think-branded products, including all commercial monitors, notebooks, desktops and others.[125]

Fairphone offers for its smartphones a two-year warranty (one year on the performance of the battery)[126]. In the case of repair or replacement of defective modules under the warranty, Fairphone might use parts that are refurbished, however guaranteeing that the appearance and the performance of the refurbished replacement will be as good as a new one.[127]

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[122] See https://www.lg.com/global/pdf/Sustainability-Report/2018-2019%20Sustainability%20Report.pdf

[123] See https://www.fairphone.com/en/legal/fairphone-2-warranty/

[124] See https://www.samsung.com/us/explore/certified-pre-owned-phones/

[125] See https://www.lenovo.com/us/en/social_responsibility/2017.18-lenovo-sustainability-report.pdf

[126] See https://shop.fairphone.com/en/?ref=header

[127] See https://www.fairphone.com/en/legal/fairphone-2-warranty/

4.2.5. Scoring system for the repair and upgrade of products, applied to laptops

The European Commission, DG JRC Seville, has carried out a study for the analysis and development of a possible scoring system to inform about the ability to repair and upgrade products[128]. The assessment framework is composed of pass/fail criteria that products have to fulfil in order to be considered as reparable/upgradeable at all, i.e. eligible for being assessed through the scoring criteria; by additional scoring criteria the extent to which products are reparable or upgradeable can be rated. According to the study, this scoring system could serve as a technical reference for potential use in policy-making, such as Ecodesign, Ecolabel or GPP, for example as public guidance document.

Inter alia, the study has applied the general approach of such a scoring system also to the product group of laptops. As the study includes most recent analysis and information about priority parts for laptops as well as criteria and verification proposals, the main results shall also be shortly introduced here for comparison with existing requirements in labels and under GPP.

Priority parts – relevant for repair

- Batteries
- Screen
- Storage drives (Hard Disk Drives / Solid State Drives)
- Keyboards (and keys)
- Covers and outer frames
- Ports and connectors (USB, network, charging port)
- External Power Supply (EPS) / AC adaptor
- Fans and cooling fins
- Trackpad / pointing device
- Mother Board
- BIOS Battery (CMOS)
- Optical drive / PC card slots

Priority parts – relevant for upgrade

- Random Access Memory; this could be less relevant if the device has a capacity above a specific threshold
- Graphic Processing Unit
- Software (Operating system) and firmware (BIOS)

[128] See http://susproc.jrc.ec.europa.eu/ScoringSystemOnReparability/docs/JRC114337_report_repair_scoring_system_final_report_v3.2_pubsy_clean_with_identifiers.pdf

In order to rate laptops, following parameters have been chosen in order to rate laptop's reparability and upgradability:

- Disassembly depth / sequence
- Fasteners
- Tools
- Type and availability of information
- Spare parts
- Software and firmware
- Password reset and restoration to factory settings
- Data transfer and deletion
- Commercial guarantee

The following parameters of the general reparability scoring system have not been applied to the product group laptops: 'Disassembly time', 'diagnosis and support interfaces', as well as 'safety, skills and working environment'.

Table 31: Reparability Scoring Index: Parameters, criteria and weights preliminary proposed for laptops

Parameter	Pass/fail criteria	Rating classes	Assessment and verification	Weight of the parameter
1) Disassembly depth/sequence	For each priority part, information about the disassembly sequence has to be available to the target group of repairers (see #6)	None (no rating is proposed since data regarding disassembly depths has not been collected for this study)	A: A description supported by illustrations of the steps needed to disassemble priority parts is needed. The description has to show that the disassembly is reversible by including the steps needed for the reassembly of priority parts. V: physical disassembly and recording of the operation are needed.	Normal = 1
2) Fasteners and connectors	None	A score is assigned for each priority part according to the reversibility and reusability of the fasteners used for its assembly. I) Reusable: an original fastening system that can be completely re-used, or any elements of the fastening system that cannot be re-used are supplied with the new part for a repair, re-use or upgrade process = 1 pt. II) Removable: an original fastening system that is not reusable, but can be removed without causing damage or leaving residue which precludes reassembly or reuse of the removed part = 0.5 pt. III) Non-removable: original fastening systems are not removable or reusable, as defined above = 0 pt. Note: In case different types of fasteners are used in the assembly of a priority part, the score corresponding to the worst type of fasteners case will be considered.	A: A description supported by illustrations of the fasteners to be removed for the disassembly of priority parts is needed. V: Physical disassembly and inventory of fasteners are needed.	Normal = 1
3) Tools	The repair/upgrade process is feasible for each priority part with existing tools	A score is assigned for each priority part according to the complexity and availability of the tools needed for its repair/upgrade: I) Basic tools: repair/upgrade of the priority part is feasible without any tools, or with tools that are supplied with the product, or with the list of basic tools provided in note 1 = 1 pt. II) Other commercially available tools: repair/upgrade of the priority part is unfeasible only with basic tools and requires the use of other	A: Description of the repair/upgrade operations, including documentation of the tools to use, is needed. V: Physical disassembly and check of suitability of tools are needed.	Normal = 1

Parameter	Pass/fail criteria	Rating classes	Assessment and verification	Weight of the parameter
		tools that are commercially available = 0.66 pt. III) Proprietary tools: repair/upgrade of the priority parts is feasible only with one or more proprietary tools = 0.33 pt. Note: The list of basic tools includes: - Screwdriver for slotted heads, cross recess or for hexalobular recess heads (ISO2380, ISO8764, ISO10664); - Hexagon socket key (ISO2936); - Combination wrench (ISO7738); - Combination pliers (ISO5746); - Half round nose pliers (ISO5745); - Diagonal cutters (ISO5749); - Multigrip pliers (multiple slip joint pliers) (ISO8976); - Locking pliers; Combination pliers for wire stripping & terminal crimping; - Prying lever; - Tweezers; - Hammer, steel head (ISO15601); - Utility knife (cutter) with snap-off blades; - Multimeter; - Voltage tester; - Soldering iron; - Hot glue gun; - Magnifying glass; - Clean, soft, lint-free cloth; - Magnifying glass; - Quick grip clamps; - Nonslip gloves; - Painters tape;		

Parameter	Pass/fail criteria	Rating classes	Assessment and verification	Weight of the parameter
		- Isopropyl alcohol (IPA) wipe.		
4) Disassembly time	Not applied for the product group laptops	Not applied for the product group laptops	Not applied for the product group laptops	None
5) Diagnosis support and interfaces	Not applied for the product group laptops	Not applied for the product group laptops	Not applied for the product group laptops	None
6) Type and availability of information	- Manufacturers, importers or authorised representatives have to make available to professional repairers the spare parts (with regard to the priority parts) - Spare parts have to be available for a minimum period of 4 years after placing the last unit of the model on the market - The list of these spare parts and the procedure for ordering them have to be publicly available on a free access website. - The delivery of the spare parts has to be within 15 working days after having received the order. - Price of spare parts to be also disclosed	For each priority part:, a) Availability of spare parts over time: I) The spare part (or compatible spare parts) is declared by the manufacturer to be available for at least 7 years = 1 pt; II) The spare part (or compatible spare parts) is declared by the manufacturer to be available for at least 4 years = 0.5 pt. b) Target group I) The spare parts is available publicly = 1 pt; II) The spare parts is available to professional repairers = 0.5 pt. c) Interface (only for ports, connectors, EPS up to 100 W): I) The part is not proprietary and has a standard interface = 1 pt; II) The part is either proprietary or does not have a standard interface = 0.5 pt. Score (#7) = Score (#7a) x Score (#7b) x Score (#7c)	A: Commitment by the manufacturer about the availability of spare parts over time, as well as provision of information about: - Delivery time - Recommended retail price of spare parts - Target groups - Interface used. V: Check of actual availability.	High = 2
8) Software and firmware	Software (at least for the Operating System) and firmware updates and support are offered to end users for a duration of 4 years after placing	a) A score is assigned for the product based on the period of time during which software/firmware updates and support are offered: I) Software/Firmware updates and support are offered for at least 7 years = 1 pt;	A: Declaration about the duration of availability of software and firmware over time, as well as information about costs, and information about how updates will affect	High = 2

Parameter	Pass/fail criteria	Rating classes	Assessment and verification	Weight of the parameter
	the last unit of the model on the market, including the possibility to use open source Operating Systems or open source Virtual Machine software. Information about the impact of future updates on the original system characteristics (e.g. RAM, CPU) has to be provided, and there has to be always the option to not install, to install or to uninstall the update.	II) Software/Firmware updates and support are offered for at least 4 years = 0.5 pt. b) A score is assigned for the product based on the cost of the software/firmware update service: I) Software/Firmware updates and support are offered free of charge for the entire period of time during which the service is offered (either 4 or 7 years) = 1 pt; II) Software/Firmware updates and support are offered free of charge for X years = either X/7 or X/4 pt, depending on the entire period of time during which the service is offered. Score (#8) = Score (#8a) x Score (#8b)	the original system characteristics. V: Check of actual availability, compatibility, and possibility to avoid/reverse the update.	
9) Safety, skills and working environment	Not applied for the product group laptops	Not applied for the product group laptops	Not applied for the product group laptops	None
10) Data transfer and deletion	None	A score is assigned for the product based on the availability of secure data transfer and deletion functionality: I) Built-in secure data transfer and deletion functionality is available to support the deletion or transfer of all data contained in data storage parts (i.e. hard drives and solid state drives) = 1 pt. II) Secure data transfer and deletion is permitted without restrictions, using freely accessible software or hardware solutions = 0.66 pt. III) Secure data transfer and deletion is available on request to support the deletion of all data contained in data storage parts (i.e. hard drives and solid state drives) = 0.33 pt.	A: Information about the availability of secure data transfer and deletion functionality / service is needed. V: Check of actual availability.	High = 2
11) Password reset and restoration of factory settings	None	A score is assigned for the product based on the availability of an option for resetting the password and restoring the factory setting. I) Integrated reset: password reset and restoration of factory settings (whilst ensuring security of personal data of previous user) is permitted without restrictions, using functionality integrated within the product = 1 pt. II) External reset: password reset and restoration of factory settings (whilst ensuring security of personal data of previous user) is	A: Information about the availability of a feature / service for password reset and restoration of factory settings is needed. V: Check of actual availability.	High = 2

Parameter	Pass/fail criteria	Rating classes	Assessment and verification	Weight of the parameter
		permitted without restrictions, using freely accessible software or hardware solutions = 0.66 pt. III) Service reset: password reset and restoration of factory settings (whilst ensuring security of personal data of previous user) is permitted using services offered by the manufacturer = 0.33 pt.		
12) Commercial guarantee	None	A score is assigned based on the availability of a 'commercial guarantee' for the (entire) product offered by the guarantor, and including a 'commitment to free repair as first remedy' in case of failures and a 'commitment to upgrade the product periodically'. I) 1 point is assigned if a commercial guarantee is offered, in addition to the legal obligations, covering a period post-sale of at least 10 years. II) Points are modulated proportionally for intermediate cases. III) 0 points are assigned in case of fulfilling only the minimum legal requirements of 2 years. Note: 1) 'Commercial guarantee' means any undertaking by the seller or a producer (the guarantor) to the consumer, in addition to his legal obligation relating to the guarantee of conformity, to reimburse the price paid or to replace, repair or service goods in any way if they do not meet the specifications or any other requirements not related to conformity set out in the guarantee statement or in the relevant advertising available at the time of, or before the conclusion of the contract. 2) For the purpose of being able to be taken into account in the 'Repair Score System', the commercial guarantee must be related to the entire product (not only specific components), provided in the entire EU, be included in the sale price of the product, and the remedies proposed by the guarantor will not result in any costs for the consumer (e.g. it means that the repair is for free).	V: Check of availability of guarantee, clauses statement and actual possibility of repair in case of failure.	Not weight applied as it is considered as complementary metric and not to be aggregated with the other parameters

4.2.6. Summary and conclusions with regard to the revision of EU GPP criteria on product lifetime extension

4.2.6.1. Warranties

The analysis reveals that requirements on warranties are so far not included in Ecodesign regulations for computers and displays. Among the analysed ecolabels, only TCO applies requirements on warranties for computer products (for at least one year), which is also valid for smartphones. The Blue Angel criteria for smartphones include requirements on a warranty (minimum two years on the mobile phone, except for the batteries, and in addition, a minimum 1-warranty on the battery). This means, that current EU GPP criteria are far more challenging by requiring at least a warranty of two years (core criteria) or three years (comprehensive criteria), with the possibility to acknowledge extended warranties with additional points for each additional year of warranty beyond the minimum technical specification through applying award criteria. Further, comprehensive GPP award criteria include extra points if rechargeable battery replacement is provided free of charge within the first three years in case of capacity loss of more than 50 percent. However, according to some feedback from the stakeholder consultation, the three year warranty was considered to be very challenging whereas the 2 years requirement was considered reasonable in the EU context. Further, the EU GPP criteria do not specify the coverage of the warranty, i.e. which components should be included (besides battery defects) or may not be excluded.

For comparison, the reparability scoring system proposes assignment of a score based on the availability and duration of a 'commercial guarantee' for the (entire, i.e. not only specific components) product offered by the guarantor, and including a 'commitment to free repair as first remedy' in case of failures and a 'commitment to upgrade the product periodically'. The points are modulated proportionally between 0 points if fulfilling only the minimum legal requirements of 2 years and maximum 1 point for a commercial guarantee covering a period post-sale of at least 10 years.

For the revision of the GPP criteria for computers and monitors as well as the possible inclusion of smartphones into GPP, it has to be considered that in praxis, warranties and their coverage or exclusion of certain components vary widely; also, in B2B, manufacturers increasingly offer 'Device / Hardware / PC as a Service' models which include maintenance and repairs (if necessary) as well. Finally, tenderers often have contracts with IT service providers and not with the manufacturers of IT equipment. Thus, it should be discussed if warranties should still be included in the revised GPP requirements. If so, it is suggested that the coverage of the mandatory warranty should be specified (and explicitly cover batteries). An alternative for lifetime extension criteria could be requiring the provision of a service management and shifting to Service models as described above. Another stakeholder suggested including helpdesk support that would also include software.

4.2.6.2. Availability and cost competitiveness of spare parts

Besides EU GPP, most of the analysed EU Ecolabel schemes have applied criteria for the availability of spare parts. EU GPP and Green Product Mark require duration of at least three years availability. Comprehensive EU GPP criteria, as well as Blue Angel even request that the availability of spare parts is guaranteed for at least 5 years, which specifically includes rechargeable batteries if applicable. However, they differ with regard to the starting point: For EU GPP the time counts from the date of purchase, whereas for Blue Angel, it is following the end of production of the labelled product which might result in even more than five years after purchasing the product.

EPEAT label for computers, based on the IEEE standard, does not require a minimum time span for the availability of spare parts but manufacturers shall declare if spare parts are available at all and if so, the length of time the spare parts are available after the end of production, as well as a list of available spare parts. However, the time span is indirectly

addressed in the optional IEEE criteria on ‘product upgradeability and repairability’, where it says that for these listed components ‘the manufacturer, authorized service providers or other service providers offer upgrades, repair or replacement to purchasers for 5 years after the point of sale’.

There is also a difference in the definition of spare parts: Whereas Green Product Mark does not specify spare parts at all, Blue Angel provides a rather general definition, delimitating them from ‘other parts which normally exceed the life of the product’ that are not to be considered as spare parts. EU GPP and TCO provide a specific list of components for different product types (TCO: including smartphones) that fall under the criterion of spare parts availability.

Only EU GPP and Blue Angel address costs of spare parts. Whereas Blue Angel requirements state that spare parts must be offered at reasonable cost without defining this more specifically, EU GPP award criteria include the provision of a price list for a defined set of component parts including the requirement of indicative *labour* costs for replacements; points could be awarded then for the most cost-competitive offers.

For comparison, the reparability scoring system proposes as pass/fail requirement for reparability of laptops a minimum period of four years after placing the last unit of the model on the market, with a dedicated list of components. Also the price of spare parts (however, not labour costs) has to be disclosed. If spare parts availability is extended to seven years, a better rating class can be achieved.

Requirements on spare parts are included in the draft revised EU Ecodesign regulation on displays which might apply from March 2021, with a minimum period of seven years after placing the last unit of the model on the market, specifying a dedicated list of spare parts. It can be expected that also the revised EU Ecodesign regulation on computers will include requirements on spare parts.

For smartphones, Blue Angel, TÜV and EPEAT all require a three years availability of spare parts after end of the production.

For the revision of the GPP criteria it is recommended to keep criteria on spare parts availability, at least as long as the mandatory Ecodesign requirements do not apply. If requirements on spare parts availability will still be included, the list of components might be extended and aligned to the draft revised EU Ecodesign regulation on displays as well as oriented towards either the key components of laptops identified by the JRC study on a reparability scoring system, or to the list of critical replaceable components of the TCO ecolabel which also specifies relevant spare parts for smartphones. Due to the different lifetimes of computers, monitors and smartphones, it is recommended to apply also different time spans the availability of spare parts (recommended: 5 years for computers and monitors, and 3 years for smartphones. With regard to the requirements on cost competitiveness of spare parts, according to stakeholder feedback it seems to be very difficult to include the cost of the spare parts in the financial model or criteria besides for example costs of accessories (e.g. power cable, batteries); spare parts are often included in the maintenance services; manufacturers or IT service providers increasingly offer ‘Device / Hardware / PC as a Service’ models which include maintenance and repairs (if necessary) as well and thus dedicated costs of spare parts are not relevant, but rather the total cost of ownership. Against this background, also the provision of indicative labour costs for replacements seems to be debatable.

4.2.6.3. Design for reparability

EU GPP, EPEAT Computer & Display (IEEE) and TCO, as well as the draft revised EU Ecodesign regulation on displays, the preparatory study for the revision of the EU Ecodesign regulation on computers and the study on a Reparability Scoring System all have criteria addressing the design for repairability in a sense that certain defined components have to be easily accessible, repairable and/or replaceable. For EPEAT Computer & Display (IEEE), this criterion is optional, i.e. optional points can be awarded depending on the number of

hardware features out of the list that are upgradeable, repairable or replacable (for example, for desktop computers minimum 7 features; for displays minimum 2 features to reach one additional point).

The following table provides an overview of the critical components addressed to see similarities and differences between the current GPP criteria and the other schemes.

Table 32: Critical components to be reparable addressed by different schemes

Components addressed by the criteria	EU GPP	EPEAT Computer & Display (IEEE) (Optional)	TCO Computers	Reparability Scoring System (laptops)	Draft EU Ecodesign regulation for Displays	Preparatory study for revision of EU Ecodesign regulation for computers
HDD / SSD	X (computers*: core/comprehensive)	X (Mass storage capacity)	X (Storage: HDD, SSD => Notebooks, Desktops, All-in-one PCs; ODD => Desktops, All-in-one PCs)	X	X (if applicable)	X (data storage)
Memory	X (computers*: core/comprehensive)	X (Main memory capacity)	X (RAM => Notebooks, desktops, All-in-One PCs)	X (BIOS battery CMOS)		X
Recharcheable Battery	X (computers: core/comprehensive)	All batteries	X (notebooks, tablets)	X	X (batteries and accumulators)	X
Screen assembly and LCD backlight	X (computers: comprehensive; displays: core/comprehensive)	X (Display panel or display assembly)	X (display panel/display assembly; notebooks, tablets)	X		X (Display panel)
Key board and mousepad	X (computers: comprehensive)	X (Integrated mechanical keyboards / touchpad)		X (Keyboard and keys) X (Trackpad / pointing device)		X (keyboard, trackpad or other pointing devices)
Power and control circuit boards	X (displays: core/comprehensive)	X (All external and internal power supplies)	External/internal power supply unit: Notebooks, Desktops, All-in-One PCs, Tablets; External PSU: Displays	X (External power supply EPS / AC Adaptor)	X (Internal power supply) X (External power supply)	X (internal power supply units)
Stands	X (displays: core/comprehensive)					
Main processor(s) or system on a chip (SOC)		X	CPU, GPU (PCIe), System/motherboard => Desktops, All-in-One PCs	X Motherboard		Standby button cells on motherboards

Components addressed by the criteria	EU GPP	EPEAT Computer & Display (IEEE) (Optional)	TCO Computers	Reparability Scoring System (laptops)	Draft EU Ecodesign regulation for Displays	Preparatory study for revision of EU Ecodesign regulation for computers
Wireless network capability		X				
Graphics capability (integrated or discrete)		X				
All fan assemblies		X		X (Fans and cooling fins)		
Speakers		X				
Camera		X				
I/O connectors and external power connection		X	Connectivity cables, power cables => Displays	X (ports and connectors => USB, network, charging port)	X (connectors to connect external equipment: cable, antenna, USB, DVD and Blue-ray)	
Readers (magnetic stripes, Dallas key, finger print, Smart card)		X		X (PC card slots)		
Optical drive				X	X (DVD/Blue-ray module if applicable)	
Covers and outer frames				X		
Capacitors					X	

* Tablets and two-in-one notebooks shall be exempt for computer parts HDD/SSD and Memory; source: own compilation

Usable tools: All schemes specify tools that may be used for the repairability, however in different ways:

- EU GPP requires that the components shall be easily accessible and replaceable 'by the use of universal tools (i.e. screwdriver, spatula, plier or tweezers)'.
- TCO requires in their 'products and sustainability information' criteria that information shall be provided if the replacement of the listed critical parts 'is possible without the use of heat or other tools than those intended to turn, slotted (ISO 2380), cross-recessed (Philips® and Pozidriv®, ISO 8764), or hexalobular recess heads (Torx®, ISO 10664).
- IEEE criteria require 'without soldering or de-soldering, using only commonly available tools', however not further defining these tools.
- The draft revised EU Ecodesign regulation for displays requires that 'the spare parts can be replaced with the use of commonly available tools and without permanent damage to the appliance'.
- The study on Reparability Scoring System provides comprehensive lists of tools for the repair of laptops, differentiating between basic and other commercially available tools:
- Basic tools: Screwdriver for slotted heads, cross recess or for hexalobular recess heads (ISO2380, ISO8764, ISO10664); Hexagon socket key (ISO2936); Combination wrench (ISO7738); Combination pliers (ISO5746); Half round nose pliers (ISO5745); Diagonal cutters (ISO5749); Multigrip pliers (multiple slip joint pliers) (ISO8976); Locking pliers; Combination pliers for wire stripping & terminal crimping; Prying lever; Tweezers; Hammer, steel head (ISO15601); Utility knife (cutter) with snap-off blades; Multimeter; Voltage tester; Soldering iron; Hot glue gun; Magnifying glass; Clean, soft, lint-free cloth; Magnifying glass; Quick grip clamps; Nonslip gloves; Painters tape; Isopropyl alcohol (IPA) wipe.
- Other commercially available tools: Bench power supply (for electric testing); Micro soldering iron; Oscilloscope; Fume extractor (workshop requirement); Solder fux; 'Tin' solder; Ultrasonic cleaning system; Oven for drying; Hot air welding device; Ultrasonic cleaning solution; Brush (for cleaning); Microscope; ESD-safe workstation, including ESD mat and wrist or heel strap; ESD bags (for storing ESD-sensitive parts); ESD-safe tweezers; Suction cup; Pentalobe screwdriver; Torque driver; IPR security bit for use with Torque driver; Trilobe screwdriver; Torx screwdrivers; Black stick or other nonconductive nylon or plastic flat-blade tool; Thermal grease syringe.

Additional information for repair: The analysed schemes have information requirements to facilitate repairs:

- EU GPP: clear disassembly and repair instructions, e.g. hard or electronic copy, video; to be made available via hard copy or via the manufacturer's webpage.
- IEEE: list of the hardware features that are upgradeable, repairable or replaceable and indicate, for each, whether it is upgradeable, repairable and/or replaceable.
- TCO: service manual including step by step instructions and component descriptions for the disassembly/assembly. Instructions on how to replace the critical components must be available online throughout the whole lifetime of the certificate.
- The draft EU Ecodesign regulation for displays has dedicated requirements related to the access to repair and maintenance information, however targeted to professional repairers only.
- The Reparability Scoring System for laptops proposes as pass/fail criteria that for each priority part, information about the disassembly sequence has to be available to the target group of repairers, where a description supported by illustrations of the steps needed to disassemble priority parts is needed. The description has to show that the disassembly is reversible by including the steps needed for the reassembly of priority parts.

For smartphones, TCO, TÜV and EPEAT each have dedicated requirements on design for reparability. TCO criteria for computers and smartphones only differ with regard to the components addressed, which are for smartphones the battery, display panel and assembly as well as the charger. Others than for computers, the EPEAT label for smartphones and its underlying UL110 standard have dedicated requirements on the ease of disassembling for the relevant components (display assembly, primary circuit board, and battery) including a specification of joining techniques and usable tools.

For the revision of the GPP criteria it is recommended to keep criteria on design for reparability, at least as long as the mandatory Ecodesign requirements do not apply. GPP requirements on design for reparability can also be applied to the product group smartphones. Based on the analyses of other schemes, the list of parts to be easily accessible and replacable, as well as the description of tools to be used for computers and monitors, might be revised and parts specific for smartphones should be added aligned to the lists in the TCO or EPEAT label for smartphones. For example, according to stakeholder feedback, the list of critical parts for displays is considered too strict as display panels are difficult to repair. A further aspect that might be considered in the criteria could be that the product shall have to maintain its properties after a repair operation (e.g. dustproof, waterproof, etc.).

As procurement authorities often have contracts with IT service providers and not with the manufacturers of IT equipment, the tenderer is not the organisation in charge of providing for example clear disassembly and repair instructions, thus it was suggested to ensure these aspects through the use of labelled products.

4.2.6.4. Battery replaceability

Most of the analysed ecolabel schemes as well as the EU GPP criteria have dedicated requirements with regard to the replaceability of the notebook battery; the following table provides an overview to show similarities or differences.

All schemes require information, most of them instructions how to remove the battery from the product; for the required IEEE criteria, however, the manufacturer-provided instructions shall only guide customers to have the battery replaced at a manufacturer-authorized service center whereas the optional IEEE criteria shall include the method of attachment to the product, a description how to remove the battery from the product as well as a list of the tools required for removal and, if they are not commonly available, how to obtain them.

Only EU GPP criteria prescribe that batteries shall not be glued or soldered into the products. Also, the comprehensive EU GPP criteria provide most details with regard to the number and kind of tools to be used for replacement. TCO only requires information if the battery can be replaced without tools. IEEE optional criteria require replacement either without tools or with commonly available tools, and without the use of external heat sources. Further, IEEE optional criteria prescribe the maximum time (three minutes) allowed for the battery replacement by one person.

None of the schemes explicitly requires that the battery shall be replaceable by the end-user; only Blue Angel says that replacement shall be able without the need of expert knowledge. TCO criteria on battery replacement are oriented towards both end-user and/or technician.

Green Product Mark criteria are alined to the required EPEAT/IEEE criteria ‘battery replacement and information’. Only the verification method slightly differs. Green Product Mark differentiates between batteries being user-replaceable, where for example the disassembly steps might demonstrate that the batteries are replaceable; and batteries that are not user replaceable, where manufacturer-provided instructions shall be given guiding consumers to have the battery replaced at a manufacturer-authorized service center.

Table 33: Analysis of EU GPP and ecolabel schemes: Differences in criteria on battery replacability

	Fixing of battery specified?	Tools to be used	Replacement by end user or professional service?	Disassembly information?
EU GPP	Batteries shall not be glued or soldered into portable products	Comprehensive criteria: Notebooks / portable all-in-one PCs: manually without tools Subnotebooks: maximum of 3 steps using a screwdriver Tablets and two-in-one notebooks: maximum of 4 steps using a screwdriver and spudger	Professional user or repair service provider	Instructions how to remove the battery packs shall be provided in the user instructions or via the manufacturer's webpage
EPEAT Computer & Display (IEEE) **required**	---	---	It is not required for the batteries to be user-replaceable	Information how to obtain and replace the battery, irrespective whether the product is out of warranty; Manufacturer-provided instructions guiding customers to have the battery replaced at a manufacturer-authorized service center.
EPEAT Computer & Display (IEEE) **optional**	---	Easily removable without the use of external heat sources, with no tools or with commonly available tools, and without damage that would preclude reuse or refurbishment of the product. Easily removable means that one person can remove the battery, starting from the point addressing the battery attachment, in less than three minutes following the manufacturers instructions.	Not specified	Information regarding lithium ion batteries: Indicating the method of attachment to the product Describing how to remove from the product Listing the tools required for removal and, if they are not commonly available, how to obtain them
Blue Angel Computers	---	Not specified; 'easy' replacement	'Without expert knowledge'	The product documents shall describe the battery replacement process
Green Product Mark Computers	---	---	It is not required for the batteries to be user-replaceable	Manufacturer-provided instructions guiding customers to have the battery replaced at a manufacturer-authorized service center. If battery is user-replaceable, demonstration that it is replaceable, e.g.

	Fixing of battery specified?	Tools to be used	Replacement by end user or professional service?	Disassembly information?
				disassembly / assembly steps)
TCO Computers	---	Product information criteria: Product replaceable without tools?	End-user and/or technician	Instructions on how to replace the battery must be available for anyone to read, free of charge, online through the whole lifetime of the certificate

Source: Own compilation according to sources in Table 7

GPP criteria are strictest with regard to prohibiting the glueing or soldering of batteries into portable products at all; however, with feedback from some stakeholders of being too restrictive as many products have the battery soldered and can only be replaced by a certified technician. Blue Angel and TCO go beyond GPP criteria by addressing also end-users as potential target group for battery replacements. On the other hand, procurement authorities often have contracts with IT service providers and not with the manufacturers of IT equipment, so that the responsibility of the tenderer, service provider and manufacturers with regard to battery replacement (which is sometimes even covered by 'product as a service' models should be clearly defined.

TCO criteria related to instructions on how to replace the battery are most detailed and ambitious as they must be available for anyone to read, free of charge, online through the whole lifetime of the certificate. For the revision of the GPP criteria, for example, the duration of information availability could be specified as well.

Finally, TCO, Blue Angel and EPEAT criteria for smartphones are the same or very similar to the according criteria schemes for notebooks. Thus, if the scope of the GPP criteria is widened to the product group smartphones, requirements on battery replacement for notebooks should also apply to smartphones.

4.2.6.5. Rechargeable battery life and endurance

EU GPP as well as all analysed labelling schemes except for Green Product Mark have criteria with regard to life and endurance of the rechargeable battery; Blue Angel, TCO and Nordic Swan as obligatory, EU GPP as award, and IEEE as optional criteria. All schemes refer to standard IEC 61960 or related EN 61960 / DIN EN 61960 standards respectively. IEC 61960-3:2017 specifies performance tests, designations, markings, dimensions and other requirements for secondary lithium single cells and batteries for portable applications.

However, detailed test conditions and endurance requirements seem to differ slightly between the schemes, see following overview:

Table 34: Analysis of EU GPP and ecolabel schemes: Differences in test conditions of rechargeable battery life and endurance measurements

	Test procedure	Minimum number of cycles
EU GPP (award criteria)	IEC EN 61960 'endurance in cycles' test carried out at 25°C and at a rate of either 0.2 ItA or 0.5 ITA	Core award criteria: Greater than 300 cycles (80% capacity retention) Comprehensive award criteria: Greater than 500 cycles (80% capacity retention) Additional points can be given for cycle numbers beyond the above limits up to 1000 cycles and more
EPEAT Computer & Display (IEEE) **optional**	IEC 61960. The IEC 61960 test parameters and definitions (for cycle, C and ambient temperature) shall be modified as specified in the IEEE requirement.	1000 cycles (65% of its original design capacity). A battery that is tested to a shorter cycle count with a greater capacity, e.g., 80% capacity after 300 cycles, does not meet the requirements of this criterion.
Blue Angel Computers	EN 61960, as amended (current version: DIN EN 61960:2012-04), in accordance with standard paragraph 7.3.1 'Discharge performance at 20°C (rated capacity)'	500 cycles (at least 80% of the nominal capacity)
Nordic ecolabelling	In accordance with standard paragraph 7.3. 'Discharge performance at 20°C (rated capacity)' of IEC 61960-3:2017	Examples of requirements for minimum number of cycles for secondary lithium cells and batteries: Endurance in cycles at a rate of 0.2 ItA: Number of cycles – cells: ≥ 700 Number of cycles – battery: ≥525
TCO Computers	Not specified; standard used for testing shall be included in the required product form to be submitted to the verifier	300 charging cycles with at least 60% of the initial capacity.

Source: Own compilation according to sources in Table 7

Ideally, the different capacity retentions and number of cycles applied so far in various label schemes and GPP criteria should be harmonized, also to allow existing ecolabel certification as verification method for GPP. Therefore, it should also be discussed if the optional EPEAT criteria (1000 cycles, but only 65% residual capacity) might be best reflecting the longevity of the battery, as the degradation of a battery might not be linear. In total, more than 1400 notebooks and tablets/slates listed in the EPEAT database of four manufacturers fulfil this requirement. On the other hand, TCO criteria seem not challenging as according to feedback by TCO, most of products they tested perform at 300 charging cycles still with more than 90% of SoC. For comparison: The preparatory study on the revision of the EU Ecodesign regulation for computers proposes criteria with regard to the provision of information on battery lifetime: Manufacturers shall test the batteries of mobile personal computers in accordance with the most recent version of the standard EN 61960 and communicate in the user documentation the remaining full charge capacity of the battery compared to the initial charge capacity, after 300 and 500 charge/discharge cycles. The remaining full charge capacity of the battery compared to the initial charge capacity after 500 charge/discharge cycles shall be indicated in the product information sheet and in the energy label.

With regard to smartphones, TCO, Blue Angel as well as TÜV have requirements on battery life and endurance; TCO requirements for smartphones are the same as for notebook

batteries; Blue Angel criteria only differ with regard to the remaining capacity (80% for notebook batteries, 90% for smartphone batteries). Both label schemes as well refer to EN 61960 as test standard. Thus, as the criteria for smartphones are the same or very similar to the according criteria schemes for notebooks, requirements on battery life and endurance for notebooks should also apply to smartphones if the scope of the GPP criteria is widened to the product group smartphones.

In addition to the endurance requirements for batteries, it should be discussed to add another software related requirement: Blue Angel requires the existence of software determining the Battery/Accumulator status and allowing the reading of the battery's/accumulator's 'state of health', 'state of charge', as well as the number of full charge cycles already performed from the battery/accumulator and to display these data for the user. Further, a required Battery/Accumulator Protection Software shall be able to limit the battery's/accumulator's charge to a value smaller than the maximum amount of usable electricity (e.g. 80% of full charge capacity) to extend the battery's life.

Also the preparatory study on the revision of the EU Ecodesign regulation for computers proposes criteria with regard to a 'Battery optimization built-in functionality': Manufacturers shall provide pre-installed software to enable a limit on the battery state of charge (SoC) when the computer is used systematically in grid operation. Such functionality shall prevent the battery to be loaded at full charge. The manufacturer shall inform the user of the existence and the benefits of using such functionality.

Similar to that, another proposal to be discussed would be adding a requirement on the provision of certain benchmarking software to calculate the charge duration of a laptop in a typical use profile. For example, DG DIGIT applied the BAPCo MobileMark 2014 version 1.5 (patch 1 v1.5.1.55)[129] rating with 330 minutes as minimum requirement. This performance battery life metrics is based on real applications and does not only measure battery life, but battery life and performance at the same time to show how well a system design handles the trade-off between performance and energy management.

4.2.6.6. Product durability

Only EU GPP award criteria (comprehensive) and TCO ecolabel have requirements on durability tests for notebooks and tablets, both referring to test procedures as specified in the US MIL-STD-810G or IEC 60068. The TCO criteria also apply to smartphones.

TCO requires a drop test as well as a temperature stress test (high and low temperature); in addition to a drop and temperature stress test, EU GPP criteria further entail resistance to shock and vibration as well as screen resilience. Additionally, EU GPP has dedicated durability criteria for computer drives.

The detailed conditions of the drop and temperature tests slightly differ with stricter requirements for EU GPP; see following table.

Test conditions for temperature test: According to EU GPP, the notebook shall be subjected to a minimum of four 24 hour exposure cycles in a test chamber. TCO test cycles are ≥ 48h for storage and ≥ 4h for operational temperature.

[129] See https://bapco.com/products/mobilemark-2014/

Table 35: Differences in test conditions of durability tests between EU GPP and TCO

	High temperature	Low temperature	Drop test
EU GPP	The notebook shall be operational during a dry heat cycle at +40°C. The notebook shall be non-operational a dry heat cycling between +35°C and +60°C.	The notebook shall be operational during a cold cycle at -25°C. The notebook shall be non-operational during a cold cycle at -50°C	≥ 76 cm drop height onto a non-yielding surface. A minimum of one drop shall be made on each bottom side and each bottom corner.
TCO Computers	Operational temperature for ≥ 4h: ≥ +40°C Storage temperature for ≥ 48h: ≥ +60°C;	Operational temperature for ≥ 4h: ≤ -20°C Storage temperature for ≥ 48h: ≤ -30°C;	≥ 45 cm drop height

Source: Own compilation according to sources in Table 7

According to stakeholder feedback the approach of the durability testing is generally supported. TCO has set the drop test limit to 45cm after discussions with the industry. TCO reports that, even at this level, there are premium products not being able to pass this criterion and therefore fail to certify accordingly to TCO Certified.

Further, the analysis of voluntary approaches of front-running companies (see section 4.2.4) revealed that only few companies seem to apply US MIL-STD-810G or IEC 60068 as regular product durability tests, either to appliances for professional use (see example of HP), or especially for so called 'rugged' appliances (see examples of Dell and Zebra Technologies). On the other hand, some manufacturers at least seem to use the International Protection (IP) marking standard for dust and water resistance for their products.

For the revision of the GPP criteria, it should be discussed if for example the TCO conditions for temperature and drop tests could be introduced as core criteria, whereas the so far more ambitious GPP criteria could still be kept as comprehensive award levels. It was also suggested to better specify how to determine if a product passes or fails the test. Further, according to stakeholder feedback, it was suggested to use internationally acknowledged standards (similar to MIL standard 810-G) with regard to the durability requirement for computer drives.

Finally, it should be discussed if the IP marking standard for dust and water resistance is of relevance for IT products used in professional working environments and should be included as further GPP criteria. For example, the preparatory study for the revision of the EU Ecodesign regulation for computers proposes a requirement on 'Liquid spill protection': Manufacturers shall inform consumers in user documentation and publicly available websites on the liquid protection class for mobile personal computers, assessed in accordance with the most recent version of the standard EN 60529.A logo shall indicate the liquid protection class in accordance with the most recent version of the standard IEC 60529. The logo shall be included on the label and the product information sheet of the mobile personal computers with keyboard not detached. Liquid spill protection is not addressed in the current EU GPP criteria so far.

As smartphones due to their mobile use are generally prone to the conditions described above (dust, drops, liquid spill, and temperature stress), product durability criteria should also applied if the scope of the GPP criteria is widened to the product group smartphones.

4.2.6.7. Upgradability, capacity extension and standardised interfaces

EU GPP award criteria as well as several ecolabel schemes have rather different criteria on upgradeability, capacity expansion or standardised interfaces. The comprehensive award criteria of EU GPP foresee certain requirements for the RAM memory (minimum capacity or the potential to upgrade it) as well as the potential to upgrade the mass storage. However, according to stakeholder feedback, the criterion on minimum RAM memory capacity restricts the market, and that some Operating Systems require less RAM (only 2 to 4 GB).

Also Blue Angel requires the replacement or expansion of RAM and of the mass storage. Further, Blue Angel has criteria on interfaces, on the one hand connectivity to external monitors, on the other hand the existence of two or more USB 3.0 or later ports. The latest TCO Generation 8 criteria even go beyond and require computers to carry at least – built-in or delivered as separate adapter – one USB-Type C connector which is a universal connector with more pins, different design and performance compared to USB 3.0, that allows both charging and data transfer. According to the TCO criteria document, USB-C is designed to be more robust and future proof than existing USB interfaces, helping to prevent problems with failing ports and to decrease the need for different cables. The TCO criteria also apply to smartphones.

The Green Product Mark requires using a standardized power supply to enable easy reuse of used power supplies.

For the revision of the GPP criteria, it should be discussed if separate criteria on upgradeability are still needed, against the background that more and more 'Product as a Service' models include also regular upgrades, the requirement on minimum memory capacity was critizised by stakeholders, and the potential to replace and upgrade the RAM might already be covered by the requirements on design for reparability.

In this context, it is noteworthy that TÜV and Blue Angel criteria for smartphones include requirements on the upgradeability / update of the operating system. The aim of these updates is, above all, the closing of security holes, as well as other software updates, if applicable. For Blue Angel, security updates for the operating system of the mobile phone shall be offered for at least 4 years from the time that production ceases. As such updates are often precondition for the further operation of IT devices in Public Authorities, it has direct relevance to the usage time and durability and should be included into GPP criteria, either as dedicated requirement or included in criteria on a service agreement.

4.2.6.8. Secure data removal from products

TCO has dedicated requirements on secure data removal from products (valid for computers and smartphones) due to the experience that fear of confidential data leakage often prevents companies and individuals from making their products available on the second-hand market. By reusing computers, their usable life can be extended which is an effective way of reducing their environmental impact. The requirements include the provision of media sanitization software by the brand owner. The IEEE standard, basis for the **EPEAT ecolabel for computers**, refers to secure data removal from computers only in their optional information requirements, requesting instructions on how the user can remove personal data, whereas the UL110 standard as basis for the EPEAT ecolabel for smartphones requires a feature (software function or another option) to erase all user data from the mobile phone. Also the **Blue Angel ecolabel for smartphones** has criteria on data deletion, i.e. a design to enable the user to completely and securely delete all personal data without the help of pay software.
The **preparatory study on the revision of the EU Ecodesign regulation for computers** proposes to introduce requirements on personal data deletion: A built-in secure data deletion functionality or software shall be made available to support the deletion of data contained in data storage components (e.g. hard drives and solid state drives) in function of the risks faced and in order to grant the security of personal data and to facilitate the reuse. Availability of functionality for secure data deletion is already included in EU Ecodesign regulation 2019/424 on servers and data storage products:

Functionality for secure data deletion shall be made available for the deletion of data contained in all data storage devices of the product; information requirements on the secure data deletion functionality, including instructions on how to use the functionality, the techniques used and the supported secure data deletion standard(s), if any. According to the regulation, the requirement on a functionality for secure data deletion could be implemented by means of technical solutions such as, but not limited to, a functionality implemented in firmware, typically in the Basic Input/Output System (BIOS), in software included in a self-contained bootable environment provided in a bootable compact disc, digital versatile disc or universal serial bus memory storage device included with the product, or in software installable in the supported operating systems provided with the product. Also the **study on Reparability Scoring System** proposes to assign a scoring for the product based on the availability of secure data transfer and deletion functionality, either if built-in secure data transfer and deletion functionality is available to support the deletion or transfer of all data contained in data storage parts (i.e. hard drives and solid state drives), secure data transfer and deletion is permitted without restrictions, using freely accessible software or hardware solutions, or secure data transfer and deletion is available on request to support the deletion of all data contained in data storage parts (i.e. hard drives and solid state drives).

So far, EU GPP criteria address secure data erasure only indirectly under the technical specifications (core and comprehensive) on 'secure computer collection, sanitisation, re-use and recycling' where tenderers shall provide a re-use and recycling service and demonstrate how they will carry out confidential handling and secure data erasure; see 'Take-back schemes' in section 0. For the revision of GPP criteria it is recommended to include also dedicated requirements on the product's or service provider's availability of functionality for secure data deletion, not only at the end-of-life, but also to facilitate reuse and thus product lifetime extension. The criteria should not only apply to computers, but also to smartphones if the scope of the GPP criteria is expanded to this product category.

4.2.6.9. Product information and service support

Some Ecolabel schemes, namely EPEA/IEEE, Blue Angel and Green Product Mark have dedicated criteria sections summarizing information requirements which also include those ones on lifetime extension. However, it seems that most of this required information is also already included in the other criteria sections, e.g. information on repairability, list of spare parts etc. Thus, it is not recommended to include separate product information requirements into the revised GPP criteria.

4.2.6.10. Further criteria proposals

Product lifetime extension:

- According to stakeholder feedback, it was suggested to have second-hand products as first option for less demanding users (e.g. education). The analysis of voluntary approaches of manufacturers revealed that some manufacturers offer own refurbished products, see for example Apple's 'Certified Refurbished products' which are based on full testing to meet the same functional standards as new products and have a one-year guarantee (cf. section 4.2.4).
- Instead of criteria on warranties and cost competitiveness of spare parts, for Green Public Procurement requirements with regard to offers of 'Product as a Service' models could be of higher relevance which often include regular software updates, repairs (if necessary) as well as end-of-life management.
- Dedicated requirements on the availability of functionality for secure data deletion, not only at the end-of-life, but also to facilitate reuse and thus product lifetime extension. For example, some companies offer Device Recovery Services, which also include data sanitization (cf. section 4.2.4).

4.3. Design for End-of-life, materials selection and End-of-life management

4.3.1. Current EU GPP criteria and their application

Recyclability of plastics casings, enclosures and bezels

No applications are reported. Some respondent consider this not fully targeting the real issues as most recycling facilities now and in the future are going to be automated, meaning that the product is shredded and separated by chemical or mechanical processes. Other stakeholders from Flanders reported plastic to be separated and recycled (Renewi plant)

Verification process of the TS7b is considered as challenging and costly, especially if verification is needed for all plastic parts before a certificate can be issued (TCO).

For the Marking of plastic casings, enclosures and bezels (TS8) as verification, one of the following (granted to the product) is reported to be sufficient for this criterion: TCO Certified Displays 7.0, or TCO Certified Notebooks 5.0, or TCO Certified Desktops 5.0, or other proof given by the Supplier.

Product dismantling potential

Product dismantling potential (AC10) is not supported by respondents from industry in absence of standardised methods.

4.3.2. Legal provisions

4.3.2.1. EU Ecodesign Regulation 617/2013 on computers and computer servers

Current EU Ecodesign regulation 617/2013 with regard to ecodesign requirements for computers and computer servers do not address the topic of end-of-life management at all. The EU Ecodesign regulation and its requirements on computers and computer servers are under revision; the revision study has been finalised in July 2018. No draft regulation was available at the time of the analysis for this report (mid July 2019). Task 7 report of the revision study[130] provides the following proposals related to end-of-life management:

Table 36: EU Ecodesign revision study for computers: Proposals (overview) of requirements with regard to end-of-life management

Potential requirement	Product sub-group		Type of requirement	Focus area
	Mobile	Non-mobile		
Computer dismantling	✓	✓	Dismantlability features for key components available and described in *technical documentation*	Recyclability
Plastic parts	✓	✓	Marking of plastic components > 50 g	
Plastic parts containing flame retardants	✓	✓	Declaration of flame retardants in *technical documentation*	
Batteries	✓		Marking of battery chemistry by a *standardised logo*	

Source: Preparatory study on the Review of Regulation 617/2013 (Lot 3) Computers and Computer Servers, Task 7 report

[130] https://computerregulationreview.eu/sites/computerregulationreview.eu/files/Preparatory%20study%20on%20review%20computer%20regulation%20-%20Task%207%20VM%2019072018.pdf

Proposed requirements (details) related to product lifetime extension according to EU Ecodesign revision study on computers and computer servers, Task 7 report[131].

Table 37: EU Ecodesign revision study for computers: Proposals (details) of requirements with regard to end-of-life management

Topic	Proposed Ecodesign requirement(s)
Computer dismantling	Manufacturers shall ensure that joining or sealing technique do not prevent the dismantling of components listed in point 1 of Annex VII of Directive 2012/19/EU, when present. Dismantling of these components shall be ensured by making an exploded diagram of the computer with the location of the components available in technical documentation, and the sequence of dismantling operations needed to access and remove the components, including: type of operation, type and number of fastening technique(s) to be unlocked, tool(s) required, safety requirements and risks (if any) related to the dismantling operations. Exemptions apply where non removable joining and sealing techniques are required to assure safety. When exemptions apply, these should be described in the technical documentation.
Plastic parts	Manufacturers shall mark plastic components heavier than 50 g by specifying the type of plastic and flame retardant(s) using symbols and abbreviations in line with standard series EN ISO 11469 and EN ISO 1043. For the following plastic components, no marking is required: • packaging, tape and stretch wraps • labels, wiring and cables • PCB assemblies, PMMA board and optical plastics, electrostatic discharge components; electromagnetic interference components, acoustic modules. In addition, plastic components in the following circumstances are exempted from marking requirements: • the marking is not possible because of the shape or size • the marking would impact on the performance or functionality of the plastic component • marking is technically not possible because of the molding method. For exempted plastic parts, manufacturer shall provide a justification in the technical documentation.
Batteries	Battery packs and cells (including those incorporated into battery packs) shall be marked with marking symbols for the correct identification of their chemistry. The marking symbol shall be durable and legible. (Standardization activities are needed to define useable marking symbols and their correlation with battery types. The draft standard IEC 62902 can be used as a reference, or may be adapted, to mark batteries with volume equal or smaller than 900 cm^3.)

Source: Preparatory study on the Review of Regulation 617/2013 (Lot 3) Computers and Computer Servers, Task 7 report

[131] https://computerregulationreview.eu/sites/computerregulationreview.eu/files/Preparatory%20study%20on%20review%20computer%20regulation%20-%20Task%207%20VM%2019072018.pdf

4.3.2.2. EU Ecodesign Regulation 2019/424 on servers and data storage products

Although EU Ecodesign regulation 2019/494 does not cover product groups being in scope of the EU GPP criteria for computers and monitors, the most recent Ecodesign criteria on computer equipment could nevertheless be guiding also for the revision of the GPP criteria. Related to End-of-life management, the EU Ecodesign regulation 2019/424 applies following criteria to servers and online data storage products:

Table 38: EU Ecodesign Regulation 2019/424 on servers and data storage products: Requirements with regard to end-of-life management

Instructions on Critical Raw Materials (CRM)	The following product information on servers and online data storage products shall be made available from the time a product model is placed on the market until at least eight years after the placing on the market of the last product of a certain product model free of charge by manufacturers, their authorised representatives and importers to third parties dealing with maintenance, repair, reuse, recycling and upgrading of servers (including brokers, spare parts repairers, spare parts providers, recyclers and third party maintenance) upon registration by the interested third party on a website provided: Indicative weight range (less than 5 g, between 5 g and 25 g, above 25 g) at component level, of the following critical raw materials: (a) Cobalt in the batteries; (b) Neodymium in the HDDs.
Instructions on disassembly operations	The following product information on servers and online data storage products shall be made available from the time a product model is placed on the market until at least eight years after the placing on the market of the last product of a certain product model free of charge by manufacturers, their authorised representatives and importers to third parties dealing with maintenance, repair, reuse, recycling and upgrading of servers (including brokers, spare parts repairers, spare parts providers, recyclers and third party maintenance) upon registration by the interested third party on a website provided: Instructions on the disassembly operations referred to in the requirements, including, for each necessary operation and component: (a) the type of operation; (b) the type and number of fastening technique(s) to be unlocked; (c) the tool(s) required. Components addressed: - data storage devices; - memory; - processor (CPU); - motherboard; - expansion card / graphic card; - PSU; - chassis; - batteries.

Source: EU Ecodesign regulation 2019/424

4.3.2.4. EU Ecodesign Regulation on electronic displays (draft revised)

The draft version of the revised Ecodesign regulation on electronic displays inter alia applies to computer monitors, whereas electronic displays integrated into computers, such as tablets, laptops or 'all-in-one' desktops should be covered in the review of Regulation 617/2013 on computers.

Related to end-of-life management, draft revised EU Ecodesign regulation on electronic displays has proposed following criteria:

Table 39: Draft revised EU Ecodesign Regulation on electronic displays: Requirements with regard to end-of-life management

Design for disassembly, recycling and recovery	Manufacturers, importers or their authorised representatives shall ensure that joining, fastening or sealing techniques do not prevent the removal, using commonly available tools, of the components indicated in point 1 of Annex VII of Directive 2012/19/EU on WEEE or in Article 11 of Directive 2006/66/EC on batteries and accumulators and waste batteries and accumulators, when present. Manufacturers, importers or their authorised representatives shall, without prejudice to point 1 Article 15 of Directive 2012/19/EU, make available the dismantling information needed to access, any of the products components referred to in point 1 of Annex VII of Directive 2012/19/EU on a free-access website. This dismantling information shall include the sequence of dismantling steps, tools or technologies needed to access the targeted components. The end of life information shall be available until at least 15 years after the placing on the market of the last unit of a product model.
Marking of plastic components	Plastic components heavier than 50 g: (a) Shall be marked by specifying the type of polymer with the appropriate standard symbols or abbreviated terms set between the punctuation marks '>' and '<' as specified in available standards. The marking shall be legible. Plastic components are exempt from marking requirements in the following circumstances: (i) The marking is not possible because of the shape or size; (ii) The marking would impact on the performance or functionality of the plastic component; and (iii) Marking is technically not possible because of the molding method. For the following plastic components no marking is required: (i) Packaging, tape, labels and stretch wraps; (ii) Wiring, cables and connectors, rubber parts and anywhere not enough appropriate surface area is available for the marking to be of a legible size; (iii) PCB assemblies, PMMA boards, optical components, electrostatic discharge components, electromagnetic interference components, speakers; (iv) Transparent parts where the marking would obstruct the function of the part in question. (b) Components containing flame retardants shall additionally be marked with the abbreviated term of the polymer followed by hyphen, then the symbol 'FR' followed by the code number of the flame retardant in parentheses. The marking on the enclosure and stand components shall be clearly visible and readable.

Source: Draft revised EU Ecodesign Regulation on electronic displays

4.3.3. Analysis of Design for End-of-life, materials selection and End-of-life management requirements in EU GPP and Ecolabel schemes

Table 40: Analysis of EU GPP and ecolabel schemes: Criteria on materials selection: Recycled or biobased plastic content

EPEAT Computer & Display (IEEE)	Required: Minimum post-consumer recycled plastic, ITE-derived post-consumer recycled plastic or biobased plastic content Product shall contain, on average, a minimum of 2% of any combination of postconsumer recycled plastic, ITE-derived post-consumer recycled plastic, or bio based plastic, measured as a percentage of total amount of plastic (by weight) in the product. The following may be excluded from the calculation of percentage: a) Printed circuit boards, labels, cables, connectors, electronic components, optical components, ESD components, EMI components, adhesives, and coatings b) For ruggedized devices - External enclosure and - Specialized parts, such as swivels and hinges c) External components integral to the operation of the product and sold with the product If an allowable exclusion is used, the plastic content of the component or part must be excluded from both the numerator and the denominator of the calculation of percentage. This criterion is 'Not Applicable' if the product contains a total combined weight of plastic < 100 g after exclusions are removed. --- Optional: Higher post-consumer recycled plastic, ITE-derived post-consumer recycled plastic or biobased plastic content Product shall contain, on average, a minimum total percentage of any combination of post-consumer recycled plastic content, ITE-derived post-consumer recycled plastic content, or bio-based plastic content as defined in Table 6. The portion of ITE-derived post-consumer recycled plastic content applied toward Criterion 4.2.1.3 shall not be applied toward this criterion (i.e., shall not be included in the numerator, and shall be included in the denominator for the calculation). Total percentage content is measured as a percentage of total included plastic (by weight) in the product. Minimum % content for 1 optional point: - Desktop computer, workstation, thin client, portable all-in-one computer, and small scale server: 10% - Integrated Desktop computer: 15% - Notebook computer: 5% - Tablet / Slate: 3% - Monitor: 15% Minimum % content for 2 optional points: - Desktop computer, workstation, thin client, portable all-in-one computer, and small scale server: 35% - Integrated Desktop computer: 40% - Notebook computer: 10% - Tablet / Slate: 5% - Monitor: 50% The following may be excluded from the calculation of percentage: - Printed circuit boards, labels, cables, connectors, electronic components, optical components, ESD components, EMI components, adhesives and coatings. - Specialized plastic parts such as swivels and hinges for ruggedized devices. - External components integral to the operation of the product and sold with the product. If an allowable exclusion is used, the plastic content of the component or part must be excluded

	from both the numerator and the denominator of the calculation of percentage. If the sum of included plastic after exclusions are removed weighs less than 100 g, the manufacturer may declare 'Not Applicable' for this criterion. If conformance to this criterion is interrupted by temporary circumstances limited to natural disasters (i.e., fire, flood, earthquakes, typhoons, hurricanes, etc.), acts of war or terrorism, significant labor strikes, or devastating accidents to a supplier facility (i.e., explosion, structural collapse, fire, etc.), conformance to the criterion may be retained if the manufacturer demonstrates the intent to reinstate the supply. This criterion cannot be initially claimed during such a supply interruption. --- Optional: ITE-derived post-consumer recycled plastic content Product shall contain, on average, a minimum of ITE-derived post-consumer recycled plastic per either following methods: a) Product external enclosure shall contain, on average, a minimum of 10% ITE-derived postconsumer recycled plastic, measured as a percentage of total plastic (by weight) in the enclosure. The following may be excluded from the calculation of percentage if applicable to the enclosure: printed circuit boards, labels, cables, connectors, electronic components, optical components, ESD components, and EMI components. b) Product shall contain, on average, a minimum of 10% ITE-derived post-consumer recycled plastic, measured as a percentage of total amount of plastic (by weight) in the product. The following may be excluded from the calculation of percentage: 1) Printed circuit boards, labels, cables, connectors, electronic components, optical components, ESD components, EMI components, adhesives and coatings 2) Specialized parts such as swivels and hinges for ruggedized devices 3) External components integral to the operation of the product and sold with the product For external enclosures for which the sum of plastic parts in the enclosure weighs less than 10% by weight of the enclosure and the sum of included plastic after exclusions are removed weighs less than 100 g the manufacturer may declare 'Not Applicable' for this criterion.
Blue Angel Computers	Material selection (Post-consumer) recyclate material may be used in housing parts and chassis. It may be used on a percentage basis.
TÜV Green Product Mark Computers	Recycled (Post Consumer) plastic material Content For Recycled (Post Consumer) plastic material Content, the applicant shall provide evidence based on the Verification ISO14021:1999, National Green Scheme (Eco Label, IEEE1680:2006). The limit should conform to optional requirement until Dec.31st, 2014 to use ≥10% Post Consumer plastic material Content (PCC) of the enclosure, keyboard and stand. Starting with Jan. 1st. 2015, 10% PCC becomes a mandatory obligation.
TCO Computers / TCO Smartphones	The published sustainability performance indicators Percentage of post-consumer recycled plastic by weight of total weight of all product parts made out of plastic (except panels, electronic components, cables, connectors, PWBs, insulating mylar sheets and labels).
TUV Green Product Mark Mobile Phones	The applicant shall provide the declaration that states post-consumer recycled material content of plastic part (Enclosure, frame and keyboard, excluding PCB, cable, label and electronic components) of the product shall not less than 10%.
EPEAT Mobile Phones (UL 110)	Required – Declaration of post-consumer recycled and biobased plastics content Manufacturer shall declare both the minimum percentage of post-consumer recycled plastic content, and minimum percentage of biobased plastic content, each calculated as a percentage of total plastic (by weight) in the product. This declaration shall be available to the public through the manufacturer's website, or other publicly accessible electronic resources. The following may be excluded from the calculation of percentage: printed circuit boards, labels, cables, connectors, electronic components, optical components, electrostatic discharge (ESD)

components, electromagnetic interference (EMI) components, films, coatings and adhesives.

Demonstration of conformance shall include a supplier letter stating minimum percentage of post-consumer recycled and biobased plastic content in material supplied to manufacturer or to manufacturer's part supplier, and documentation of calculation; and is not required if a declaration is zero content.

Note: A declaration of 0% is acceptable for this criterion.

If the product does not contain any non-excluded plastics, "Not Applicable" may be declared.

Optional – Post-consumer recycled plastic and biobased plastic content in the mobile phone

The use of any combination of post-consumer recycled and biobased plastic content in the mobile phone – calculated as a percentage of total plastic (by weight) in the mobile phone – shall be awarded points on a sliding scale as shown in Table 8.1.

Table 8.1
Post-Consumer Recycled Content and Biobased Content
(measured as a percentage of the total weight of plastic in the mobile phone)

Total Combined Post-Consumer Recycled Content and Biobased Content	Points Awarded
1% – 5%	1
> 5% – 10%	2
> 10% – 25%	3
> 25%	4

The following may be excluded from the calculation of percentage: printed circuit boards, labels, cables, connectors, electronic components, optical components, ESD components, EMI components, films, coatings and adhesives.

If the mobile phone does not contain any non-excluded plastics, "Not Applicable" may be declared.

Note: Verification of biobased content can be determined using ASTM D6866-04a.

Optional – Post-consumer recycled plastic and biobased plastic content in accessories

The use of post-consumer recycled plastic and biobased plastic content in the accessories – calculated as a percentage of total plastic (by weight) in the accessories – shall be awarded points on a sliding scale as shown in Table 8.2.

Table 8.2
Post-Consumer Recycled Content and Biobased Content of Accessories
(measured as a percentage of the total weight of plastic in the accessories)

Total Combined Post-Consumer Recycled Content and Biobased Plastic Content	Points Awarded
1% – 5%	1
> 5% – 10%	2
> 10%	3

The following may be excluded from the calculation of percentage: printed circuit boards, labels, cables, connectors, electronic components, optical components, ESD components, EMI components, films, coatings and adhesives.

If the accessories do not contain any non-excluded plastics, "Not Applicable" may be declared.

Source: Own compilation according to sources in Table 7

Table 41: Analysis of EU GPP and ecolabel schemes: Criteria on marking of plastic parts for recycling

EU GPP	Technical specification (core) Marking of plastic casings, enclosures and bezels External plastic casings, enclosures and bezels with a weight greater than 100 grams and a surface area greater than 50 cm^2 shall be marked in accordance with ISO 11469 and ISO 1043-1.	Technical specification (comprehensive) Marking of plastic casings, enclosures and bezels External plastic casings, enclosures and bezels with a weight greater than 25 grams for tablet and portable all-in-one notebooks and 100 grams for computers and monitors and in all cases a surface area greater than 50 cm2 shall be marked in accordance with ISO 11469 and ISO 1043, sections 1 and 4.
EPEAT Computer & Display (IEEE)	Required: Plastics recyclability / Plastic parts compatible with recycling All discrete plastic parts shall meet the following requirements: For discrete plastic parts >25 g: a) Clearly marked with material type in accordance with ISO 11469/1043, excluding optical parts. The following are excluded from this requirement: - Printed circuit boards for item a) - Wires and cables, connectors, electronic components, optical components, acoustic components, ESD components, and EMI components	
Blue Angel Computers	Material selection Plastic parts with an mass greater than 25 grams each and an even surface area of more than 200 mm^2 must be permanently marked in accordance with ISO 11469 with due regard to ISO 1043, Parts 1 to 4. Transparent plastic parts the function of which requires transparency (e.g. visible plastic films in displays) shall be exempt from marking according to ISO 11469.	
TÜV Green Product Mark Computers	Recycle Design / Material Labelling For Material Labelling, the applicant shall provide evidence based on the ISO 11469. The limit shall ensure that: - Plastic components greater than 25 grams in mass shall be marked in accordance with ISO 11469.	
TCO Computers / TCO Smartphones	Material recovery / Material coding of plastics - Parts made mainly of plastics weighing more than 25 grams (5 grams for smartphones) must be material coded in accordance with ISO 11469 and ISO 1043-1, -2, -3, -4. - Exempted are printed wiring board laminates as well as plastic parts containing other materials in any significant amounts. Applicable to Displays, notebooks, tablets, smartphones, desktops, and all-in-one PCs	
TÜV Green Product Mark Mobile Phones	The applicant shall provide declaration that states plastic components greater than 25 grams in mass shall be marked in accordance with ISO 11469.	

Source: Own compilation according to sources in Table 7

Table 42: Analysis of EU GPP and ecolabel schemes: Criteria on marking of batteries for recycling

Blue Angel Computers	Battery / Accumulator Marking The battery/accumulator (or battery/accumulator pack) must be marked in accordance with standard EN 61960 providing at least the following information: • nominal capacity (N), • nominal voltage, • type designation, • date of manufacture (may be coded). These specifications (except for the date of manufacture) shall also be given in the product documents. In case the date of manufacture has been given in coded form the product documents shall include instructions for decoding. In addition, the battery/accumulator (or battery /accumulator pack) shall provide the following information to help improve the recycling process: • indication of the metal with the greatest mass percentage (e.g. cobalt, manganese, nickel, iron), • indication of substances contained in the battery/accumulator that hinder the recycling process (e.g. tin, phosphorous). • This information may also be provided in coded form, for example, in accordance with the marking system proposed by the Battery Association of Japan (BAJ).
Blue Angel Mobile Phones	Battery Marking: The battery (or battery pack) must be marked in accordance with EN 61960 providing at least the following information: • nominal capacity (N), • nominal voltage, • type designation, • date of manufacture (may be coded). These specifications (except for the date of manufacture) shall also be given in the product documents. In case the date of manufacture is coded the product documents shall include instructions for decoding. In addition, the battery (or battery pack) shall be marked with an international recycling symbol as given in ISO 7000 (Graphical symbols for use on equipment) and specify the cell chemistry of the battery (e.g. Li-Ion, Ni-MH). This symbol shall be colour-coded in accordance with the recommendations of the Battery Association of Japan[132] or the draft IEC 62902 standard (Secondary batteries: Marking symbols for identification of their chemistry):  Colour: blue (Pantone 312)  Colour: orange (Pantone 1375) Compliance Verification: The applicant shall declare compliance with the requirements, specify nominal capacity (in mAh or Ah), nominal voltage and type designation as well as the cell chemistry in Annex 1 to the Contract, highlight the relevant passages in the product documents that include these data and present the relevant pages of the product documents in Annex 2 to the Contract. Also, the applicant shall present (in Annex 6 to the Contract) a photo of the secondary battery that shows all of the data mentioned above.

Source: Own compilation according to sources in Table 7

[132] Battery Association of Japan, Recycling portable rechargeable batteries, http://www.baj.or.jp/e/recycle/recycle04.html

Table 43: Analysis of EU GPP and ecolabel schemes: Criteria on recyclability of products, structure / joining techniques, dismantling

EU GPP	Technical specification (comprehensive) Recyclability of plastics casings, enclosures and bezels Parts shall not contain moulded-in or glued-on metal inserts unless they can be removed with commonly available tools. Disassembly instructions shall show how to remove them. The presence of paints and coatings shall not significantly impact upon the resilience of plastic recyclate produced from these components upon recycling and when tested according to ISO 18012 or equivalent. --- Award criteria (comprehensive) Dismantling to facilitate recycling Points shall be awarded to tenderers that dismantle equipment and extract (before any treatment) relevant components for recycling in accordance with Annexes A2 through to A6 of EN 50625-1 --- Award criteria (comprehensive) Product dismantling potential Points shall be awarded for the time efficient manual dismantling and extraction of the following components from products, excluding tablets, subnotebooks and two-in-one notebooks: All products (i) Printed Circuit Boards relating to computing functions >10 cm^2 Stationary computer products e.g. desktops (ii) Internal Power Supply Unit (iii) HDD drives Portable computer products e.g. notebooks (iv) Rechargeable battery (v) HDD and optical drives (excluding SSD) Computer monitors (vi) Display panel >100 cm2 (the Thin Film Transistor unit and film conductors) (vii) LED backlight units Extraction of the relevant components shall be possible using universally available tools. The maximum time required to extract them shall not exceed the following thresholds: Computers: - 600 seconds Monitors: - 400 seconds for screen sizes smaller than 25 inches; - 500 seconds for screen sizes greater than or equal to 25 inches and smaller than 40 inches; - 600 seconds for screen sizes greater than or equal to 40 inches and smaller than 55 inches. Points shall be awarded in proportion to reduction in the time required compared to the stated thresholds. A maximum of x points [to be specified] shall be awarded: (i) over 60% lower: x points (ii) 31-60% lower: 0.6x points (iii) 10-30% lower: 0.3x points
EPEAT Computer & Display	Required: Plastics recyclability / Plastic parts compatible with recycling All discrete plastic parts shall meet the following requirements:

(IEEE)	For discrete plastic parts >25 g: b) Do not contain a metal insert or fastener that is (1) molded-in, (2) heat or ultrasonically inserted, or (3) glued-in, unless the metal component is either separable by breaking off from the plastic part, or is separable with commonly available tools. Fan impellers are excluded from this requirement. For discrete plastic parts >100 g: c) Do not have an adhesive, coating, paint, or finish that is not compatible with recycling. Plastic parts with > 25% post-consumer recycled content are exempt from this requirement. The following are excluded from this requirement: - Printed circuit boards assemblies for items b)and c), - Wires and cables, connectors, electronic components, optical components, acoustic components, ESD components, and EMI components - An adhesive, coating, paint, and finish for item c), or a metal insert/fastener for item b), required for safety, legal, or technical requirements --- Required: Plastics recyclability / Plastic parts separable for recycling All discrete plastic parts > 25 g shall be: - Comprised of a single resin, or a combination of resins (e.g., a blend) that are compatible for recycling, and - Separable by hand or with commonly available tools from other plastic parts that are > 25 g and not compatible together for recycling. Printed circuit boards, wires and cables, connectors, electronic components, optical components, acoustic components, ESD components, and EMI components are excluded from this requirement. If the product does not contain discrete plastic parts weighing > 25 g, the manufacturer may declare 'Not Applicable.'
Blue Angel Computers	Material Selection: - The following applies to plastic parts with a mass greater than 25 grams as well as to key caps, provided that their total mass is greater than 25 grams: A maximum of 4 types of plastic may be used for these parts. The plastic housings may consist of two separable polymers or polymer blends at the most. - It shall not be permitted to apply metallic coatings to plastic housing parts. Exception: plastic housing parts of notebook computers may have a metallic coating provided that such coating is technically required. However, galvanic coatings of plastic housing parts shall not be permitted. - 90% of the mass of plastics and of the metals of housing parts and chassis must be recyclable by material (this does not mean the recovery of thermal energy by incineration). --- Structure and Connection Technology The following applies to computers and keyboards: • The devices to be Blue Angel eco-labelled must be so designed as to allow easy disassembly for recycling purposes to make sure that housing parts, Chassis, batteries (if any), display units (if any) and printed circuit boards can be separated as fractions from materials of other functional units and, if possible, recycled by the type of material. They shall be so designed as to allow manual disassembly by a waste disposal company by the use of universal tools and it shall be possible for a single person to disassemble the device. • Batteries/accumulators (if any) must be easy to remove without the use of any tools or with the use of universal tools. • Electrical/electronic components must be easy to remove from the housing.
TÜV Green Product Mark Computers	Recycle Design / Material Selection For Material Selection, the applicant shall provide evidence based on the ISO 11469. The limit shall ensure that: - Plastic parts with a mass greater than 25 grams shall consist of a single polymer or a polymer blend compatible with recycling. A maximum of 4 types of plastic may be used for these parts.

	Plastic cases may consist of two separable polymers or polymer blends at the most. Recycle Design / Structure and Joining Technique The limit shall ensure that: - An efficient (manual) disassembly of case, chassis, display units (if applicable), batteries (if applicable) and printed circuit boards by a specialized firm will be supported or can be done by the use of universal tools; - One person alone shall be able to disassemble case, chassis, display units (if applicable), batteries (if applicable) and printed circuit boards; - Electrical modules must be easily removable from the case; - No moulded-in metal parts and metallization of plastic housing.
Nordic Ecolabelling	Recycable design of the portable charger The portable charger must be designed in such a way that dismantling is possible. The requirement consists of the following individual requirements: - A qualified professional, working alone, must be able to dismantle the product. - It must be possible to separate the substances, preparations and components listed in ANNEX VII of the WEEE Directive (2012/19/EU). - It must be possible to remove the secondary batteries/cells for recycling purposes. - The battery/cell chemicals must be prevented from leaking during the removal.
TÜV Green Product Mark Mobile Phones	The applicant shall provide declaration that states an efficient (manual) disassembly of case, chassis, LCD units (if applicable), batteries (if applicable) and printed circuit boards by a specialized firm will be supported or can be done by the use of universal tools. The applicant shall provide declaration that states easy removal of external enclosure, all screws required to open the mobile enclosure shall be disassembled form the same direction or the enclosure shall be removable with snap connections that are accessed from the same direction and do not require simultaneous disengagement. The applicant shall provide declaration that states electrical modules must be easily removable from the case. The applicant shall provide declaration that states battery must be easy to remove without the use of special tools at end of life. The applicant shall provide declaration that states no moulded-in metal parts and metallization of plastic housing. The applicant shall provide declaration that states a maximum of 2 types of plastic may be used in the structural plastic parts of the mobile phone including enclosure, internal frame, and keyboard. Plastic cases may consist of two separable polymers or polymer blends at the most. The applicant shall provide declaration that states plastic parts with a mass greater than 25 grams shall consist of a single polymer or a polymer blend compatible with recycling.
Blue Angel Mobile Phones	An efficient removal of the secondary batteries for recycling purpose shall be possible with no special knowledge being required (guidance value: in no more than 5 seconds). The battery chemicals must be prevented from leaking during the removal

Source: Own compilation according to sources in Table 7

Table 44: Analysis of EU GPP and ecolabel schemes: Criteria on take-back schemes

EU GPP	Technical specification (core) Secure computer collection, sanitisation, re-use and recycling Tenderers shall provide a re-use and recycling service for a specified inventory of equipment that has reached the end of its service life. They shall report on the proportion of equipment re-used or recycled. The tenderer shall demonstrate how they will carry out the following aspects of the overall service (according to the type, the state and amount of the equipment, the public authority needs to detail the following points. It may also consider in addition an award criterion rewarding tenderers offering e.g. higher levels of reuse or recycling) : - Collection - Confidential handling and secure data erasure (Unless carried out in-house); - Testing, servicing and upgrading; - Remarketing for re-use in the EU; - Dismantling for recycling and disposal. Preparation of items for re-use, as well as recycling and disposal operations shall be carried out in full compliance with the requirements in Article 8 and Annexes VII and VIII of the (recast) WEEE Directive 2012/19/EU. Contract performance clause (core) Operation of re-use and recycling facilities The successful tenderer shall provide valid certificates verifying the permitting for the re-use and recycling facilities used to fulfil the contract. Award criteria (comprehensive) Inventory tracking system Points shall be awarded to tenderers operating a tracking system with a unique identifier for each item of equipment in the Contracting Authority's equipment inventory. The system shall enable the proportion of items re-used or recycled, and whether they remained in the EU or were exported. Contract performance clause (core)	Technical specification (comprehensive) Secure computer collection, sanitisation, re-use and recycling Tenderers shall provide a re-use and recycling service for a specified inventory of equipment that has reached the end of its service life. They shall report on the proportion of equipment re-used or recycled. The tenderer shall demonstrate how they will carry out the following aspects of the overall service (according to the type, the state and amount of the equipment, the public authority needs to detail the following points. It may also consider in addition an award criterion rewarding tenderers offering e.g. higher levels of reuse or recycling): - Collection; - Confidential handling and secure data erasure (Unless carried out in-house. The requirements to be specified by the contracting authority); - Testing, servicing and upgrading; - Remarketing for re-use in the EU; - Dismantling for recycling and/or disposal. Preparation of items for re-use, as well as recycling and disposal operations shall be carried out in full compliance with the requirements in Article 8 and Annexes VII and VIII of the (recast) WEEE Directive. Contract performance clause (comprehensive) Operation of re-use and recycling facilities The successful tenderer shall provide valid certificates verifying the permitting for the re-use and recycling facilities used to fulfil the contract. Valid certification that dismantling has been carried out prior to treatment and in accordance with Annexes A2 through to A6 of EN 50625-1 shall also be provided. Contract performance clause (core)

	Reporting on equipment status The successful tenderer shall provide a report on the status of the equipment in the inventory once all items have been processed for re-use or recycling/disposal. The report shall identify the proportion of items re-used or recycled, whether they remained in the EU or were exported.	Reporting on equipment status The successful tenderer shall provide a report on the status of the equipment in the inventory once all items have been processed for re-use, recycling or disposal. The report shall identify the proportion of items re-used or recycled
EPEAT Computer & Display (IEEE)	End-of-life management / Product take-back service Required: Provision of product take-back services The manufacturer shall provide a nationwide product take-back service for reuse, refurbishment, and/or recycling for products in countries within which the product is declared to conform to this standard. Processing of equipment recovered by the product take-back service should support the hierarchy of management of used and end-of-life electronic equipment and components based on reuse, refurbishment, and/or recycling first, before considering energy recovery and/or disposal. The manufacturer shall make information publicly available describing the product take-back service, including how to utilize the service, or for institutional customers, the manufacturer may provide information directly (e.g., by way of the contract). Manufacturer shall make information publicly available that identifies any direct costs associated with use of the product take-back service. In addition, any direct costs to the customer shall be made available or disclosed to the customer at the time of sale. In jurisdictions where there are existing laws and/or regulations, which establish, sanction, or require the establishment of a program for the collection and recycling of registered products, demonstration of compliance with those legal requirements meets the requirements of this criterion. --- End-of-life management / Product take-back service Required: Provision of a removable rechargeable battery take-back program Manufacturer shall provide a take-back program for user-removable rechargeable batteries in declared products.The manufacturer shall make information publicly available describing the product take-back service, including how to utilize the service, or for institutional customers, the manufacturer may provide information directly (e.g., by way of the contract). The manufacturer shall identify and make publicly available any direct costs associated with use of the program. The manufacturer shall demonstrate that the removable rechargeable battery take-back program meets one of the following options: Option 1: The manufacturer provides an independent removable rechargeable battery take-back program that meets all of the conditions (a-e) listed below with the following two additional requirements for battery return (condition b) below): - In jurisdictions where a voluntary collective scheme is also in operation, an independent take-back program shall offer: - At least 10% of the number of drop-off locations as compared to the voluntary collective scheme at the time of declaration of conformity to the standard. - 50% or more drop-off locations as compared to the voluntary collective scheme within a year from when the product is declared to conform to this criterion, and, 70% within two years. - In jurisdictions that do not have a voluntary collective scheme at the time of declaration of conformance to this criterion, the program shall offer drop off locations that are convenient for the consumer and/or a mail back option. If a mail-back program is offered, information shall be provided to the customer regarding how to package returns for safe and legal transportation in those countries within which the product is declared conformant. Option 2: The manufacturer participates in a voluntary collective scheme that meets all the conditions (a-e) listed below. Participating in the Call2Recycle Program [B4] as a Licensee is an example that meets Option 2 requirements. Option 3: The manufacturer participates in and complies with legal requirements for a battery take-back program in jurisdictions where there are existing laws and/or regulations, which establish, sanction, or require the establishment of a program for the	

	collection and recycling of removable rechargeable batteries from declared products. Manufacturer demonstration of participation in and compliance with those legal requirements meets Option 3 requirements. For Options 1 and 2 above, the following conditions shall be met for a removable rechargeable battery take-back program: a) The program documentation shall require that the collection, transportation, and processing of the batteries be in accordance with all applicable laws, including international trans-boundary shipment regulations. b) Battery return: The program shall allow customers to return their removable rechargeable batteries used in declared products. Examples of acceptable battery return options: Mail-back, collection locations at retail stores, small and large businesses, cities, towns and government agencies. c) Transportation: The program shall have a contract, specification, or equivalent in effect that requires safe and legal transport of shipments from collection to final disposition to be in accordance with applicable laws and regulations. d) Data collection: The manufacturer shall require service providers associated with the program to provide information on the batteries collected, including their chemistry, weight, and type. e) Process and recovery: The program requires batteries and processing by-product to be: 1) Processed for extraction and recycling of selected chemicals, metals, and materials. 2) Responsibly and safely managed and disposed of according to recognized and certifiable international environmental and occupational health and safety (OHandS) standards from the point of collection to final disposition. If all products declared by the manufacturer to conform to this standard do not contain removable rechargeable batteries, the manufacturer may declare 'Not Applicable' to this criterion.
TCO Computers / TCO Smartphones	Material recovery / Take-back system The brand owner (or its representative, associated company or affiliate) must offer their customers the option to return used products for environmentally acceptable recycling methods in at least one market where the product is sold and where electronics take back regulation is not in practice at the date of application. At least one option must be fulfilled: 1. Product sold on WEEE legislation markets or similar 2. World-wide product take back 3. One additional market lacking WEEE legislation where product take back is offered
Blue Angel Mobile Phones	The applicant shall operate its own take-back scheme for mobile phones to direct all collected devices to reuse or professional recycling. The applicant shall actively communicate this system to its customers. This take-back scheme can be based on collections at the branches, return campaigns, deposit systems or the like. A mere reference to the collection governed by the Elektro- and Elektronikgesetz (ElektroG) (Electrical and Electronic Equipment Act) would not be sufficient. The collection system can be organised by the applicant itself, by contracting partners and/or together with other manufacturers of mobile phones.
EPEAT Mobile Phones (UL 110)	Required – Take-back program (Corporate criterion) Manufacturer shall provide a take-back program for products declared to conform to this Standard, either directly or through a contracted third-party. The program shall be publicly disclosed to the user through the manufacturer's website. In jurisdictions where there are existing laws and/or regulations which establish a program for the collection and recycling of products, demonstration of compliance with those legal requirements satisfies the requirements of this criterion for that country or region. This requirement is applicable only in countries or regions for which the product is declared to conform to this standard. --- Required – Primary recyclers third party certified (Corporate criterion) Primary recyclers for programs in 11.1.1 shall achieve both of the following:

	a) Certification to an Environmental Management System (ISO 14001, RIOS, EMAS (EU Eco-Management and Audit Scheme) or similar standard) and; b) At least one of the following: 1) Certification to The Responsible Recycling ('R2') Standard for Electronics Recyclers, or 2) Certification to e-Stewards Standard for Responsible Recycling and Reuse of Electronic Equipment, or 3) Certification to WEEELABEX, or 4) Evidence of annual audits of all primary recyclers, conducted by qualified third partyauditors, to demonstrate recyclers meet the requirements of a program that meets the Recycling Program Minimum Technical Requirements in Appendix B, or 5) Certification to EN 50625. In jurisdictions where there are existing laws and/or regulations which establish a program for the collection and recycling of products, demonstration of participation in a jurisdictionally sanctioned program satisfies the requirements of this criterion for that country or region.

Source: Own compilation according to sources in Table 7

Table 45: Analysis of EU GPP and ecolabel schemes: Criteria on information

EPEAT Computer & Display (IEEE)	Required: Design for end-of-life / End-of-life processing information Identification of materials and components requiring selective treatment The manufacturer shall make available to reuse and recycling facilities via a central information source or a website the following: - Information identifying the presence and location of all materials and components that require selective treatment. - Information regarding lithium ion battery(ies): - Indicating the method of attachment to the product - Describing how to remove from the product - Listing the tools required for removal and, if they are not commonly available, how to obtain them. The manufacturer shall have a one-year grace period from the date of declaration to conform to this standard to make this information available. Applies to: All covered products.
Blue Angel Computers	Product documents (only those information requirements related to end-of-life) The product documents included with the computer shall include both the technical specifications and the environment and health-related user information. These documents shall either be installed on the computer, supplied as a CD-ROM or in printed form, preferably on recycled paper, together with the device or made available on the Internet from the time of delivery for a period of at least 5 years after the end of production. The product documents shall at least provide the following user information: e) Instructions for environmentally sound disposal at the end of the life cycle in accordance with the German Elektrogesetz (Electrical and Electronic Equipment Act), f) Information on manufacturer-operated product take-back programs to allow reuse (if any), g) If the computer is a notebook computer the product documents shall additionally include information according to para. 4 (Special Requirements for Notebook Computers): - A note advising the user that batteries/accumulators must not be disposed of with the normal household waste but instead should be taken to a waste collection facility.
TÜV Green Product Mark Computers	User Guide Information: Information shall be publicly available and shall contain the following information so far as applicable:

	- Instructions for environmentally sound disposal at the end of the life cycle
Blue Angel Mobile Phones	The product documents included with the devices shall include both the technical specifications and the user information relating to environment and health. They shall be either installed on the mobile phone, easily accessible on the Internet or supplied as a data medium or in printed form together with the device. The product documents shall include and manufacturer's website shall allow easy access to the following basic user information: - Specification of nominal capacity, nominal voltage and type designation of the battery as well as information on the recycling process - Information on environmental and resource significance of proper product disposal as well as information on the take-back scheme - Information on an environmentally sound disposal at the end of use in accordance with the German Elektrogesetz (Electrical and Electronic Equipment Act) as well as instructions that the battery should not be disposed of as normal household waste but instead should be taken to a battery collection facility

Source: Own compilation according to sources in Table 7

The following table provides an overview about the number of EPEAT labelled products fulfilling dedicated optional criteria with regard to materials selection.[133] It has to be noted, however, that the number of product types indeed is lower due to multiple counts as the database also includes same models marketed in different countries.

Table 46: Number of products with EPEAT labelling fulfilling optional criteria with regard to materials selection

(4.2.1.2) Higher post-consumer recycled, ITE-derived post-consumer recycled plastic, or bio-based content	3212 (HP, Lenovo, Apple Inc., Teknoservice S.L., ASUSTeK Computer Inc.)
(4.2.1.3) Post-consumer recycled, ITE-derived post-consumer recycled plastic	131 (Lenovo)

Source: Own compilation

[133] According to https://epeat.sourcemap.com/?category=pcsdisplays as of 17 July 2019

4.3.4. Voluntary approaches of front-running companies

Materials selection and recycled content

HP achieved 7% postconsumer recycled content plastic use in HP personal systems; the HP 400 G5/G6 ProBook series, launched in November 2018, has more than 10% PCR plastic compared with no recycled plastic content in the prior generation. HP business PCs and displays include on average 24% recycled plastic content as deflned by the IEEE 1680.1 2018 EPEAT standard. All of HP Elite Series desktops contain post-consumer recycled plastic material content. EliteOne and EliteDesk products are TCO Certified (EliteOne Products are TCO Edge for 50% recycled plastic in accordance with the TCO definition for recycled plastic, excluding panels, electronic components, cables, connectors, PWBs, insulating mylar sheets, and labels). All of HP EliteDisplays (and some Z displays), which meet criteria for TCO Edge certification, contain around 85% PCR plastic content. Further, for HP 800 G5 notebooks, HP moved from a magnesium/aluminum/plastic chassis to a primarily aluminum chassis to facilitate materials recycling and reuse.[134]

Dell models Latitude™ 5285 2-in-1 include motherboards containing **gold recycled** from old motherboards collected through the services 'Dell Reconnect' and 'Asset Resale and Recycling Services (ARR)'. Further, Dell partnered with the companies Teleplan and Seagate to create a new process for **closed-loop recycling of rare earth magnets**, which are used in many technology products. Teleplan will recover the magnets from recycled enterprise equipment collected through Dell Technologies' takeback programs (e.g. Trade-in Swap and Incentive Program), extract rare earth oxides and then reform them into new magnets for Seagate hard drives, i.e. the nonreusable drives will be mined for rare earth magnets, which will then be recycled into magnets for new hard drives. In a May 2019 pilot program, Dell will use reformed drives in select Dell Latitude 5400 and 5500 laptops, being the first time Dell Technologies has recycled materials from enterprise equipment into client computing equipment.[135] Further, Dell makes efforts to scale the **reuse of plastics** coming from closed-loop efforts from used electronics as well as from post-consumer recycled content (sourced from water bottles, CD cases etc.). Dell also used **reclaimed carbon fiber** from aerospace industry waste, across the bases and backs of Dell Latitude™ and Precision products, helping make mobility products stronger, lighter and thinner.

Apple strives to achieve recycled materials solutions, focusing initial effort on the following 14 priority materials for transitioning to 100% recycled or renewable content: Aluminum, Cobalt, Copper, Glass, Gold, Lithium, Paper, Plastics, Rare earth elements, Steel, Tantalum, Tin, Tungsten, and Zinc.[136] For example, Apple has identified recycled alternatives for 24 different grades of plastic allowing the use of an average of 38 percent **recycled plastic** across 82 components for products currently released. Also, Apple has introduced in 2018 two notebook types with enclosures made from 100% **recycled aluminium**. As standard recycled aluminum accumulates impurities each time it's recycled, Apple engineered an alloy that can accommodate scrap sources of aluminum and delivers the same strength and durability. They use sophisticated computational models to identify an alloy chemistry that

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[134] See http://www8.hp.com/h20195/v2/GetPDF.aspx/c06293935.pdf and https://www8.hp.com/h20195/v2/GetPDF.aspx/c05968416.pdf

[135] See https://corporate.delltechnologies.com/en-us/social-impact/reporting/fy19-csr-report.htm#overlay=/content/dam/delltechnologies/assets/corporate/pdf/progress-made-real-reports/dell-fy19-csr-report.pdf

[136] See https://www.apple.com/environment/pdf/Apple_Environmental_Responsibility_Report_2019.pdf, pages 25 to 29

can withstand a countless number of recycling loops. Apple's own products and processes are a valuable source of aluminum scrap for their custom alloy. Further, Apple is specifying 100 percent **recycled tin** for the solder of the main logic boards of the newly released MacBook Air with Retina display, iPad Air, and iPad mini. Apple started to use **recycled cobalt** in the batteries of new products, which is sourced from iPhone batteries recovered from 'Daisy' (Apple's iPhone disassembly robot) and scrap from select supplier sites. According to Apple, a limited supply of recycled cobalt is available on the market for use in batteries, because many recyclers don't have enough scrap sources, like batteries. So Apple started with its own supply chain and began sending iPhone batteries to their upstream recycler in Apple's battery supply chain. Apple is engaging with its suppliers to investigate new methods to manufacture their printed circuit boards in a way that uses less copper. For the copper used, Apple is moving to recycled sources, currently certifying the **recycled copper** content in the printed circuit boards of select iPhone models. Apple's iPhone disassembly robot Daisy liberates seven different components from which copper can be recovered, including the main logic board and the camera; Apple is directing these components to recyclers and smelters that can recover copper at high rates. Further, Apple is continuing to identify ways to reduce the amount of gold used in the plating of components like printed circuit boards. Apple is working within the complex gold supply chain in order to increase the use of certified **recycled gold**. According to Apple, **rare earth elements** like neodymium, praseodymium, and dysprosium are used in magnets for audio applications, in cameras, and in haptics technology. Traditional recyclers don't recover these rare earth elements, because they are used in small quantities and technology has not advanced sufficiently to recover them. However, Apple's disassembly robot recovers the small components containing rare earth elements from the iPhones. By consolidating these sources, Apple is creating an opportunity for new technology to efficiently recover these materials. Apple designed their disassembly robot 'Daisy' as an alternative to whole unit shredding; it is able to separate out the Taptic Engine, which is then sent to speciality recyclers that recover tungsten from it. Apple is also working with its suppliers to certify the use of **recycled tungsten** in their products. Finally, Apple has begun exploring new recycled sources and prioritizing recyclers that can recover **lithium, tantalum,** and **zinc**.

For example, Apple's iPhones 11, 11 Pro and 11 Pro Max use 100% recycled tin in the solder of the main logic board and power adapter and 100% recycled rare earth elements in the Taptic Engine which represents about 28 percent of the total rare earth elements used in the product. For iPhones 11, 11 Pro and 11 Pro Max, Apple uses 35 percent or more recycled plastic in multiple components. Further, Apple also requires 100 percent of identified tin, tantalum, tungsten, gold, and cobalt smelters and refiners to participate in third-party audits.[137] In Apple's iPhone XR, the main logic board is assembled with 100 percent recycled tin solder, the cover glass frame is made with 32 percent bio-based plastic and the speaker enclosure is made with 35 percent post-consumer recycled plastic.[138] In Apple's iPhone 8 and 8 Plus, plastics used in the internal antenna and receiver are made with 35 percent post-consumer recycled content.[139]

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[137] See https://www.apple.com/environment/pdf/products/iphone/iPhone_11_Pro_Max_PER_sept2019.pdf, https://www.apple.com/environment/pdf/products/iphone/iPhone_11_Pro_PER_sept2019.pdf, https://www.apple.com/environment/pdf/products/iphone/iPhone_11_PER_sept2019.pdf

[138] See https://www.apple.com/environment/pdf/products/iphone/iPhone_XR_PER_sept2018.pdf

[139] See https://www.apple.com/environment/pdf/products/iphone/iPhone_8_PER_sept2017.pdf; https://www.apple.com/environment/pdf/products/iphone/iPhone_8_Plus_PER_sept2017.pdf

Fujitsu uses hybrid molded components made of magnesium alloy and glass fiber reinforced plastic for the internal cover of its ARROWS Tab Q736/M for corporate clients. Post-consumer recycled materials are employed in the glass fiber reinforced plastic.[140]

Lenovo is incorporating Closed Loop Recycled Plastic: In early 2017, Lenovo investigated the feasibility of using closed loop post-consumer recycled (CL PCR) content plastic in its products, i.e. plastic derived from recycled electronics. Lenovo worked with vendors to identify supply sources and the Lenovo R&D team provided testing support. The team demonstrated that CL PCR content plastic could pass the same stringent performance tests that are applied to other plastics used in the products. In summer 2017 the V410Z All-in-One desktop was launched containing 12 percent net (by weight) CL PCR. In October, the ThinkVision T22v-10 monitor was launched comprised of 45 percent net (by weight) CL PCR. Based on these successes, Lenovo plans to expand CL PCR use. The LCD cover, palm rests and top and bottom cases of ThinkPad L notebooks use up to 30 percent PCC from sources such as used office water jugs and IT equipment. ThinkPad has also succeeded in using PCC in the very thin walls of battery packs. The ThinkPad Ultra Dock, ThinkPad Pro Dock and ThinkPad Basic Dock use PCC as well. Depending on the final application requirements, the plastic resins contain between 10 and 85 percent Post-Consumer Recycled Content (PCC), with some plastic resins also containing up to 20 percent Post-Industrial Recycled Content (PIC)[141].

Fairphone uses copper from recycled sources.[142]

Google has set a target to build 100% of consumer electronic products launching in 2022 and every year after with the inclusion of recycled materials, with a drive to maximize recycled content wherever possible. According to their 2019 report 'A Circular Google', however, so far none of the smartphones has included recycled materials, but only Google's Nest Thermostat E, Google Home, and Chromecast are reported to contain parts with 20%–75% post-consumer recycled plastic content.[143]

Samsung has developed its Galaxy S10 charger made of 20% recycled plastic. Further, the Galaxy S10's earjack housing and Galaxy S10e's front deco part contain bio-based plastics (29% for the S10 and 37% for the S10e which is derived from castor oil). Samsung's smartphone Galaxy Note9 includes 20% of recycled plastic use.[144]

LG Electronics uses recycled materials for a wide range of products including smartphones.[145]

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[140] See https://www.fujitsu.com/global/about/environment/society/energyefficiency/casestudy/

[141] See https://www.lenovo.com/us/en/social_responsibility/2017.18-lenovo-sustainability-report.pdf

[142] See https://www.fairphone.com/en/our-impact/

[143] See https://services.google.com/fh/files/misc/circular-google.pdf

[144] See https://images.samsung.com/is/content/samsung/p5/global/mkt/pdf/SustainabilityReport2019-en.pdf

[145] See https://www.lg.com/global/pdf/Sustainability-Report/2018-2019%20Sustainability%20Report.pdf

Marking of plastic parts for recycling

Lenovo has specified in its 'Baseline Environmental Requirements for Lenovo Products, Materials and Parts'[146] requirements for Marking of Hardware Plastic Parts: Hardware plastic Parts molded and/or fabricated from thermoplastic materials and weighing 25 grams or more must be marked in accordance with the International Organization for Standardization's international standard ISO 11469, 2000-05 'Plastics- Generic identification and marking of plastics products.' Marking is optional for Parts weighing less than 25 grams, however, all Parts having adequate surface area for coding should be marked. Marking requirements do not apply to cable and cable assemblies or experimental tooling. When two or more resins may be used for production of a Part, identification of the actual resin used for fabrication is required. If the Parts must be plated or painted on the internal surface, it may not be possible to have a readily visible injection molded-in marking. In such cases, it may be necessary to code the Parts with a stamp or other means of permanently affixing the information. If the Parts must be painted with a decorative paint, it must be indicated on the internal surface with an appropriate means (for example, stamp) that the Part has been painted. Further, Resin Generic Identification is required to be marked on Parts using the symbol for polymer type in between the symbols > and <. The symbols for the plastic Materials shall be selected from Part 1 of international standard ISO 1043, Plastics-Symbols and abbreviated terms. Symbols of plastics not appearing in ISO 1043-1 shall be selected from ASTM D 4000, Classification System for Specifying Plastic Materials; and ASTM D 1600, Terminology Relating to Abbreviations, Acronyms and Codes for Terms Relating to Plastics. When two or more resins may be used for production of a Part, identification of the actual resin used for fabrication can be displayed by arrows. Additives identification shall be marked on Parts using the generic symbols from the series of international standards ISO 1043-2, 1043-3 and 1043-4.[147]

Take-back schemes

Dell's programme 'Dell Reconnect' for example enables customers to drop off their used electronics at more than 2,000 Goodwill locations across the U.S. for free recycling. The program has collected over 500 million pounds of used electronics since the Financial Year 2008. It has helped people with disabilities and disadvantages learn to recycle electronics and gain other technical skills and training. Dell's Asset Resale and Recycling Services (ARR) for commercial customers provides pickup logistics, data protection and responsible retirement of any brand of owned or leased hardware. It also includes detailed reporting of each system's journey from collection to final disposition.[148] Dell's Asset recovery: at the end of the PC lifecycle, Dell will facilitate the transition to the latest technology by handling the pick-up logistics of the hardware and if needed, options for data sanitization. As no data removal process leaves a hard drive or computer as free from residual data as a new product, Dell makes no recommendations regarding the effectiveness of one method of data removal over another.[149]

Lenovo offers Asset Recovery Service (ARS) to business customers to help manage their end-of-life technology equipment by providing PC take-back, data destruction,

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[146] According to the document, this specification implements Lenovo's environmental policy objectives and contains some, but not all, environmental legal requirements for Materials, Parts and Products.

[147] See https://www.lenovo.com/us/en/pdf/41A7731.pdf

[148] See https://corporate.delltechnologies.com/en-us/social-impact/reporting/fy19-csr-report.htm#overlay=/content/dam/delltechnologies/assets/corporate/pdf/progress-made-real-reports/dell-fy19-csr-report.pdf

[149] See https://i.dell.com/sites/csdocuments/Learn_Docs/en/pc_as_a_service_brochure.pdf

refurbishment and recycling. Lenovo also offers additional services including inventory, value assessment, on-site de-installation and data encryption. This service gives customers an end-to-end solution from Lenovo from the point of computer purchase to take-back and disposal.[150]

Fairphone offers a return service for non-used smartphones, providing a refund[151]

Shiftphone has established a deposit system for its smartphones. Returned Shiftphones are reused as Second-Life-Appliances or dismantled into their components. If not the whole smartphone can be reused, functioning components are extracted to use them for repairs of other appliances.[152]

4.3.5. Summary and conclusions with regard to the revision of EU GPP criteria on product lifetime extension

4.3.5.1. Marking of plastic parts for recycling

EU GPP, most analysed ecolabel schemes as well as the draft revised EU Ecodesign regulation on Displays (which shall apply from 1 March 2021) have criteria with regard to marking of plastic parts to facilitate recycling processes, referring to ISO 11469 and/or ISO 1043 sections 1-4, however slightly differing with regard to the components covered or exempted, the weight and size of plastic parts to be marked and the specific marking reference, see following table.

Table 47: Analysis of EU GPP and ecolabel schemes: Differences in criteria on marking of plastic parts

	Components	Weight / size of plastic parts for which the requirements apply	Marking reference
EU GPP	External plastic casings, enclosures and bezels	Core: Weight greater than 100 grams and a surface area greater than 50 cm² Comprehensive: Weight greater than 25 grams for tablet and portable all-in-one notebooks and 100 grams for computers and monitors and in all cases a surface area greater than 50 cm²	Core: ISO 11469 and ISO 1043 section 1 Comprehensive: ISO 11469 and ISO 1043, sections 1-4
EPEAT Computer & Display (IEEE)	All discrete plastic parts; excluded from the requirement: printed circuit boards; wires and cables, connectors, electronic components, optical components, acoustic components, ESD components, and EMI components	Weight greater than 25 grams	ISO 11469/1043, excluding optical parts
Blue Angel	Plastic parts; Exempted: transparent plastic	Mass greater than 25	ISO 11469

[150] See https://www.lenovo.com/us/en/social_responsibility/product_recycling_program/

[151] See https://www.fairphone.com/en/recycle-your-phone/

[152] See https://www.shiftphones.com/downloads/SHIFT-wirkungsbericht-2019-05-10.pdf

	Components	Weight / size of plastic parts for which the requirements apply	Marking reference
Computers	parts the function of which requires transparency (e.g. visible plastic films in displays)	grams each and an even surface of more than 200 mm²	with due regard to ISO 1043, parts 1-4
Green Product Mark Computers	Plastic components	Weight greater than 25 grams	ISO 11469
TCO Computers	Parts made mainly of plastics; exempted are printed wiring board laminates as well as plastic parts containing other materials in any significant amounts	Weight greater than 25 grams	ISO 11469 and ISO 1043, sections 1-4
Draft revised EU Ecodesign Regulation on Displays	Plastic components; Plastic components are exempt from marking requirements in the following circumstances: (i) The marking is not possible because of the shape or size; (ii) The marking would impact on the performance or functionality of the plastic component; and (iii) Marking is technically not possible because of the molding method. Marking is not required for (i) Packaging, tape, labels and stretch wraps; (ii) Wiring, cables and connectors, rubber parts and anywhere not enough appropriate surface area is available for the marking to be of a legible size; (iii) PCB assemblies, PMMA boards, optical components, electrostatic discharge components, electromagnetic interference components, speakers; (iv) Transparent parts where the marking would obstruct the function of the part in question. Components containing flame retardants shall additionally be marked with the abbreviated term of the polymer followed by hyphen, then the symbol 'FR' followed by the code number of the flame retardant in parentheses. The marking on the enclosure and stand components shall be clearly visible and readable.	Weight heavier than 50 grams	'Appropriate standard symbols or abbreviated terms set between the punctuation marks '>' and '<' as specified in available standards.

It is expected that the future revised EU Ecodesign regulation for computers will include the same criteria as the draft revised EU Ecodesign regulation on electronic displays.[153]

So far, EU GPP criteria are less ambitious than the requirements of ecolabel schemes, due to higher weight limits (greater than 100 grams, compared to 25 grams in ecolabel requirements), and focus on selected plastic parts only (external plastic casings, enclosures and bezels, whereas ecolabel schemes take into account all plastic parts with some dedicated exemptions). Also the future mandatory requirements of EU Ecodesign regulation(s) for electronic displays (draft published) and computers (expected) will be stricter than the current GPP criteria, covering all plastic parts with exemptions only, and a

[153] Almost identical requirements are proposed by the preparatory study on the revision of EU Ecodesign requirements for computers, cf. Section 4.3.2.1

weight greater than 50 grams. Against this background, it is recommended that the current EU GPP criteria shall be revised, aligning them to the criteria of existing ecolabel schemes or the upcoming Ecodesign requirements. The criteria should also apply to smartphones if the scope of the GPP criteria would be widened to this product category; however, due to the lighter weight of smartphones, it could be practicable also to reduce the weight limit (e.g., TCO criteria take 5 grams for smartphones and 25 grams for computers as limit).

Even if some stakholders might consider plastic marking less relevant due to recycling processes based on shredding, mechanical and chemical separation, it is recommended to keep marking as on the other hand the analysis of voluntary approaches of companies (see section 4.3.4) show that some manufacturers work on own approaches for closed-loop recycling, i.e. reuse of plastics coming from closed-loop efforts of used electronics.

4.3.5.2. Recyclability of products, structure / joining techniques, dismantling

Most of the analysed schemes include requirements on the recyclability of products, joining techniques and/or dismantling.

For example, EU GPP as well as Blue Angel, and Green Product Mark have requirements with regard to the joining techniques and dismantling of products to facilitate recycling:

Table 48: Analysis of EU GPP and ecolabel schemes: Differences in criteria on joining techniques and dismantling to facilitate recycling

	Components addressed to be dismantled separately	**Dismantling process**
EU GPP (award criteria, comprehensive)	All products: Printed circuit boards relating to computing functions > 10 cm²; Stationary computer products: Internal Power Supply Unit, HDD drives Portable computer products: Rechargeable battery; HDD and optical drives (excluding SSD) Computer monitors: Display panel > 100 cm² (the Thin Film Transistor unit and film conductors); LED backlight units	Extraxtion shall be possible using universally available tools
Blue Angel Computers	Housing parts, chassis, batteries (if any), display units (if any) and printed circuit boards Batteries/accumulators (if any) must be easy to remove Electrical/electronic components must be easy to remove from the housing.	Manual disassembly by a waste disposal company; single person, by the use of universal tools Without the use of any tools or with the use of universal tools.
Green Product Mark Computers	Case, chassis, display units (if applicable), batteries (if applicable) and printed circuit boards	An efficient (manual) disassembly by a specialized firm; one person alone, by the use of universal tools
Nordic Ecolabelling	Portable charger; it must be possible to remove the secondary batteries/cells for recycling purposes	A qualified professional, working alone

For smartphones, only TÜV and Blue Angel have criteria with regard to the recyclability of products; whereas TÜV requires a declaration stating that an efficient (manual) disassembly of case, chassis, LCD units (if applicable), batteries (if applicable) and printed circuit boards

by a specialized firm will be supported or can be done by the use of universal tools, and also no moulded-in metal parts and metallization of plastic housing is allowed, Blue Angel only requires an efficient removal of the secondary batteries for recycling purpose.

Also the draft revised EU Ecodesign regulation for displays has requirements on design for disassembly, recycling and recovery:

- Manufacturers, importers or their authorised representatives shall ensure that joining, fastening or sealing techniques do not prevent the removal, using commonly available tools, of the components indicated in point 1 of Annex VII of Directive 2012/19/EU on WEEE or in Article 11 of Directive 2006/66/EC on batteries and accumulators and waste batteries and accumulators, when present.
- Manufacturers, importers or their authorised representatives shall, without prejudice to point 1 Article 15 of Directive 2012/19/EU, make available the dismantling information needed to access, any of the products components referred to in point 1 of Annex VII of Directive 2012/19/EU on a free-access website. This dismantling information shall include the sequence of dismantling steps, tools or technologies needed to access the targeted components.
- The end of life information shall be available until at least 15 years after the placing on the market of the last unit of a product model.

These criteria refer directly to the WEEE Directive and to the Battery Directive and those materials and components of waste electrical and electronic equipment which require selective treatment. However, the objectives of the WEEE Directive are mainly based on a precautionary principle to prevent pollution of the environment, for example requiring selective treatment due to the content of hazardous components in EEE. These components are listed in Annex VII of the Directive as a minimum to be removed separately.

Current GPP and some of the ecolabel criteria go beyond these components; for example, the Internal Power Supply Unit, HDD and optical drives, housing parts, or the chassis are not listed in the Annex of the WEEE Directive and rather addresses the retrieval of valuable secondary raw materials. Thus, it is recommended to keep the current approach of the EU GPP criteria; if the scope of the GPP criteria is widened to smartphones, requirements on recyclability should also applied to this product group. In addition, it is recommended to include the information requirements as foreseen in the revised EU Ecodesign requirements for displays (dismantling instructions and availability of end-of-life information) also in the revised EU GPP criteria.

Further, metal inserts or paints and coatings in certain plastic parts are restricted to facilitate their recycling. However, there are slightly differences with regard to the type of plastic parts affected, as well as how the criteria are applied or which exemptions exist, see following table. It is recommended to keep the existing EU GPP criteria and apply the requirements also to smartphones if the scope of the GPP criteria is widened to that product category.

Table 49: Analysis of EU GPP and ecolabel schemes: Differences in criteria on composition of plastic parts to facilitate recycling

	Plastic components	**Metals not allowed**	**Paints and coatings restricted**
EU GPP (technical specification, comprehensive)	Plastics casings, enclosures and bezels	Moulded-in or glued-on metal inserts unless they can be removed with commonly available tools	The presence of paints and coatings shall not significantly impact upon the resilience of plastic recyclate produced from these components upon recycling and when tested according to ISO 18012 or equivalent

	Plastic components	Metals not allowed	Paints and coatings restricted
EPEAT Computer & Display (IEEE) **Required**	Discrete plastic parts > 25g Exempt from this requirement: Printed circuit board assemblies, Fan impellers; wires and cables, connectors, electronic components, optical components, acoustic components, ESD components and EMI components; Metal insert or fastener required for safety, legal or technical requirements Discrete plastic parts > 100g; Exempt from this requirement: Plastic parts with >25% post-consumer recycled content; Printed circuit board assemblies; wires and cables, connectors, electronic components, optical components, acoustic components, ESD components, EMI components Adhesive, coating, paint or finish required for safety, legal or technical requirements	Metal insert or fastener that is molded-in, heat or ultrasonically inserted, or glued-in, unless the metal component is either separable by breaking off from the plastic part or is separable with commonly available tools.	They shall not have an adhesive, coating, paint, or finish that is not compatible with recycling.
Blue Angel Computers	Plastic housing parts Exception: plastic housing parts of notebook computers may have a metallic coating provided that such coating is technically required.	Metallic coatings Galvanic coatings of plastic housing parts shall not be permitted.	
Green Product Mark Computers	Plastic parts with a mass greater than 25 grams	No moulded-in metal parts and metallization of plastic housing	

Source: Own compilation according to sources in Table 7

Finally, only EU GPP requirements have thresholds on the maximum time required to extract the listed components. The reason behind is to ensure manual extraction of valuable components for further separate treatment within profitable time for recycling facilities. Also the study 'Analysis and development of a scoring system for repair and upgrade of products' includes disassembly time as one of the key parameters, however not applying it to the analysed product groups. The argument given for laptops was that although this parameter can be relevant since the repair duration affects repair costs, disassembly time is also covered indirectly by other parameters (e.g. disassembly depth, fasteners, tools, availability of repair information). Moreover, the study argued that methodological developments are still needed before such parameter can be measured in a standardised and not-too-burdening way. As the same arguments also apply to the disassembly time for recycling operations, it is recommended to remove this requirement from the revised GPP criteria.

4.3.5.3. Take back schemes

EU GPP, EPEAT (for computers and smartphones), TCO (for computers and smartphones) as well as Blue Angel for smartphones have dedicated requirements on take-back schemes. It has to be noted, however, that in Europe the collection and recycling is regulatory approached by the WEEE legislation with extended producer responsibility for the

participation and/or financing of collection and recycling processes. Therefore, EU GPP is already generally covered by WEEE regulation as well; additional GPP requirements, if needed, should only be formulated in a way going beyond WEEE to further enhance recycling processes. On the other hand, IEEE and TCO labelling schemes not only address products in European but also international markets where WEEE does not apply and additional requirements on take-back, collection and recycling schemes as listed in the labelling schemes are reasonable or necessary. Further, especially for smaller electronic items as smartphones it is known that current collection schemes do not function well enough.

Therefore, for the revision of the EU GPP criteria it should be discussed with stakeholders if at all and in which way requirements on take-back schemes for computers and/or smartphones are useful for the GPP process. Whereas from the perspective of the procurement authority it should be ensured that the procured appliances will be collected, sanitized and properly recycled at the end-of-life (for which some manufacturers or IT service providers already offer 'Product as a Service' models, see voluntary approaches of companies in section 4.3.4), especially the current EU GPP award criteria on inventory tracking system and reporting on equipment status rather tend to target more generally proper implementation of the WEEE Directive and might not refer directly to the needs of procurement authorities.

4.3.5.4. Information

Some Ecolabel schemes, namely EPEAT/IEEE, Blue Angel and Green Product Mark have dedicated criteria sections summarizing information requirements which mainly include those ones on end-of-life management. However, it seems that most of this required information is also already included in the other criteria sections. Thus, it is not recommended to include separate product information requirements into the revised GPP criteria.

4.3.5.5. Further criteria proposals

Materials selection: Recycled or biobased plastic content

So far, neither EU Ecodesign regulations nor the EU GPP criteria for computers and monitors include requirements on recycled or biobased plastic content. On the other side, EPEAT, TÜV Green Product Mark, TCO (all three schemes for computers as well as for smartphones) and Blue Angel criteria for computers have requirements for the content of recycled and/or biobased plastics. Blue Angel only states that Post-consumer recyclate material may be used in housing parts and chassis.

TCO requires information about the percentage of post-consumer recycled plastic; this percentage will be published as one of the sustainability performance indicators, which will be printed on the certificate. Applicants for the TCO ecolabel have to fill out and provide a product declaration which inter alia includes as declared sustainability information the ‚Percentage of recycled plastic by weight of total weight of plastic parts'. Together with the application and product form to be delivered to TCO Development, a copy of the verification report(s) from a verifier approved by TCO Development has to be submitted.

Green Product Mark and EPEAT obligatory even require a minimum Post-consumer recycled content (PCC).

- Green Product Mark: minimum 10% PCC
- EPEAT/IEEE for computers (required): minimum 2% of any combination of postconsumer recycled plastic, ITE-derived post-consumer recycled plastic or bio based plastic, measured as a percentage of total amount of plastic (by weight) in the product. Several components might be excluded from the calculation of percentage, differing between normal and 'ruggedized' devices.

- Optional EPEAT/IEEE criteria for computers require or provide optional points for higher contents of postconsumer recycled plastic, ITE-derived post-consumer recycled plastic or bio based plastic, depending on the product type.
- EPEAT/UL110 criteria for smartphones require only a declaration of post-consumer recycled and biobased plastic content, where a declaration of 0% is acceptable for this criterion; in the optional criteria, the use of post-consumer recycled plastic and biobased plastic content in the accessories will be awarded points

According to the EPEAT/IEEE standard, verification of the postconsumer recycled plastic content is based on self-declaration of the supplier only, i.e. by supplier letter(s) stating the percentage of applicable content(s) in plastic(s) supplied to the manufacturer or to the manufacturer's part supplier, documentation of calculation, including plastic part name(s) or other part identifiers and the total weight of their plastic content, as well as the weight of plastic content that is post-consumer, ITE derived post-consumer, or bio based, and, if excluding parts, a list of excluded parts and reason for exclusion. In case of the optional IEEE criteria, if supply is temporarily disrupted, the manufacturer shall provide information regarding the disruption, including the dates in which the impacted supply was disrupted and reinstated, the reason for the disruption, and information or attestations from suppliers, and steps the manufacturer is taking to reinstate supply, as relevant.

On the other hand, the EPEAT/UL110 standard specifies ASTM D6866-04a as verification method to determin the biobased content.

The analysis of voluntary approaches of companies (cf. section 4.3.4) revealed that many of them already make efforts and claim to achieve a certain percentage of postconsumer recycled content in their computer and monitor products.

If EU GPP criteria on recycled or biobased plastic content should be introduced, it should be discussed with these manufacturers if and how they guarantee the validity of those declarations with their suppliers. If possible, also the use of further recycled materials as used by some front-running manufacturers (see section 4.3.4) might be applied as additional GPP award criteria.

Recyclability of products

So far, neither EU Ecodesign regulations nor the EU GPP criteria for computers and monitors include requirements restricting the number of plastic parts. On the other side, IEEE/EPEAT, Blue Angel and Green Product Mark have requirements on the maximum number of materials to facilitate recycling processes:

- IEEE (required): All discrete plastic parts > 25 g shall be comprised of a single resin, or a combination of resins (e.g., a blend) that are compatible for recycling. Printed circuit boards, wires and cables, connectors, electronic components, optical components, acoustic components, ESD components, and EMI components are excluded from this requirement.
- Blue Angel: For plastic parts with a mass greater than 25 grams as well as key caps, provided that their total mass is greater than 25 grams: A maximum of 4 types of plastic may be used for these parts. The plastic housings may consist of two separable polymers or polymer blends at the most.
- Green Product Mark: Plastic parts with a mass greater than 25 grams shall consist of a single polymer or a polymer blend compatible with recycling. A maximum of 4 types of plastic may be used for these parts. Plastic cases may consist of two separable polymers or polymer blends at the most.

It is recommended to introduce such requirements also under EU GPP criteria for computers and monitors.

Marking of batteries for recycling

In addition to the plastics marking, the Blue Angel ecolabel schemes for computers as well as for smartphones have further marking requirements for the battery/accumulator. Besides common information, for the end-of-life management an indication of the metal with the greatest mass percentage (e.g. cobalt, manganese, nickel, iron), as well as an indication of substances contained in the battery/accumulator that hinder the recycling process (e.g. tin, phosphorous) shall be provided, also possible in coded form, for example, in accordance with the marking system proposed by the Battery Association of Japan (BAJ). Also the preparatory study on the revision of EU Ecodesign requirements proposes requirements on battery marking: Battery packs and cells (including those incorporated into battery packs) shall be marked with marking symbols for the correct identification of their chemistry. The marking symbol shall be durable and legible. Although standardization activities are needed to define useable marking symbols and their correlation with battery types, it is proposed that the draft standard IEC 62902 can be used as a reference, or may be adapted, to mark batteries with volume equal or smaller than 900 cm^3.

It could be discussed to introduce such requirements also under EU GPP criteria.

4.4. Hazardous Substances

The focus of the technical analysis should be on an update of legal provisions and furthermore on existing voluntary approaches that comprises besides the assessment of current chemicals criteria of ecolabel schemes also voluntary approaches of companies for restriction of hazardous substances.

Hazardous substances that are used in the production process will not further be considered, beyond the existing process criteria (emission of fluorinated GHG in production and proper WEEE collection).

4.4.1. Current EU GPP criteria and their application

The following feedback was given in the stakeholder consultation to the application of current EU GPP criteria:

Restricted substance controls

The importance of this criterion is recognised especially to limit the exposure of workers to process chemicals. However, it is not applied by the respondents due to lack of knowledge about these standards and uncertainty on market uptake and recognition of the IEC 62476 standard / IEC 62474 database. Manufacturers are reported to produce their restricted substance lists. EPEAT is reported to require a substance inventory (as optional criterion).

Declaration for REACH Candidate List substances

This criterion is reported to be applied by some PPs (DIGIT and Hansel Oy). There is some doubt if the simple declaration / letter from the CEO could be considered sufficient (DIGIT). Different approaches are observed e.g. a positive list proposed by TCO based on an accepted substances list instead of a black list. Some stakeholders believe that procurers can't interpret all information received in a useful way and are sceptical about the use of this idea to ‘raise awareness’ with procurers.

Plasticisers in external cables

This TS is reported to be applied by some respondents. It is suggested to refer directly to RohS as it applies to the entire EE product, so we think it is better to refer to the RoHS directive as such rather than to pick certain parts of the EE product, as cables. Also in this case an approach based on accepted substances is proposed.

Hazardous end-of-life emissions from components

A ‘Halogen Free Criterion’ is supported by several respondents, others consider that the hazardous end-of-life emissions can be reduced by end-of-life criteria directed towards ensuring proper recycling; less consensuses is expressed for fire tests, considered by some respondent not to be possible in practice. ‘TCO Certified Edge halogen free display’ is reported as verification method for displays. It also suggested referring to self-declaration such as the ECOdeclaration.

4.4.2. Legal provisions

In Europe, manufacture and use of chemicals is regulated under REACH. Besides, there are complemental legal provisions that regulate the containment of chemicals in specific products which is for electrical and electronic equipment the RoHS Directive.

This section provides information on the recent amendments in legislation with relevance for chemicals in the manufacture of computers or components. The objective is to clarify if certain hazardous substances are recently added for restriction so that they do not need to be addressed by GPP criteria.

4.4.2.1. RoHS Directive

The current RoHS Directive 2011/65/EU[154] prohibits the use of lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls (PBB) and polybrominated diphenyl ethers (PBDE) in electrical and electronic equipment placed on the Union market.

Four phthalates added to RoHS Annex II

This list of restricted substances in Annex II has been amended by the Commission Delegated Directive (EU) 2015/863 of 31 March 2015: Accordingly, the four phthalates Bis(2-ethylhexyl) phthalate (DEHP), Butyl benzyl phthalate (BBP), Dibutyl phthalate (DBP) and Diisobutyl phthalate (DIBP) have been added to Annex II and the restriction applies for most product EEE (including computers) from 22 July 2019 on. It has to be noted that the restriction of DEHP, BBP, DBP and DIBP shall not apply to cables or spare parts for the repair, the reuse, the updating of functionalities or upgrading of capacity of EEE placed on the market before 22 July 2019.[155] This is also relevant for computers and monitors for a certain period, which would be the period of the service life of computers and monitors.

Exemptions for the restricted substances reviewed periodically for possibilities of substitution

Exemptions for the use of the restricted substances are listed in Annex III of the Directive.[156] Article 5 of the Directive on the Adaptation of the Annexes to scientific and technical progress stipulates the criteria for providing an exemption. An exemption can be justified if at least one of the following criteria is fulfilled:

- the elimination or substitution of the restricted substance via design changes or materials and components is **scientifically or technically impracticable**, meaning that a substitute material, or a substitute for the application in which the restricted substance is used, is yet to be discovered, developed and, in some cases, approved for use in the specific application;
- the **reliability of substitutes is not ensured**, meaning that the probability that EEE using the substitute will perform the required function without failure for a period of time comparable to that of the application in which the original substance is included, is lower than for the application itself;
- the total negative environmental, health and consumer safety impacts caused by substitution are likely to outweigh the total environmental, health and consumer safety benefits thereof.

Once one of these conditions is fulfilled, the evaluation of exemptions, including an assessment of the duration needed, shall consider the availability of substitutes and the socio-economic impact of substitution, as well as adverse impacts on innovation, and life cycle analysis concerning the overall impacts of the exemption. All exemptions need to have an expiry date and they can only be renewed upon submission of a new application. For EEE

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[154] See the consolidated version and all amendments of the Annexes at: http://ec.europa.eu/environment/waste/rohs_eee/legis_en.htm

[155] Further provisions that are not relevant for computers but for e.g. medical devices, are not further described here.

[156] Annex IV lists exemptions that are valid only for Annex II, Category 8 (medical devices) and/or Category 9 (monitoring and control instruments) EEE. Exemptions listed in Annex III are valid for all product categories in coherence with Article 5 of the directive, unless listed otherwise (e.g. through the exemption formulation or through the scope and dates of applicability column).

of the categories 1 to 7and thus for computers and monitors the maximum duration of an exemption is set at five years.

The periodic exemption review assesses whether substitutes are available and reliable. For the assessment, a targeted stakeholder consultation is conducted and manufacturers of the application under review are actively contacted to provide information on their products. As an outcome of an assessment, the scope of an exemption might be narrowed down and the application still needing the restricted substances might further be specified. An example for narrowing down of the scope of an exemption can be found in the Annex, see section 5.6.

Mercury in display lamps

Mercury in light sources for displays is covered by exemption 3 of Annex III *'Mercury in cold cathode fluorescent lamps and external electrode fluorescent lamps (CCFL and EEFL) for special purposes not exceeding (per lamp):*

3(a) Short length (≤ 500 mm): No limitation of use until 31 December 2011; 3,5 mg may be used per lamp after 31 December 2011

3(b) Medium length (> 500 mm and ≤ 1 500 mm): No limitation of use until 31 December 2011; 5 mg may be used per lamp after 31 December 2011

3(c) Long length (> 1 500 mm): No limitation of use until; 13 mg may be used per lamp after 31 December 2011'

Mercury in cold cathode fluorescent lamps and external electrode fluorescent lamps (CCFL and EEFL) are mostly used for applications for backlighting of liquid crystal displays such as in computer displays and monitors. The exemption 3 was part of a comprehensive review in 2015 / 2016. The recommendation specified in the final report of Gensch et al. (2016) is shown in the following figure. According to this recommendation, the exemption would only be valid for computers and monitors that came on the market before 21 July 2016, which are in the scope of Annex II, category 3 (IT and telecommunications equipment). The final decision is still being processed by the EU Commission and has not been taken so far (1 July 2019). With regards to possible GPP criteria for computers and monitors, banning mercury in display lamps would be redundant to the already existing restriction under the RoHS directive.

Table 50: Oeko-Institut recommendation on RoHS exemption 3

Exemption 3	Duration*
Mercury in cold cathode fluorescent lamps and external electrode fluorescent lamps (CCFL and EEFL) for special purposes not exceeding (per lamp):	
(a) Short length (≤ 500 mm), 3.5 mg may be used per lamp	For Cat. 8 & 9: 21 July 2021; For Sub-Cat. 8 in-vitro: 21 July 2023; For Sub-Cat. 9 industrial: 21 July 2024
(b) Medium length (> 500 mm and ≤ 1 500 mm), 5 mg may be used per lamp	
(c) Long length (> 1 500 mm) 13 mg may be used per lamp	
*(d) Short length (≤ 500 mm), 3.5 mg may be used per lamp in EEE placed on the market before 22 July 2016**	For Cat. 5: 21 July 2021
*(e) Medium length (> 500 mm and ≤ 1 500 mm), 5 mg may be used per lamp in EEE placed on the market before 22 July 2016**	
*(f) Long length (> 1 500 mm) 13 mg may be used per lamp in EEE placed on the market before 22 July 2016**	
(g) For back-lighting liquid crystal displays, not exceeding 5 mg per lamp, used in industrial monitoring and control instruments placed on the market before 22 July 2017	Alternative a: For Cat. 5: 21 July 2021; or Alternative b: For Sub-Cat. industrial: 21 July 2024

Source: Gensch et al. (2016)

Cadmium quantum dot technology

Quantum dot technology can be used to achieve high-quality colour performance in televisions and monitors. Many quantum dot solutions are based on materials that involve cadmium, such as cadmium sulfide (CdS) or selenide (CdSe); alternatives are based on indium phosphide technology.

Cadmium quantum dot technology is under heavy debate; the European Parliament objected a Commission Delegated Act on the 20 May 2015 claiming that the report in which the decision was based on needed be updated.[157] As outcome of this re-evaluation the current exemption 39(a) of Annex III was granted for *'cadmium selenide in downshifting cadmium-based semiconductor nanocrystal quantum dots for use in display lighting applications (< 0.2 µg Cd per mm2 of display screen area)'* which has been granted for two years and expires on 31 October 2019.[158] Two requests for renewal of Exemption 39a of Annex III and one further request also dealing with in quantum dots applications have been submitted and have been subject to a targeted stakeholder consultation in spring 2019. The joint evlauation is currently ongoing.[159]

[157] See Communication here: http://www.europarl.europa.eu/sides/getDoc.do?pubRef=-//EP//TEXT+TA+P8-TA-2015-0205+0+DOC+XML+V0//EN&language=EN

[158] COMMISSION DELEGATED DIRECTIVE (EU) 2017/1975 of 7 August 2017 amending, for the purposes of adapting to scientific and technical progress, Annex III to Directive 2011/65/EU of the European Parliament and of the Council as regards an exemption for cadmium in colour converting light-emitting diodes (LEDs) for use in display systems;
see at https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32017L1975&from=EN

[159] See the consultation webpage providing the applications and contributions at: https://rohs.exemptions.oeko.info/index.php?id=316

RoHS Conclusion:

The four phthalates DEHP, BBP, DBP and DiBP are restricted from July 2019 in EEE including computers and monitors. No request for exemption for the use of these four phthalates has so far been submitted that is relevant for computers and monitors.

Therefore, addressing the four phthalates under GPP criteria would be redundant to the existing RoHS restriction.

Based on the RoHS Article 5(1) criteria, exemptions can only be justified where substances are not yet available or where they are not sufficiently reliable or where the impact of substitutes on the environment and on health is higher than the original RoHS substance based application. As long as exemptions are valid, it is thus to be assumed that substitutes are not available or are not preferable in terms of reliability and or impacts on the environment and on health. Requiring manufacturers to substitute a RoHS substance in such cases would not be feasible or would lead to increased impacts on the environment and/or in health. Specifying GPP criteria in relation to mercury or the phthalates or any other substance already restricted under RoHS would be contra productive and may also not be legally coherent.

4.4.2.2. REACH Regulation

Regulation (EC) No 1907/2006 regulates the safe use of chemical substances, and is commonly referred to as the REACH Regulation since it deals with **R**egistration, **E**valuation, **A**uthorisation and Restriction of **Ch**emical substances. REACH, for its part, addresses hazardous substances through processes of authorisation and restriction:

- Substances that may have serious and often irreversible effects on human health and the environment can be added to the candidate list to be identified as Substances of Very High Concern (SVHCs). Following the identification as SVHC, a substance may be included in the Authorisation list, available under Annex XIV of the REACH Regulation. Substances included in Annex XIV cannot be used on its own or in mixtures after the sunset date unless the manufacture or the specified use is authorized.[160]
- However, this ban does not apply on substances in articles, e.g. Annex XIV phthalates DEHP, BBP, DBP and DiBP in plastic parts unless product specific restrictions apply e.g. under REACH Annex XVII or by RoHS.
- For substances identified as SVHCs, thus for the Candidate list substances, a particular duty to communicate the content of the substances in articles applies according to REACH Article 33. This communication should happen along the supply chain without being requested.[161]

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[160] The detailed provisions for authorization are laid down in Article 56.

[161] Article 33 says:

"1. Any supplier of an article containing a substance meeting the criteria in Article 57 and identified in accordance with Article 59(1) in a concentration above 0,1 % weight by weight (w/w) shall provide the recipient of the article with sufficient information, available to the supplier, to allow safe use of the article including, as a minimum, the name of that substance.

2. On request by a consumer any supplier of an article containing a substance meeting the criteria in Article 57 and identified in accordance with Article 59(1) in a concentration above 0,1 % weight by weight (w/w) shall provide the consumer with sufficient information, available to the supplier, to allow safe use of the article including, as a minimum, the name of that substance. The relevant information shall be provided, free of charge, within 45 days of receipt of the request."

- If the use of a substance (or compound) in specific articles, or its placement on the market in a certain form, poses an unacceptable risk to human health and/or to the environment that is not adequately controlled, the European Chemicals Agency (ECHA) may restrict its use, or placement on the market. These restrictions are laid down in Annex XVII of the REACH Regulation.

There are certain restrictions of substances that apply to other product groups such as e.g. toys or textiles or jewellery.[162] Some of them are taken up with regards to computers and displays in ecolabel schemes or companies' substance restrictions, e.g.

- the restriction of the phthalates DINP, DIDP and DNOP in plasticised material for toys and childcare articles which can be placed in the mouth by children (entry 52);[163]
- the restriction of Nickel in articles intended to come into direct and prolonged contact with the skin such as jewellery and textile accessories (entry 27)[164]
- restriction on azocolourants and azodyes (entry 43)[165] that shall not be used, in textile and leather articles which may come into direct and prolonged contact with the human skin or oral cavity.

Substances being restricted in REACH Annex XVII for specific applications are often listed in ecolabel schemes and voluntary approaches of companies. The relevance for computers and monitors in terms of use and risk might not always be checked by e.g. the companies before listing the substance.

REACH Conclusion:

The declaration of the REACH Candidate List substances has to be considered as legal obligation at least in the supply chain. However, a procurer if considered being a consumer, a GPP criterion on the declaration of REACH Candidate List substances constitutes an information request.

Companies or ecolabel schemes restricts substances of REACH Annex XVII, thereby transferring the restriction to the product group computers and display.

It will be further checked if these voluntary approaches consisting of companies' restrictions and ecolabel schemes consistently ban certain substance groups.

4.4.2.3. POP Regulation

The EU POPs Regulation (EC) No 850/2004 is the Community legislation that implements the Stockholm Convention and the POP Protocol. Persistent organic pollutants (POPs) are chemical substances that persist in the environment, bioaccumulate through the food web, and pose a risk of causing adverse effects to human health and the environment.

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[162] The substances restricted under REACH and the conditions of restrictions for each entry can be found at the ECHA webpage at: https://echa.europa.eu/substances-restricted-under-reach

[163] ANNEX XVII TO REACH–Conditions of restriction Entry 52: https://echa.europa.eu/documents/10162/57096439-2ddd-4f14-b832-85181a09f595

[164] ANNEX XVII TO REACH–Conditions of restriction Entry 27: https://echa.europa.eu/documents/10162/7851171d-53e9-455a-8bb8-7ca22e89ad87

[165] ANNEX XVII TO REACH–Conditions of restriction Entry 43: https://echa.europa.eu/documents/10162/6f65910f-f80b-41c3-9c15-026731e4c03d

In the last years, new POPs have been internationally recognized and yet have also been taken up in the EU POP regulation in Annex I that prohibits the production, placing on the market and use of substances whether on their own, in preparations or as constituents of articles: [166]

- SCCPs (Alkanes C10-C13, chloro (short-chain chlorinated paraffins; CAS 85535-84-8),
- HBCDD (Hexabromocyclododecane; CAS 25637-99-4, 3194-55-6, 134237-50-6, 134237-51-7, 134237-52-8).

The specific conditions for both substances are cited in the Annex, see section 5.8.

Thus, the substances banned under the EU POP regulation bans - besides various pesticides and chemicals that are unintentionally produced - the following industrial chemicals:

- Polychlorinated biphenyls (PCB),
- Different types of PBDEs (PBDEs are also restricted under RoHS),
- Hexabromobiphenyl (PBBs are also restricted under RoHS);
- Pentachlorobenzene,
- Perfluorooctane sulfonic acid (PFOS), its salts and perfluorooctane sulfonyl fluoride (PFOS-F).

POP Conclusion:

The POP regulation bans substance as substance or in preparation as well as their presence in articles. Thus also imported articles (EEE or components) are covered by the ban. Therefore restrictions e.g. by ecolabel schemes of SCCP and HBCDD have to be considered as being legal obligation in the EU.

4.4.2.4. Ecodesign

The Ecodesign Directive 2009/125/EC provides a framework for the setting of ecodesign requirements for energy-related products. Ecodesign, in principle, can define substance related requirements (or benchmarks) for products that help improve any of the following in any life cycle phase: [167]

- Consumption of materials, of energy and of other resources such as fresh water,
- Emissions to air, water or soil,
- Pollution through physical effects such as noise, vibration, radiation, electromagnetic fields,
- Generation of waste material,
- Possibilities for reuse, recycling and recovery of materials and/or energy.

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[166] Regulation (EC) No 850/2004 of the European Parliament and of the Council of 29 April 2004 on persistent organic pollutants and amending Directive 79/117/EEC; see a consolidated version at: https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:02004R0850-20160930&rid=1

[167] Directive 2009/125/EC, Annex 1

The draft Ecodesign regulation for electronic displays,[168] whose adoption is expected in early July, proposes a ban on halogenated flame retardants in enclosures and stands of electronic displays in appliances, such as televisions and computer monitors. The ban is based the consideration that the *'presence of halogenated flame retardants represents a major issue in the recycling of plastics of electronic displays. Some halogenated compounds have been restricted by Directive 2011/65/EU because of their high toxicity, others are still allowed. Separation of plastics containing permitted halogenated compounds from the non-permitted ones is not cost-effective, resulting in all being incinerated. Alternative solutions would exist for the bulk of the plastic part in an electronic display, such as the enclosure and stand, permitting higher yields of recycled plastics. Use of halogenated flame retardants in these parts should be limited, however legislative instruments other than eco-design may be considered better suited. Detailed plastic marking, particularly in respect to any flame retardant shall be required in any case also in light of a future review of the regulation.'*

With regard to facilitating circular economy, there are provisions for the declaration of hazardous substances:

- Plastic components heavier than 50g shall be directly marked by specifying the type of polymer,
- Components containing flame retardants shall be marked by the polymer and the used flame retardant,
- Electronic displays which contain Cold Cathode Fluorescent Lamps (CCFL) shall be labelled with the 'Mercury inside' logo,
- Cadmium exceeding a certain threshold shall also be marked.

It has to be stated that no explicit verification has been worked out for these requirements, which are the '*requirements established in point D and E of Annex II*' because in the Annexes it is stated as follows: *'Verification procedure for requirements established in point D and E of Annex II: The model shall be considered to comply with the applicable requirements if, when the Member State authorities check the unit of the model, it complies with the requirements on resource efficiency in Annex II D.'* It is understood that for public procurement this approach would not be acceptable but rather certain documentation would need to be requested.

Ecodesign Conclusion:

A restriction of halogenated flame retardants in plastics is drafted for electronic displays. The restriction comprises halogenated flame retardants as a group of substances referring to circular economy whereas under the European legal provisions such as RoHS, REACH and POP, rather single substances are restricted.

As displays are part of computers and monitors, the ecodesign requirements for displays should further be considered for GPP criteria as well, also with regards to provide harmonized approaches for substance restrictions.

[168] See the draft document at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=pi_com:Ares(2018)5173952; see the Annexes at: https://data.consilium.europa.eu/doc/document/ST-6246-2019-ADD-1/en/pdf

4.4.3. Analysis of chemical requirements in Ecolabel schemes for computers

It was agreed to analyse the following labelling schemes and related documents, the analysis of the requirements on chemicals was sorted out from task 1 to this section.

The US Energy Star Program Requirements Version 7.1 for Computers defines as material requirements that a compliance with the RoHS regulation. As this is legal obligation in the EU, the US Energy Star will not be further looked at. Nordic Ecolabelling Version 5.0 for rechargeable batteries and portable chargers (as of 06/2018) will not be looked at as the focus is on energy issues.

The following sections shortly compile the requirements of each scheme; the compilation is followed by a section on the comparison of the requirements.

The ecolabel schemes EPEAT / IEEE and TCO refer to the GreenScreen® for Safer Chemicals method as methodology for assessing chemicals. As the Green Screen methodology was already mentioned in the last JRC report on the revision of the EU Green Public Procurement (GPP) Criteria for Office IT Equipment, it will not be further explained here.

The requirements on packaging are cited however not further looked at.

4.4.3.1. EPEAT: IEEE Std. 1680.1TM-2018 for computers (as of 02/2018) - PCs & DISPLAYS IEEE 1680.1:2018 CRITERIA

The section 'substance management' addresses the reduction of use of hazardous substances and specifies four so called 'required' criteria and eleven 'optional' criteria. The criteria are displayed in the following table and commented with regard to their level of ambition e.g. whether they are legal obligation in the EU.

Table 51: EPEAT / IEEE criteria on Substance Management provided with comments

EPEAT Computer & Display (IEEE)	Further specification and comment
Required Criteria	
4.1.1.1 (Required) – Conformance with European Union RoHS Directive substance restrictions	RoHS Directive, legal obligation in the EU
4.1.3.1 (Required) – Elimination of intentionally added mercury in light sources	Legal obligation in the EU Mercury in light sources as far as computers and monitors are concerned has been covered by exemption 3 under the RoHS Directive; the last revision did not recommend this exemption for computers and monitors. See section 0 for further explanation.
4.1.5.1 (Required) – Reduction of bromine and chlorine content in plastic parts > 25g	The requirement refers to each plastic part in the product exceeding 25 g, the threshold is indicated be 1000 ppm chlorine or 1000 ppm bromine at the homogeneous level. The following exceptions are specified: 'a) For parts that exceed the specified concentrations of bromine and chlorine, the manufacturer shall perform a hazard assessment in accordance with criterion 4.1.8.1 [Optional—Chemical assessment and selection] on the substance(s) responsible for exceeding the bromine and chlorine levels and the viable alternative substance(s) being considered. The manufacturer shall demonstrate either: 1) The brominated and chlorinated compounds used in the product received a GreenScreen® for Safer Chemicals Benchmark score of 2, 3, and 4 or 2) No viable alternatives to the brominated or chlorinated compounds can achieve a GreenScreen Benchmark score of 2, 3, or 4.

EPEAT Computer & Display (IEEE)	Further specification and comment
	All assessments shall consider the health and environmental impacts of transformation products associated with combustion.' To conclude on the level of ambition, the manufacturer has to make an inventory of the plastic parts, printed circuit boards, cables and wiring, fans, and electronic components are excluded. The inventory also has to include the flame retardants used; if halogenated substances are used, the use should be reflected using the GreenScreen® methodology. However, the benchmark 2[169] has to be recognized as permission of the status quo where the company however should make further efforts.
4.1.7.1 (Required) – Compliance with provisions of EU Battery Directive	Legal obligation in the EU Criterion covers the compliance of the substance content limits of the EU Battery Directive.
Optional Criteria	
4.1.2.1 (Optional) – Restriction on the use of cadmium	The product shall not use any exempted cadmium applications under the EU RoHS Directive. The current exemptions seem to be of less relevance for computers and monitors: Exemption 8(b) on Cadmium and its compounds in electrical contacts: 'Electrical contact materials containing cadmium are used in many electromechanical devices as components which can carry current intermittently through contact surfaces. Devices concerned are in particular power switching of electric motors, relays and contactors, switches for power tools, appliance switches, circuit breakers for switching equipment, power packs, occupancy/time delay sensors, and lighting control panels.'[170] The use of cadmium selenide in downshifting cadmium-based semiconductor nanocrystal quantum dots for use in display lighting applications was granted as an exemption for two years and is currently under review (exemption 39 Annex III; see at https://rohs.exemptions.oeko.info/index.php?id=316).
4.1.4.1 (Optional) – Restriction of the use of beryllium	In EEE, beryllium-containing alloys (copper and nickel alloys contain from 0.15 - 2.0 % weight beryllium) are used; in consumer EEE such as e.g. electrical and electronic connectors for communications equipment, mobile phones, cell phone systems, as well as in medical device connections, fire suppression sprinkler systems and emergency rescue equipment. Beryllium and its compounds is currently subject to an assessment with a view to the review and amendment of the RoHS Annex II list of restricted substances (see at https://rohs.exemptions.oeko.info/index.php?id=289). The relevance of this requirement for computers and monitors cannot be judged here.
4.1.5.2 (Optional) – Further reduction of bromine and chlorine content of plastic materials	The 'required' criterion on the reduction of bromine and chlorine content of plastic materials is further developed and covers all plastic materials exceeding 0.5 g. The following exceptions are described: 'Materials which exceed 25% post-consumer recycled content may contain a

[169] Benchmark score of 2 means "Use but search for safer substitutes" and 3 "Use but Still Opportunity for Improvement". Benchmark 4 is the highest score where the chemical passes all of the criteria.

[170] Recital 5 of COMMISSION DELEGATED DIRECTIVE (EU) 2019/171 of 16 November 2018 amending, for the purposes of adapting to scientific and technical progress, Annex III to Directive 2011/65/EU of the European Parliament and of the Council as regards an exemption for cadmium and its compounds in electrical contacts; https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019L0171&from=EN

EPEAT Computer & Display (IEEE)	Further specification and comment
	maximum of 5000 ppm chlorine and a maximum of 5000 ppm bromine. Power cords in jurisdictions where PVC-free power cords have not been approved by safety agencies for use in the product. In contrast to the required criterion on the reduction of bromine and chlorine content of plastic materials, this criterion describes a ban of halogenated flame retardants and also PVC material.
4.1.6.1 (Optional) – Avoidance or elimination of substances on EU REACH Annex XIV (authorization list)	Avoidance or elimination means 'all articles in the product shall not contain […]' Substances on REACH Annex XIV are also on the REACH Candidate List. Thus the substance list of Annex XIV is a subset of the REACH Candidate List. Thus, if the following criterion is fulfilled, this criterion is automatically fulfilled as well. The criterion refers to the IEC 62474 declarable substance list, where EU REACH Candidate List substances are taken up after a relevance check on potential presence in EEE.
4.1.6.2 (Optional) – Reduction of substances on the EU REACH Candidate List of SVHCs	Reduction also means 'shall not contain applicable substances […] in all articles' The criterion also refers to the IEC 62474 declarable substance list, where EU REACH Candidate List substances are taken up after a relevance check on potential presence in EEE.
4.1.8.1 (Optional) – Chemical assessment and selection	Manufacturer shall demonstrate that all substances used in the following materials and applications are assessed in accordance with the GreenScreen® for Safer Chemicals method and assigned a GreenScreen® Benchmark™ score. Flame retardants in plastic parts > 25 g. The assessment may exclude printed circuit boards, wires and cables, and power supplies. Plasticizers in plastic parts > 25 g. Thus, the assessment focuses on two important functional groups flame retardants and plasticizer.
4.1.9.1 (Optional) – IEC 62474 declarable substances	'For each of the declarable substance groups and declarable substances that fall under designated criteria 1, 2, and 3 on the IEC 62474 Declarable Substances List, the manufacturer shall have at least one of the following: a) A process to obtain and maintain data on the substances covered by this criterion that are in the product; or b) A CAP that demonstrates the product does not contain those substances at or above the specified reporting thresholds in IEC 62474.' The IEC 62474 is an international standard and the Declarable Substance List is a central part of the standard. In fact, it has rather to be considered a basic requirement to collect these data.
4.1.9.2 (Optional) – Requesting substance inventory	'The manufacturer shall request information from suppliers on the inventory of substances in the materials, components, and parts contained in the product. The manufacturer shall have a documented process, and a system or tool, to record the collected information that is used to calculate the percentage of suppliers for the product or percentage mass of the product. The manufacturer shall request suppliers of the materials, components, and parts in the product to disclose the inventory of substances comprising either: Materials, components, and parts encompassing at least 90% of the total product mass At least 90% of the suppliers of materials, components, and parts for the product' It has to be stressed that the criterion requires the request of information and not the responses to the request.
4.1.9.3 (Optional) – Acquiring substance inventory	This criterion is a further development of the previous criterion and requires responses to the information request: 'The manufacturer shall demonstrate that it has received, validated, and is maintaining an inventory of the substances in accordance with 4.1.9.2 contained

EPEAT Computer & Display (IEEE)	Further specification and comment
	in the materials, components, and parts contained in the product at the percentage mass level specified in Table 3.'
4.1.10.1 (Optional) – Reduce fluorinated gas emissions from flat panel display manufacturing	Process related criterion; a reduction of at least 90% of fluorinated greenhouse gas (F-GHG) emissions resulting from the production of flat panel displays shall be achieved.
4.1.10.2 (Optional) – Reduce fluorinated greenhouse gas emissions from semiconductor production	Process related criterion; includes all 300 mm process semiconductor manufacturing facilities (fabs) that produce semiconductor components (e.g., CPUs, DRAM, accelerators) from 75% (by annual fiscal or calendar spend) of all the manufacturer's semiconductor component suppliers for those products.

Source: Own compilation according to sources in Table 7

As for the four required criteria, it has to be noted that two of them are legal obligation in the EU demanding compliance with the RoHS and the Battery Directive. One required criterion refers to the 'elimination of intentionally added mercury in light sources'. As this refers to exemption 3 of Annex III of the RoHS Directive (see section 4.4.2.1), this can also basically be considered as being legal obligation.

The required criterion on the reduction of bromine and chlorine content in plastic parts > 25g unfortunately leaves a loophole for continuing the use of halogenated substances because it allows the continuous use after an assessment with the GreenScreen® for Safer Chemicals method.

As for the optional criteria, a subset of criteria can be chosen for fulfilment e.g. EPEAT Silver rated products meet all the required criteria and 50% of the optional criteria. Thus, a level of ambition depends on the combinations of criteria chosen.

One focus of the optional criteria lies on the ban of certain substances / group of substances, a ban of halogenated flame retardants and a ban of the REACH Candidate List substances.

A second focus concerns assessing the chemicals used and the establishment of chemical inventories. The criteria suggest this at different levels of ambition and finally also suggest an assessment and selection of all chemicals used.

There are several redundancies in the set of the optional criteria. E.g. substances on REACH Annex XIV are also included on the REACH Candidate List: The substance list of Annex XIV is a subset of the REACH Candidate List. Thus, if the criterion on the reduction of substances on the EU REACH Candidate List of SVHCs is fulfilled, the previous criterion on the avoidance or elimination of substances on EU REACH Annex XIV (authorization list) is automatically fulfilled as well. A similar redundancy holds true for the criteria on Declarable substances and substance inventory; the criteria there rather describe steps towards a full substance inventory.

The following table provides an overview about the number of EPEAT labelled products fulfilling dedicated optional criteria with regard to substance management.[171] It has to be noted, however, that the number of product types indeed is lower due to multiple counts as the database also includes same models marketed in different countries.

[171] According to https://epeat.sourcemap.com/?category=pcsdisplays as of 17 July 2019

Table 52: Number of computer products with EPEAT labelling fulfilling optional criteria with regard to substance management according to the EPEAT Registry as of 17.07.2019

(4.1.2.1) Restrictions of the use of cadmium	4583
(4.1.4.1) Restriction of the use of beryllium	4449
(4.1.5.2) Further reduction of bromine and chlorine content of plastic materials	576 (HP, Apple Inc., EIZO, Google)
(4.1.6.1) Avoidance or elimination of substances on EU REACH Annex XIV (authorization list)	4540
(4.1.6.2) Reduction of substances on the EU REACH Candidate List of SVHCs	17 (HP, Lenovo, Zebratechnologies)
(4.1.8.1) Chemical assessment and selection	2984
(4.1.9.1) IEC 62474 declarable substances	4469
(4.1.9.2) Requesting substance inventory	4460
(4.1.9.3) Acquiring substance inventory	1824
(4.1.10.1) Reduce fluorinated gas emissions from flat panel display manufacturing	4508
(4.1.10.2) Reduce fluorinated greenhouse emissions from semiconductor production	4549

Source: Own compilation

4.4.3.2. TCO Certified Generation 8

The section on reduction of hazardous substances in the TCO Certified Generation 8 standard addresses five topics: Heavy metals, halogens, non-halogenated substances, plasticizers and hazardous substances in product packaging.

The criteria of TOC Certifies Generation 8 focus on the ban of certain groups of substances:

- The ban of heavy metals comprises the heavy metals banned under the RoHS Directive thus being legal obligation in the EU.
- For the ban of halogenated substances or intentionally added halogens as part of the polymer, there are exemptions made for printed wiring board laminates, electronic components and all kinds of cable insulation. There are no reasons provided therefore.
- The use of plasticiszers is regulated as explained below.

As for non-halogenated flame retardants and plasticizers, the substances used have to be assessed according to the GreenScreen® for Safer Chemicals method and have to be listed on the public TCO Certified Accepted Substance List,[172] which lists 15 flame retardants, e.g. metal hydroxides and phosphorus based flame retardants and 14 plasticisers, e.g. adipates

[172] TCO Certified Accepted Substance List, last updated: 27 May 2019: https://tcocertified.com/accepted-substance-list/

and also two phthalates, DMP and DPHP. It is understood that this list intents to avoid 'regrettable substitution'[173] in the field of flame retardants and plasticizers.

There is no criterion that concerns the manufacturing process as done by e.g. the EPEAT criteria. There is one criterion on packaging, which is not further considered here.

Table 53: TCO Generation 8 criteria on the reduction of hazardous substances

Substance groups	Further description and comments
Heavy metals	The product must not contain cadmium, mercury, lead and hexavalent chromium; mercury is not allowed in the display panel backlight. Legal obligation in the EU
Halogens	Parts that weigh more than 25 grams (10 g for headsets and 5 g for smartphones) and are made mainly of plastics must not contain flame retardants or plasticizers with halogenated substances or intentionally added halogens as part of the polymer. Exempted are printed wiring board laminates, electronic components and all kinds of cable insulation. The product must not contain PBB, PBDE and HBCDD, which is legal obligation in the EU.
Non-halogenated substances	Non-halogenated flame retardants used in parts that weigh more than 25 grams (10 g for headsets and 5 g for smartphones) and are made mainly of plastics must have been assigned a GreenScreen benchmark score of 2, 3 or 4 by a licensed GreenScreen Profiler and appear on the public TCO Certified Accepted Substance List. (A benchmark U may only be accepted when the 'worst case scenario' for data gaps is considered to be a benchmark 2 or above.). Exempted are printed wiring board laminates, electronic components and all kinds of cable insulation.
Plasticizers	Plasticizers used in product housing and cable insulations must have been assigned a GreenScreen benchmark score of 2, 3 or 4 by a licensed GreenScreen profiler and appear on the public TCO Certified Accepted Substance List. A benchmark U is only accepted when the 'worst case scenario' for data gaps is considered to be a benchmark 2 or above. The product must not contain Bis (2-ethylhexyl) phthalate (DEHP), Butyl benzyl phthalate (BBP), Dibutyl phthalate (DBP), and Diisobutyl phthalate (DIBP). No parts of the product are exempted. All substances of a plasticizer mixture must be accounted for. Non-accepted ingredients must not exceed concentration levels of 0.1% by weight of the plasticizer.
Hazardous substances in product packaging	Refers to a content limit of heavv metals in the packaging material; however packaging requirements will not be further looked at.

Source: Own compilation according to sources in Table 7

[173] Replacement of a toxic substance with one that has unknown –if not greater –toxic effects; see Study for the strategy for a non-toxic environment of the 7th EAP; Sub-study a: Substitution, including grouping of chemicals & measures to support substitution; http://ec.europa.eu/environment/chemicals/non-toxic/pdf/Sub-study%20a%20substitution%20grouping%20NTE%20final.pdf

4.4.3.3. TÜV Rheinland Green Product Mark 2PFG-E 2354:07.2018 for Portable Computers (as of 07/2018)

In the section 'product environmental criteria' there are 16 criteria on 'reduction and avoiding hazardous substances'. Two criteria are mentioned twice (SVHC and PAHs), one criterion covers 'odour' which does not refer to specific substances; one criterion refers to packaging which will not be further discussed here.

The criteria of TÜV Rheinland Green Product Mark describe the ban of different substance groups. Besides flame retardants and plasticizers, there appear also substance groups that are restricted for specific applications in REACH Annex XVII. TÜV Rheinland is the only scheme among the four schemes analysed that refers to four REACH Annex XVII restrictions PAH (Polycyclic Aromatic Hydrocarbons), the phthalates DINP, DIDP, DNOP, NP/OP + NPEO/NPEO (Nonylphenol/Octylphenol + Ethoxylates) and organotin compounds. The PAH appear with single sub-stances in the IEC Declarable Substance List, as well as dibutyltin and dioctyltin for organotin com-pounds and Nonylphenol, branched and linear, ethoxylated thus they have undergone a check for relevance in EEE.

As main threads, the following bans can be depicted:

- REACH Candidate List substances,
- Halogens with the usual exemption of cables,
- The following phthalates: 'DEHP, DBP, BBP, DINP, DIDP, DNOP + SVHC Phthalates'.

Table 54: Product environmental criteria of TÜV Rheinland Green Product Mark provided with comments

Criteria	Comment
RoHS Directive 2011/65/EU and amendments	Legal obligation in the EU
REACH Substances of Very High Concern (SVHC), Regulation (EC) No 1907/2006	REACH Candidate Substance List Limit value of 0.1% in each finished part of the article (all sub-products which can be separated without tools and spare parts) and each packaging separately
Cadmium Referring to Regulation (EC) No 1907/2006	Cadmium is covered by the RoHS Directive; legal obligation in the EU
Halogen	Covers product materials except cables
PAH (Polycyclic Aromatic Hydrocarbons) 18 PAH according to ZEK 01.4-08 Category 2 of GS requirement	See Entry 50 of REACH Annex XVII
Phthalates: DEHP, DBP, BBP, DINP, DIDP, DNOP + SVHC Phthalates Referring to Regulation (EC) No 1907/2006 Annex XIV and XVII	Ban of DEHP, DBP, BBP and DIDP legal obligation from July 2019 on under RoHS Limit value of 0.1% in each finished part of the article (all sub-products which can be separated without tools except cables*) and packaging separately.
Odour	Criterion not applicable as procurement criterion
NP/OP + NPEO/NPEO (Nonylphenol/Octylphenol + Ethoxylates)	See Entry 46 of REACH Annex XVII on Nonylphenol and Nonylphenol ethoxylates

Criteria	Comment
Referring to Regulation (EU) No 1907/2006	
Organotin Compounds Referring to Regulation (EC) No 1907/2006	See Entry 20 of REACH Annex XVII on Organostannic compounds
Packaging testing Pb+Hg+Cd+Cr(VI) < 100 mg/kg	Packaging requirements will not be further looked at.
Mercury: Portable computer using mercury backlights cannot be awarded TÜV	Legal obligation in the EU Mercury in light sources as far as computers and monitors are covered have been exempted by RoHS exemption 3; according to the consolidated version of the RoHS Directive, the exemption has expired in 2011; the exemption has been reviewed in 2015 / 2016; the recommendation given there which are however still in process and are not legally binding, however the exemptions formulated there do not refer to category 3. IT and telecommunications equipment.
Berrylium	In EEE, beryllium-containing alloys (copper and nickel alloys contain from 0.15 - 2.0 % weight beryllium) are used; in consumer EEE such as e.g. electrical and electronic connectors for communications equipment, mobile phones, cell phone systems, as well as in medical device connections, fire suppression sprinkler systems and emergency rescue equipment. Beryllium and its compounds is currently subject to an assessment with a view to the review and amendment of the RoHS Annex II list of restricted substances (see at https://rohs.exemptions.oeko.info/index.php?id=289). The relevance of this requirement for computers and monitors cannot be judged here.
Antimony	Diantimony trioxide is used as a synergist for halogenated flame retardants; thus this ban is partly redundant to the ban of halogens; there however cables are exempted; which is in the case of PVC cables also a potential application of diantimony trioxide. Limit value of 0.1% in each finished part of the article (all sub-products which can be separated without tools) and each packaging separately.
Short chain Chlorinated Paraffines, C10-C13 (SCCP)	Legal obligation in the EU

Source: Own compilation according to sources in Table 7

4.4.3.4. Blue Angel Ecolabel DE-UZ 78 for Computers (as of 01/2017)

Requirements on hazardous substances of the Blue Angel Ecolabel DE-UZ 78 for Computers concern plastics used in housings and housing parts weighing more than 25 grams. For those plastic parts the following bans apply ('*must not contain, as constituent components*'):

- REACH Candidate List substances,
- CMR substances ('classified according to the CLP Regulation for carcinogenic of category Carc. 1A or Carc. 1B, mutagenic of category Muta. 1A or Muta. 1; reprotoxic of category Repr. 1A or Repr. 1B),
- Halogenated polymers in housings and housing parts,
- Halogenated organic compounds as flame retardants,
- Flame retardants classified under the CLP Regulation as carcinogenic of Category Carc. 2 or as hazardous to waters of Category Aquatic Chronic 1.

Among the ecolabel schemes analysed, the Blue Angel is the only Typ I ecolabel. Thus, it is an inherent requirement to refer to the ban of the REACH Candidate List and also to certain hazard classifications, in this case CMR properties.

It should be noted that halogenated polymers are banned for the housing parts, which thus allows the use in wiring board laminates, electronic components and all kinds of cable insulation, which is then congruent to the TCO criterion.

4.4.3.5. Conclusion on the comparison of ecolabel schemes

The schemes analysed work towards a global validity. Thus, they partly formulate criteria that for Europe are legal obligation and would not need to be formulated as a GPP criterion.

As main threads going beyond the European legal obligations, the following appear in at least more than one scheme:

- The four ecolabel schemes analysed all target a ban of halogenated substances as flame retardant and partly also as polymer; however the formulation coverage varies. If halogenated polymers are also banned there are exemptions e.g. for cable insulation.
- Especially for EPEAT, the required criterion does not cover a ban but leaves a loophole for the continous use if searching for alternatives. The further reaching optional criterion might not be chosen for fulfilment by manufacturers, thus EPEAT does not necessarily guarantees the ban of halogenated flame retardants.
- A ban of REACH Candidate List Substances is covered by EPEAT (though optional), TÜV and Blue Angel.
- As for phthalates, TCO and TÜV both target the ban of a larger set of phthalate plasticisers; whereas TCO refers to use plasticisers from the TCO Accepted Substance List where two phthalates are listed, which are not recognized as SVHCs; TÜV bans 'DEHP, DBP, BBP, DINP, DIDP, DNOP + SVHC Phthalates'; both schemes ban the same substances, whereas TCO stipulates via the positive list the alternatives which are to be used.

These main threads – REACH Candidate List substances, halogens and phthalates - will be used to focus the analysis of the approaches of front running companies in the following section.

REACH Annex XVII restrictions did not appear in more than one scheme (TÜV Rheinland). Basically, substances being restricted under REACH Annex XVII are also part of e.g. the phthalates. However, REACH Annex XVII restrictions as such are not suggested to be a main thread for possible GPP criteria.

4.4.4. Analysis of chemical requirements in Ecolabel schemes for smartphones

It was agreed to analyse the following labelling schemes and related documents, the analysis of the requirements on chemicals was sorted out from task 1 to this section.

- EPEAT UL 110 Standard for Sustainability for Mobile Phones
- TÜV Rheinland Criteria for the award of Green Product Mark Mobile Phones
- TCO Certified Generation 8, for smartphones
- Blue Angel Mobile Phones DE-UZ 106

The requirements on packaging are cited however not further looked at.

4.4.4.1. EPEAT: SEPTEMBER 28, 2018 STANDARD FOR SUSTAINABILITY FOR MOBILE PHONES - UL 110

The chapter on 'materials' addresses the reduction of hazardous substances in the sections on 'Supply Chain Management of Materials' (section 7), and 'Substances of Concern' (section 9).

In between, Section 8 on 'Sustainable Materials Use' covers the declaration of post-consumer recycled and biobased plastics content in the mobile phone and in accessories. This refers to the plastic and not to hazardous substances. Thus, these criteria are not cited below.

Like for PCs and Displays, this EPEAT standard differentieates between 'required' criteria and 'optional' criteria. For smartphones, there are five required criteria and six optional criteria. The criteria are displayed in the following table and commented with regard to their level of ambition e.g. whether they are legal obligation in the EU.

Table 55: EPEAT UL 110 criteria on 'Supply Chain Management of Materials' and 'Substances of Concern' provided with comments

EPEAT Mobile Phones (UL 110)	**Further specification and comment**
Required Criteria	
7.1.1 Required – Compliance with the European Union REACH Regulation	The manufacturer shall disclose in accordance with Article 33 disclosure requirements for Substances of Very High Concern (SVHC) under the European REACH regulation. Thus, this criterion rather can be summarized as declaration of SVHC / REACH candidate list substances and is legal obligation in the EU.
9.1.1 Required – Compliance with the European Union RoHS Directive	Legal obligation in the EU
9.2.1 Required – Restrictions of extractable nickel	Audio, video and similar electronic apparatus – Safety requirements, shall not release nickel in excess of 0.5 µg/cm^2. This is the migration limit for articles coming into direct and prolonged contact with the skin such as e.g. jewelry and textile accessories according to REACH Annex XVII, entry 27. It should be noted that the UL 110 lacks the time parameter in its migratin limit (nickel release per week). If the articles mentioned by UL 110 come into the skin contact as specified in REACH Annex XVII, the restriction on nickel has to be cosndieren being legal obligation in the EU.
9.2.4 Required – Restriction of cadmium and mercury in the mobile phone battery cell	Criterion covers the compliance of the substance content limits of the EU Battery Directive. Legal obligation in the EU

EPEAT Mobile Phones (UL 110)	Further specification and comment
9.2.5 Required – Restriction of substances in textile and leather	The criterion says *'Textile and leather used in the product shall not contain:* *• Pentachlorophenol (including salts and esters) in a concentration greater than 0.1% by weight.* *• Dibutyltin and dioctyltin above 1000 ppm (see ISO 17353 Water quality – Determination of selected organotin compounds – Gas chromatographic method).* *• Azo dyes and colorants listed in Appendix 9 of Annex XVII of European Union REACH Regulation, in concentrations above 0.003% by weight in the finished articles or in the dyed parts thereof, according to the testing methods listed in Appendix 10 of Annex XVII of European Union REACH Regulation.* *• Dimethylfumarate above 0.1 ppmdimet'* These limits refer to restrictions under REACH Annex XVII: Entry 20 for Organostannic compounds, Entry 22 for Pentachlorophenol, Entry 43 for Azocolourants and Azodyes, Entry 61 for Dimethylfumarate (DMF). Thus these restrictions are legal obligation in the EU. It is understood that this criterion rather refers to fashion accessories in the context of smartphones.
Optional Criteria	
7.2.1 Optional – Reduction of European Union REACH Candidate SVHC substances	The criterion refers to the IEC 62474 declarable substance list, where EU REACH Candidate List substances are taken up after a relevance check on potential presence in EEE.
7.3.1 Optional – Substitutions assessment	'The manufacturer shall provide documentation showing that a recognized competent and reliable scientific manufacturer or supplier expert, or such an expert in partnership with the manufacturer, has performed a chemical hazard assessment of alternatives to one or more substances that: a) Is on the "Declarable Substances List" of IEC 62474, Material Declaration for Products of and for the Electrotechnical Industry; or b) Has been assessed using the GreenScreen© for Safer Chemicals4 protocol and achieved a BenchmarkTM score of 1 or 2.' This criterion aims to prevent regrettable substitution. In e.g. ecolabel schmes type I this is achieved by banning hazardous classifications.
7.4.1 Optional – Requesting substance inventory	The manufacturer shall request information from suppliers on the inventory of substances in the materials, components, and parts contained in the mobile phone and have a documented process, and a system or tool, to manage that information. It has to be stressed that the criterion requires the request of information and not the responses to the request.
7.4.2 Optional – Receiving substance inventory	This criterion is a further development of the previous criterion and requires responses to the information request: The manufacturer shall demonstrate that it has received, validated, and is maintaining an inventory of the substances in accordance with 7.4.1 contained in the materials, components, and parts contained in the mobile phone at the percentage mass level specified in Table 7.1. There are different points for the Inventory of substances that comprise >25%/50%/75% and 90% mass of the mobile phone
9.2.2 Optional – Restriction of phthalates in the product	Phthalates listed in the Candidate List of Substances of Very High Concern (SVHC) and REACH Annex XIV (List of Substances Subject to Authorization) shall not exceed 1,000 ppm in homogeneous plastic materials used in the product.
9.2.3 Optional – Restriction of bromine and chlorine	Plastic materials in the mobile phone and/or wire, cables, and external power supply shall not exceed 1000 ppm chlorine and 1000 ppm bromine. This criterion describes a ban of halogenated flame retardants and also PVC

EPEAT Mobile Phones (UL 110)	Further specification and comment
	material. It should be noted that no weight value is given like in the criteria for computers; there a cut-off value of >25 grams is given.

Source: Own compilation according to sources in Table 7

The five required criteria, has to be considered being legal obligation in the EU demanding compliance with the RoHS and the Battery Directive and with some restrictions under REACh Annex XVII.

It should be noted that the UL 110 standard lists different criteria compared to the computers and displays that takes into account the different use of smartphones with direct and prolonged contact to the skin e.g. with regard to release of nickel; another criterion restricts susbtances in textile and leather which rather fits to smartphone accessories that are made fromt textiles and leather then to a smartphone itself.

In contrast to the computer criteria, there is no required criterion on the reduction of bromine and chlorine content in plastic parts > 25g. This might be due to the fact that plaatic parts in smartphones are smaller and of lighter weight. The restriction of bromine and chlorine is left as an optional criterion, however without any weight threshold, but applying to '*plastic materials in the mobile phone and/or wire, cables, and external power supply*'.

Like for the EPEAT criteria for computers, optional criteria can be chosen for fulfilment e.g. EPEAT Silver rated products meet all the required criteria and 50% of the optional criteria. Thus, a level of ambition depends on the combinations of criteria chosen.

One focus of the optional criteria lies on the ban of certain substances / group of substances, a ban of the REACH Candidate List substances, a ban of halogenated substances (flame retardants and PVC material) and a ban of the phthalates on the REACH Candidate List and being recognized as SVHCs (This criterion is new compared to the computer criteria).

A second focus concerns assessing the chemicals used – here called 'substance inventory' - is suggest at different levels of ambition as 'requesting substance inventory' and 'receiving substance inventory'. This creates redundancy in the set of the optional criteria. Requesting substance inventory describes the first step towards recieving substance inventory.

The following table provides an overview about the number of EPEAT labelled smartphone products with a Silver or Gold Rating fulfilling dedicated optional criteria with regard to substance management.[174] In total, there are 75 products in the product category of mobile phones and 74 products with a Silver or Gold Rating. It should be noted that the restriction of bromine and chlorine is the criterion the most fulfilled.

[174] According to https://epeat.sourcemap.com/?category=mobilephone as of 30 September 2019

Table 56: Number of smartphone products with EPEAT silver labelling fulfilling optional criteria with regard to substance management according to the EPEAT Registry as of 30.09.2019

(7.2.1) Reduction of European Union REACH Candidate SVHC substances	**1**
(7.3.1) Substitutions assessment	**32**
(7.4.1) Requesting substance inventory	**70**
(7.4.2) Receiving substance inventory	**50**
(9.2.2) Restriction of phthalates in the product	**50**
(9.2.3) Restriction of bromine and chlorine	**74**

Source: Own compilation

4.4.4.2. TCO Certified Generation 8, for smartphones

The TCO Certified Generation 8, for smartphones is identical to the criteria for computers: The section on reduction of hazardous substances in the TCO Certified Generation 8 standard addresses five topics: Heavy metals, halogens, non-halogenated substances, plasticizers and hazardous substances in product packaging.

The criteria of TOC Certifies Generation 8 focus on the ban of certain groups of substances:

- The ban of heavy metals comprises the heavy metals banned under the RoHS Directive thus being legal obligation in the EU.
- For the ban of halogenated substances or intentionally added halogens as part of the polymer, there are exemptions made for printed wiring board laminates, electronic components and all kinds of cable insulation. There are no reasons provided therefore.

  It should be noted that the criteria on halogens and non-halogenated substances refer to parts that weigh more than 25 grams and for headseats and smartphones a lighter weight is given: 10 g for headsets and 5 g for smartphones. This values for weight is not found in other standards.
- The use of plasticiszers is regulated as explained below.

As for non-halogenated flame retardants and plasticizers, the substances used have to be assessed according to the GreenScreen® for Safer Chemicals method and have to be listed on the public TCO Certified Accepted Substance List,[175] which lists 15 flame retardants, e.g. metal hydroxides and phosphorus based flame retardants and 14 plasticisers, e.g. adipates and also two phthalates, DMP and DPHP. It is understood that this list intents to avoid 'regrettable substitution'[176] in the field of flame retardants and plasticizers.

[175] TCO Certified Accepted Substance List, last updated: 27 May 2019: https://tcocertified.com/accepted-substance-list/

[176] Replacement of a toxic substance with one that has unknown –if not greater –toxic effects; see Study for the strategy for a non-toxic environment of the 7th EAP; Sub-study a: Substitution, including grouping of chemicals & measures to support substitution;

There is no criterion that concerns the manufacturing process as done by e.g. the EPEAT criteria. There is one criterion on packaging, which is not further considered here.

Additionally, there is one criterion in another section on '4.2 Material characteristics' on the release of nickel: *'The smartphone must not release nickel from the surfaces that come in contact with user´s skin during normal use.'* The rate of nickel release must not be greater than 0,5 µg/cm2/week which is equal to the specifications in entry 27 of REACH Annex XVII.

Table 57: TCO Generation 8 criteria for smartphones on the reduction of hazardous substances

Substance groups	Further description and comments
Heavy metals	The product must not contain cadmium, mercury, lead and hexavalent chromium; mercury is not allowed in the display panel backlight. Legal obligation in the EU
Halogens	Parts that weigh more than 25 grams (10 g for headsets and 5 g for smartphones) and are made mainly of plastics must not contain flame retardants or plasticizers with halogenated substances or intentionally added halogens as part of the polymer. Exempted are printed wiring board laminates, electronic components and all kinds of cable insulation. The product must not contain PBB, PBDE and HBCDD, which is legal obligation in the EU.
Non-halogenated substances	Non-halogenated flame retardants used in parts that weigh more than 25 grams (10 g for headsets and 5 g for smartphones) and are made mainly of plastics must have been assigned a GreenScreen benchmark score of 2, 3 or 4 by a licensed GreenScreen Profiler and appear on the public TCO Certified Accepted Substance List. (A benchmark U may only be accepted when the 'worst case scenario' for data gaps is considered to be a benchmark 2 or above.). Exempted are printed wiring board laminates, electronic components and all kinds of cable insulation.
Plasticizers	Plasticizers used in product housing and cable insulations must have been assigned a GreenScreen benchmark score of 2, 3 or 4 by a licensed GreenScreen profiler and appear on the public TCO Certified Accepted Substance List. A benchmark U is only accepted when the 'worst case scenario' for data gaps is considered to be a benchmark 2 or above. The product must not contain Bis (2-ethylhexyl) phthalate (DEHP), Butyl benzyl phthalate (BBP), Dibutyl phthalate (DBP), and Diisobutyl phthalate (DIBP). No parts of the product are exempted. All substances of a plasticizer mixture must be accounted for. Non-accepted ingredients must not exceed concentration levels of 0.1% by weight of the plasticizer.
Hazardous substances in product packaging	Refers to a content limit of heavv metals in the packaging material; however packaging requirements will not be further looked at.

Source: Own compilation according to sources in Table 7

http://ec.europa.eu/environment/chemicals/non-toxic/pdf/Sub-study%20a%20substitution%20grouping%20NTE%20final.pdf

4.4.4.3. TÜV Rheinland Green Product Mark 2PFG-E 2073:07.2018 for Mobile Phones (as of 07/2018)

In the section 'product environmental criteria' there are 19 criteria on 'reduction and avoiding hazardous substances'.

The first criterion covers 'odour' which does not refer to specific substances; one criterion refers to packaging which will not be further discussed here.

The criteria for mobile phones basically cover the same threads as those for computers:

As main threads, the following bans can be depicted:

- REACH Candidate List substances,
- Halogens,
- The following phthalates: 'DEHP, DBP, BBP, DINP, DIDP, DNOP + SVHC Phthalates'.

However, the criterion on halogens refers to the weight threshold of 25 g. Taking into account the formulation of the above analysed standards, it is concluded that there are plastic parts in mobile phones that are below this weight value and that this criterion does not well gather the plastic parts in mobile phones.

The criteria of TÜV Rheinland Green Product Mark also list substances /substance groups that are restricted for specific applications in REACH Annex XVII. TÜV Rheinland is the only scheme among the four schemes analysed that refers to four REACH Annex XVII restrictions of PAH (Polycyclic Aromatic Hydrocarbons), the phthalates DINP, DIDP, DNOP, alkylpenols (NP/OP + NPEO/NPEO Nonylphenol/Octylphenol + Ethoxylates) pentoclorophenol and organotin compounds. The PAH appear with single sub-stances in the IEC Declarable Substance List, as well as dibutyltin and dioctyltin for organotin com-pounds and Nonylphenol, branched and linear, ethoxylated thus they have undergone a check for relevance in EEE.

Table 58: Product environmental criteria of TÜV Rheinland Green Product Mark provided with comments

Criteria	Comment
Odour	Criterion not applicable as procurement criterion
RoHS Directive 2011/65/EU and amendments	Legal obligation in the EU
Substances of Very High Concern (REACH SVHC) Regulation (EC) No 1907/2006	Limit value of 0.1% in each finished part of the article (all sub-products which can be separated without tools and spare parts) and each packaging separately
Phthalates: DEHP, DBP, BBP, DINP, DIDP, DNOP + SVHC-Phthalates	Limit value of 0.1% in each finished part of the article (all sub-products which can be separated without tools except cables*) and packaging separately. Ban of DEHP, DBP, BBP and DIDP legal obligation from July 2019 on under RoHS.
Alkylphenols	Refers to 100 mg/kg each (NP/OP) / 100 mg/kg each (NPEO/OPEO) See Entry 46 of REACH Annex XVII on Nonylphenol and Nonylphenol ethoxylates
Organotin Compounds	See Entry 20 of REACH Annex XVII on Organostannic compounds
Pentachlorophenol (PCP)	See Entry 22 of REACH Annex XVII on Pentachlorophenol
Flame retardants	PBBs abd PBDEs are restricted under RoHS, thus it is legal obligation in the EU.

Criteria	Comment
(PBBs, PBDEs, TRIS, TEPA)	The flame retardants 'TRIS' and 'TEPA' are not further specified in the document by e.g. CAS numbers or full names. It is however probable that TEPA is Tri(aziridin-1-yl)phosphine oxide (CAS 545-55-1) and TRIS Tris(2,3-dibromopropyl) phosphate (CAS 126-72-7). Both are coverd by restrictions in REACH Annex XVII (Entry 4 and Entry 7): Accordingly, both substances *'shall not be used in textile articles, such as garments, undergarments and linen, intended to come into contact with the skin.'*
Cadmium Referring to Regulation (EC) No 1907/2006	Cadmium is covered by the RoHS Directive; legal obligation in the EU
Lead Referring to Regulation (EC) No 1907/2006	Lead is coverd by the RoHS Directive; legal obligation in the EU
PAH (Polycyclic Aromatic Hydrocarbons) 18 PAH according to ZEK 01.4-08 Category 2 of GS requirement	See Entry 50 of REACH Annex XVII.
Halogen Referring to the 'NEMI Position Statement on 'Low Halogen' Electronics'	All Printed circuit board (PCB) and substrate laminates shall meet Br and Cl requirements for low halogen as defined in IEC 61249-2-21 and IPC-4101B per 1a (refer to IEC and IPC standards for actual requirements). The maximum total halogens contained in the plastic parts exceeding 25 g, resin plus reinforcement matrix should be less than 1500 ppm with a maximum chlorine of 900 ppm and maximum bromine being 900 ppm. For plastic parts exceeding 25 g manufacturer shall provide a declaration which declares the materials used in the production meet the above seen requirement. Other schemes skip the weight value for mobile phones, e.g. EPEAT UL 110, or set a lighter weight (TCO).
Packaging testing Pb+Hg+Cd+Cr(VI) < 100 mg/kg	Packaging requirements will not be further looked at.
Mercury: Portable computer using mercury backlights cannot be awarded TÜV	Legal obligation in the EU Mercury in light sources as far as computers and monitors are covered have been exempted by RoHS exemption 3; according to the consolidated version of the RoHS Directive, the exemption has expired in 2011; the exemption has been reviewed in 2015 / 2016; the recommendation given there which are however still in process and are not legally binding, however the exemptions formulated there do not refer to category 3. IT and telecommunications equipment.
Berrylium	In EEE, beryllium-containing alloys (copper and nickel alloys contain from 0.15 - 2.0 % weight beryllium) are used; in consumer EEE such as e.g. electrical and electronic connectors for communications equipment, mobile phones, cell phone systems, as well as in medical device connections, fire suppression sprinkler systems and emergency rescue equipment. Beryllium and its compounds is currently subject to an assessment with a view to the review and amendment of the RoHS Annex II list of restricted substances (see at https://rohs.exemptions.oeko.info/index.php?id=289). The relevance of this requirement for computers and monitors cannot be judged here.
Antimony	Diantimony trioxide is used as a synergist for halogenated flame retardants; thus this ban is partly redundant to the ban of halogens; there however cables are exempted; which is in the case of PVC cables also a

Criteria	Comment
	potential application of diantimony trioxide. Limit value of 0.1% in each finished part of the article (all sub-products which can be separated without tools) and each packaging separately.
Nickel release Referring to Regulation (EU) No 1907/2006	<0.5 µg/cm²/week Conducted on metallic parts intend to come into direct and prolonged contact with skin.
Short chain Chlorinated Paraffines, C10-C13 (SCCP)	Legal obligation in the EU (POP Regulation)
Hexabromocyclododecane (HBCDD)	Legal obligation in the EU (POP Regulation)

Source: Own compilation according to sources in Table 7

Besides the criteria depicted in the table, below the table there is a note that restricts the use of substances with certain hazardous classification. In contrast to the ban of certain sustbances / substance groups, this note has a wide implication, e.g. it implies a comprehensive substance inventory/chemical assessment. It remains unclear how compliance with this note needs to be shown as it is not taken up in the criteria catalogue.

The note below the table stipulates that:

'Products covered by this PfG shall not contain as constituents or split off under processing conditions any substances or mixtures that:

1. Identified as substances of very high concern by the REACH Regulation (EC) No 1907/2006 and have been included in the list (so-called Candidate List) set up by REACH, Article 59 paragraph 1.

2. Listed in Regulation (EC) No 1272/2008 (CLP), Annex VI, and exhibit the following properties or meet the criteria for such classification

a. Acutely toxic of category Acute Tox. 1 H330; H310 / Acute Tox. 2, H330; H300 /Acute Tox. 3, H331; H311; H301

b. Toxic to specific target organs of category STOT SE 1 H370 / STOT RE 1 H372

c. Acute Tox. 4 H332; H312; H302

d. STOT SE 2 H371 / STOT RE 2 H373

e. Asp. Tox. 1 H304

f. Skin Corr. 1B H314 and Skin Corr. 1A H314

g. Eye Dam. 1 H318

h. Resp. Sens 1 H334, Skin Sens 1 H317

3. Listed in Regulation (EC) No 1272/2008 (CLP), Annex VI, and exhibit the following properties or meet the criteria for such classification:

a. Carcinogenic of category Carc. 1A, Carc. 1B, Carc. 2 (H340, H341, H350, H351, H360, H361, H362)

b. Germ-cell mutagenic of category Muta. 1A, Muta. 1B, Muta. 2

c. Reprotoxic of category Repr. 1A, Repr. 1B, Repr. 2;

4. Classified in TRGS 905 as:

a. Carcinogenic (K1, K2, K3)

b. Mutagenic (M1, M2, M3)

c. Reprotoxic (RF1, RF2, RF3)

d. Teratogenic (RE1, RE2, RE3);

5. Are classified in the MAK value list as:

a. Carcinogenic (Category 1, Category 2, Category 3A or 3B)

b. Germ-cell mutagenic (Category 1, Category 2, Category 3A or 3B)

c. Teratogenic in the 'Pregnancy' column in group A or B;

6. According to scientific knowledge must be classified in one of the categories under point 1 to 3 either as carcinogenic, mutagenic, reprotoxic or teratogenic or have other chronically damaging properties or which as such or as their impurities or decomposition products are apt to cause considerable risk or considerable disadvantage for the public.'

4.4.4.4. Blue Angel Ecolabel DE-UZ 106 for Mobile Phones (as of 07/2017)

As in the Blue Angel criteria for Computers, requirements on hazardous substances of the Blue Angel Ecolabel DE-UZ 106 for Mobile Phones concern plastics used in housings and housing parts.[177]

There is however not reference to the weight of 25 grams, which is due to the shape of mobile phones (smaller size compared to computers and leighter weight).

For those plastic parts the following bans apply ('*must not contain, as constituent components*'):

- REACH Candidate List substances,
- CMR substances ('classified according to the CLP Regulation for carcinogenic of category Carc. 1A or Carc. 1B, mutagenic of category Muta. 1A or Muta. 1; reprotoxic of category Repr. 1A or Repr. 1B),
- Halogenated polymers in housings and housing parts,
- Halogenated organic compounds as flame retardants,
- Flame retardants classified under the CLP Regulation as carcinogenic of Category Carc. 2 or as hazardous to waters of Category Aquatic Chronic 1.

Among the ecolabel schemes analysed, the Blue Angel is the only Typ I ecolabel. Thus, it is an inherent requirement to refer to the ban of the REACH Candidate List and also to certain hazard classifications, e.g. CMR properties.

It should be noted that halogenated polymers are banned for the housing parts, which thus allows the use in wiring board laminates, electronic components and all kinds of cable insulation, which is then congruent to the TCO criterion.

A second criterion under the section on material requirements ban the use of biocidal silver on toucheabel surfaces.

[177] Section 3.6 Material Requirements : 3.6.1 Plastics used in Housings and Housing Parts

4.4.4.5. Conclusion on the comparison of ecolabel schemes

The schemes, which has been analysed here, work towards a global validity. Thus, they partly formulate criteria that for Europe are legal obligation and would not need to be formulated as a GPP criterion.

As main threads going beyond the European legal obligations, the following appear in at least more than one scheme; it has to be noted that these main threads are identical to those found for computers as well.

- The four ecolabel schemes analysed all target a ban of halogenated substances as flame retardant and partly also as polymer; however the formulation coverage varies e.g. in relation to the weight of the plastic parts.
- A ban of REACH Candidate List Substances is covered by EPEAT (though optional), TÜV and Blue Angel.
- As for phthalates, EPEAT UL 110, TCO and TÜV both target the ban of a larger set of phthalate plasticisers; whereas TCO refers to use plasticisers from the TCO Accepted Substance List where two phthalates are listed, which are not recognized as SVHCs; TÜV bans 'DEHP, DBP, BBP, DINP, DIDP, DNOP + SVHC Phthalates'; both schemes ban the same substances, whereas TCO stipulates via the positive list the alternatives which are to be used.

  For smartphones there is a greater share of ecolabel schemes that restrict phthalates. This might be due to the different use of smartphones with skin contact.

These main threads – REACH Candidate List substances, halogens and phthalates - will be used to focus the analysis of the approaches of front running companies in the following section.

REACH Annex XVII restrictions did appear in more than one scheme thus more often compared to computer criteria, especially regarding the relase of the contact allergen nickel. This can also be due to the different use with direct and prolonged skin contact. However, REACH Annex XVII restrictions as such are not suggested to be a main thread for possible GPP criteria.

4.4.5. Voluntary approaches of front-running companies for computers

As front-running companies, companies are considered that hold the above mentioned ecolabel schemes for some products. Besides, they usually report on their restriction of materials and substances. As license holders of the above mentioned schemes the following companies have been found (in alphabetical order): Dell, Fujitsu, HP, Lenovo, Samsung.

Furthermore, the substance restrictions of Apple are also considered. Apple does not hold one of the above mentioned ecolabel schemes but presents a quite sophisticated company's approach to minimize/restrict hazardous substances. Therefore, Apple's approach is also presented here.

The companies' documents that are used for the analysis are compiled in the following table.

Table 59: Reference documents of computer companies analysed for voluntary approaches

Company (alphabetical order)	Reference Documents
Apple	Apple (2019): Environmental Responsibility Report 2019 Progress Report, covering fiscal year 2018; https://www.apple.com/environment/pdf/Apple_Environmental_Responsibility_Report_2019.pdf Apple (2018): A Protocol for Prioritizing Chemicals of Concern in the Electronics Industry; https://www.apple.com/environment/pdf/Apple_Prioritizing_Chemicals_2018.pdf Apple Regulated Substances Specification 069-0135-K, September 2018; https://www.apple.com/environment/pdf/Apple_Regulated_Substances_Specification_Sept2018.pdf, provides lists on 'Restricted Substances in Products', 'Reportable Substances and Future Restrictions in Products', 'Restrictions in Manufacturing Processes' and 'Reportable Substances and Future Restrictions in Manufacturing Processes'
Dell	Dell Specification, Materials Restricted for Use, Document Number: ENV0424 Revision:A03-00; https://i.dell.com/sites/doccontent/shared-content/solutions/en/Documents/ENV0424-A02.pdf
Fujitsu	Company's webpage on 'Reducing Specific Chemical Substances in Products' at https://www.fujitsu.com/global/about/environment/society/chemical/ provides the following documents that do not carry any indication of a date or a year or an indication of a version/revision number: Fujitsu Group Specified Banned Substances (https://www.fujitsu.com/global/documents/about/environment/society/products/chemical/chemical-010_E.pdf) Fujitsu Group Specified Reportable Substances (https://www.fujitsu.com/global/documents/about/environment/society/products/chemical/chemical-020_E.pdf) Fujitsu Group Specified Control Substances (https://www.fujitsu.com/global/documents/about/environment/society/products/chemical/chemical-030_E.pdf)
HP	HP Standard 011 General Specification for the Environment, HX-00011-00, 26-Jul-2018; http://h20195.www2.hp.com/v2/getpdf.aspx/c04932490.pdf
Lenovo	Lenovo Engineering Specification 41A7731, Baseline Environmental Requirements for Lenovo Products, Materials and Parts; 01 May2019, Version 7.5; https://www.lenovo.com/us/en/pdf/41A7731.pdf
Samsung	Samsung Electronics, Standards for Control of Substances used in products (SEC Registration No. 0QA-2049), Revision 19, October 13, 2017; https://www.samsung.com/us/smg/content/dam/samsung/sg/aboutsamsung/2017/environment/pdf/standard-substances-products-en.pdf

Source: Own compilation

A comparison of the companies' documents shows that they vary in length and nomenclature. Generally, the companies provide lists for restrictions and for reporting or declaration purposes. Some also explicitly list restrictions for manufacturing processes.

The companies' lists will be compared along the main threads identified in the comparison of the ecolabel schemes: REACH Candidate List substances, halogens and plasticizers.

4.4.5.1. REACH Candidate List substances

According to the Apple Regulated Substances Specification, for the REACH Candidate List of SVHCs, the restriction applies to all materials 'unless preapproved by Apple.'

REACH Annex XIV substances are restricted for all materials by Apple as well as by Lenovo.

Lenovo further states that it *'aims to eliminate all SVHCs in a concentration of more than 0.1% w/w in the article by December 31th, 2020.'*

The other companies list the REACH Candidate List for reporting / declaration / monitoring purposes.

4.4.5.2. Halogens

Ozone depleting substances and substances that are used as pesticides e.g. pentachlorophenol are not included in the analysis as the main intention in this thread are plastic parts and the ban of halogenated flame retardants.

- **Apple** lists brominated compounds and chlorinated compounds as 'restricted substances in prodcuts'; the retrictions apply to all materials; there are not exmeptions specified.
- **Dell:** Under *'banned or restricted substances'* the entry on 'Brominated/Chlorinated flame retardants (excluding PBB, PBDE)' is specified as 'Restriction applies to mechanical plastic parts; plastic parts greater than 25 grams and products designated as Halogen Free or BFR/CFR-Free. Exemption applies to internal plastic components such as circuit boards, electronic components, fans, cables, printer fuser assembly and electrical assemblies contained in Dell products unless designated as Halogen Free or BFR/CFR-Free products.' Also the ban of Polyvinyl chloride (PVC) is specified as 'restriction applies to mechanical plastic parts, plastic parts greater than 25 grams and products. Cables, connectors, electronic components, battery trays, magnetic tape, and similar non-mechanical plastic parts are exempt unless designated as Halogen Free or PVC-Free products.'
- As mentioned in the specification, Dell provides parts and/or products designed to satisfy 'halogen-free' requirements. It is understood that this is deliverd upon requests of customers.
- **HP:** In the group of the 'Pan HP Mandatory Restrictions for All Products', there are single susbtances listed that are legally banned int he EU such as HBCD, PBBs, PBDEs, PCBs, SCCPs, Tris(2-chloroethyl) phosphate (TCEP), Tris(1,3-dichloro-2-propyl) phosphate (TDCPP), Polychlorinated naphthalenes, three substances banned by REACH Annex XVII entries 24 to 26 (Ugilec 121 and 141 and DBBT being specific substitutes of PCBs).
- Futhermore, the entry on 'Flame retardant, chlorinated flame retardants (CFR) and brominated flame retardants (BFR) - DecaBDE replacements in external housing parts of computers and televisions' restricts the use in external case plastic part with an exmeption for 'Printed circuit board base materials or printed circuit assemblies'. Polyvinyl Chloride (PVC), also restricted in external case plastic parts of products has an exemption for 'Sheathing of wires and cables, plastic parts <25 g, fabrics, protective product covers'.
- Brominated flame retardants (BFRs) and Chlorinated flame retardants are also listed under 'Class III compounds: Substances which are voluntary phased-out due to the potentially negative effects to the environment or health. These voluntary requirements may be required as specified by the business.' It is understood that products without halogens are basically availabel but only delivered by customer demand.

- **Fujitsu** bans the halogenated susbtances that are legal obligation under RoHS or the POP regulation but does not further specify a ban of brominated or chlorinated flame retardants.
- **Lenovo** lists under restricted susbtances, for brominated flame retardants only the RoHS substances such as PBBs and PBDEs including DecaBDE are mentioned. Furtheron single substances are listed as well such as PCBs and other halogenated aromatic substances, HBCDD and polychlorinated naphthalenes. Two further entries cover chlorinated organophosphates that both have exempted uses:
  - Tris (1,3-dichloro-2-propyl) phosphate (CAS 13674-87-8) - Exempt from this requirement are cables (except cables for mice), adaptors and other similar connecting devices and storage media, such as compact discs, for interactive software, such as computer games. This substance is prohibited in cables for mice.
  - Tris(2-chloroethyl) phosphate: This restriction does not apply to desktop and laptop computers, audio and video equipment, calculators, wireless telephones, game consoles, handheld devices incorporating a screen that are used to access interactive software and their associated peripherals, and cables, adaptors and other similar connecting devices (except cables for mice). This substance is prohibited in cables for mice.
- **Samsung:** Under banned and restricted substances, only single halogented substances are listed such as PBBs and PBDEs, SCCPs, Pentclorophenol, HBCD. Hoewever according to the table in the *'Voluntary phase-out of substances, Class III: Substances which are voluntary phase-out due to the potentially negative effectsto the environment or health'*, brominated flame retardants (BFR), PVC and chlorinated flame retardants are listed for specific applications: Regarding computers and monitors, BFRs are phased out in notebooks and PVC in notebooks (except power cord and adpater) and monitors (except panel).

According to the companies' lists, a ban of halogenated flame retardants is applied by Apple, Dell, HP and – for some produtcts- by Samsung:

Whereas Apple completely bans brominated and chlorinated compounds, Dell and HP limit the restriction to plastic parts heavier than 25 gr. The approaches of both companies are understood to comply with further restrictions if this is demanded by the customer. According to Samsung's Standards for Control of Substances used in products, brominated flame retardants are phased out in notebooks.

4.4.5.3. Plasticizers

All companies besides Lenovo bans further phthalates besides the four phthalates restricted under ROHS. However this further listing is very specific, there is no consensus on a concrete set of substances e.g. the REACH Annex XVII phthalates DINP, DIDP and DNOP.

- **Apple** restricts phthalates for all materials and specifies 21 substances for this group that comprises the four phthalates restricted under RoHS, the further phthalates restricted under REACH Annex XVII and the phthalats recognized as SVHC listed in the REACH Candidate List.
- **Dell** lists under the 'Banned or Restricted Substances' the four phthalates DEHP, BBP, DBP and DIBP restricted under RoHS and also DNOP and DEP.
- **Fujitsu** bans the four phthalates restricted under RoHS and further phthalates that are recognized as CMRs (1,2-benzenedicarboxylic acid; di-C 6-8-branched alkylesters, C7-rich, Bis(2-methoxyethyl) phthalate, Diisopentylphthalate, Di-n-pentyl phthalate (DPP), Di-n-hexyl phthalate (DnHP).
- **HP:** In the group of the 'Pan HP Mandatory Restrictions for All Products', HP lists the four phthaltes restricted under RoHS as well as Diisononyl phthalate (DINP). Phthalates are further listed under *'Class III compounds: Substances which are voluntary phased-out due*

to the potentially negative effects to the environment or health. These voluntary requirements may be required as specified by the business.' It is understood that products without phthalates are basically availabel but only delivered by customer demand. It has to be noted that HP specifies for substitution that 'when replacing substances, alternatives must have a lower potential impact to human health and the environment and meet HP Business performance and cost criteria. For example, when phasing out of GSE restricted phthalates, non-ortho-phthalate alternatives must be used.'

- **Lenovo** only bans the four phthalates DEHP, BBD, DBP and DiBP. Further phthalates are scheduled for being reportable substances, namely Dicyclohexyl phthalate (CAS 84-61-7), Diethyl phthalate (CAS 84-66-2), Diisodecyl phthalate (DIDP) (CAS 26761-40-0 and 68515-49-1), Diisononyl phthalate (DINP), Di-n-hexyl phthalate (DNHP) (CAS 84-75-3), Di-n-octyl phthalate (DNOP) (CAS 117-84-0), Di-n-pentyl phthalate (DNPP) (CAS131-18-0).
- **Samsung:** lists the four phthalates as class I and additionally bans 'Phthalates other than listed in Class I' and lists with a reference to ANNEX XVII of REACH Regulation (EC) No 1907/2006, CA Proposition 65 and US CPSC Public Law 110-314 the following phthalates: Diisononyl phthalate(DINP), Di-isodecyl phthalate(DIDP), Di-n-octyl phthalate(DnOP), Di-n-hexyl phthalate(DnHP), Bis(2-methoxyethyl) phthalate(DMEP), Di-iso-pentyl phthalate(DIPP), n-Pentyl-isopentyl phthalate(nPIPP), Di-n-pentyl phthalate(DnPP).

4.4.7. Voluntary approaches of front-running companies for smartphones

As front-running companies, here four companies have been considered because they are listed in the EPEAT registry for smartphones: Apple Inc., Google, LG Electronics and Samsung. Their approaches and products certified with the EPEAT silver or gold standard will be analysed in detail with regard to energy and material efficiency best practices and fulfilment of the optional EPEAT criteria.

The companies' documents that are used for the analysis are compiled in the following table.

Table 60: Reference documents of smartphone companies analysed for voluntary approaches

Company (alphabetical order)	Reference Documents
Apple	Apple (2019): Environmental Responsibility Report 2019 Progress Report, covering fiscal year 2018; https://www.apple.com/environment/pdf/Apple_Environmental_Responsibility_Report_2019.pdf Apple (2018): A Protocol for Prioritizing Chemicals of Concern in the Electronics Industry; https://www.apple.com/environment/pdf/Apple_Prioritizing_Chemicals_2018.pdf Apple Regulated Substances Specification 069-0135-K, September 2018; https://www.apple.com/environment/pdf/Apple_Regulated_Substances_Specification_Sept2018.pdf, provides lists on 'Restricted Substances in Products', 'Reportable Substances and Future Restrictions in Products', 'Restrictions in Manufacturing Processes' and 'Reportable Substances and Future Restrictions in Manufacturing Processes'
Google	Company's webpage on 'Safer chemistry for healthy manufacturing' at https://sustainability.google/projects/safer-chemistry/ Google Restricted Substances Specification 990-00012-00-C (no year indicates) at https://storage.googleapis.com/gweb-environment.appspot.com/pdf/RSS/990-00012-00-C%20Google%20Restricted%20Substances%20Spec.pdf
LG Electronics	Company's webpage on 'Hazardous Substances Management' at https://www.lg.com/global/sustainability/environment/management-of-hazardous-substances
Samsung	Samsung Electronics, Standards for Control of Substances used in products (SEC Registration No. 0QA-2049), Revision 19, October 13, 2017; https://www.samsung.com/us/smg/content/dam/samsung/sg/aboutsamsung/2017/environment/pdf/standard-substances-products-en.pdf

Source: Own compilation

A comparison of the companies' documents shows that they vary in length and nomenclature. Generally, the companies provide lists for restrictions and for reporting or declaration purposes. Some also explicitly list restrictions for manufacturing processes.

The companies' lists will be compared along the main threads identified in the comparison of the ecolabel schemes: REACH Candidate List substances, halogens and plasticizers.

4.4.7.1. REACH Candidate List substances

- According to the **Apple** Regulated Substances Specification, for the REACH Candidate List of SVHCs, the restriction applies to all materials 'unless preapproved by Apple.' REACH Annex XIV substances are restricted for all materials by Apple.
- **Google** lists the REACH Candidate List of Substances of Very High Concern (SVHC) for a 'Future Phase-Out for Prodcuts' with a prioritiy of 2. And: Suppliers must take action to report the current use in Google materials, parts, and components and proactively identify suitable replacements.

- **LG Electronics** lists 'EU REACH SVHCs' at 'Level B-II substances (substances to observe)'
- **Samsung** lists a class for monitoring which applied for all products: 'Substances need to be monitored such as EU REACH SVHC candidate list or substances which are expected which are expected which are expected which are expected to regulate in the future.'

4.4.7.2. Halogens

Ozone depleting substances and substances that are used as pesticides e.g. pentachlorophenol are not included in the analysis, as the main intention in this thread are plastic parts and the ban of halogenated flame retardants.

- **Apple** lists brominated compounds and chlorinated compounds as '*restricted substances in prodcuts*'; the retrictions apply to all materials; there are not exmeptions specified.
- **Google** lists Brominated Flame Retardants (BFRs) and Chlorinated Flame Retardants (CFRs) for 'restrictions apply to all homogenous materials in Google consumer products and accessories, or uncured formulations as designated'. The restriction applies to all materials and there are not exemptions from the restriction listed.
- **LG Electronic** lists 'PVC (Poly vinyl chloride)', 'Other brominated flame retardants (except PBB, PBDE, HBCDD)' and 'Other chlorinated flame retardants (except TCEP, TDCPP)' as 'Level B-I substances (voluntary use reduction substances)'. Accordingly, ' LG Electronics can phase out Level B-I substance of each product group according to the phase out program of the relevant business unit.'

  According to the EPEAT registry, there are LG Electronics mobile phones that fulfill the EPEAT /UL 110 criterion on the restriction of bromine and chlorine. It can be concluded therefrom that at least certain mobile phones of LG Electronics do not contain halogens:

  E.g. LM-Q720PS[178] or LM-V450VM[179] both received a score of 6 points for this criterion which means that plastic materials in the mobile phone **and** wire, cables, and external power supply do not exceed 1000 ppm chlorine and 1000 ppm bromine.
- **Samsung:** Under banned and restricted substances, only single halogented substances are listed such as PBBs and PBDEs, SCCPs, Pentaclorophenol, HBCD. Hoewever according to the 'Table 3 *Voluntary phase-out of substances'* on *'Class III: Substances which are voluntary phase-out due to the potentially negative effectsto the environment or health'*, brominated flame retardants (BFR), PVC and chlorinated flame retardants are listed for specific applications: For 'Mobile phones Tablets and (including accessories and (including accessories and chargers)', the phase-out started January 2009; as phase-out date January 2010 is indiacted in this Table 3.

According to the companies' lists, a ban of halogenated flame retardants is applied by Apple, Google and Samsung – at least for some mobile phones for some produtcts – by LG Electronics: Whereas Apple completely bans brominated and chlorinated compounds, Dell and HP limit the restriction to plastic parts heavier than 25 gr. The approaches of both companies are understood to comply with further restrictions if this is demanded by the customer. According to Samsung's Standards for Control of Substances used in products, brominated flame retardants are phased out in notebooks.

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[178] https://epeat.sourcemap.com/products/5d1690137201aa1a5b22e1fb and https://epeat.sourcemap.com/products/5d168fd07201aa1a5b22e1df

[179] https://epeat.sourcemap.com/products/5d168f247201aa1a5b22e1c3

4.4.7.3. Plasticizers

All companies bans further phthalates besides the four phthalates restricted under ROHS. However this further listing is very specific, there is no consensus on a concrete set of substances e.g. the REACH Annex XVII phthalates DINP, DIDP and DNOP.

- **Apple** restricts phthalates for all materials and specifies 21 substances for this group that comprises the four phthalates restricted under RoHS, the further phthalates restricted under REACH Annex XVII and the phthalats recognized as SVHC listed in the REACH Candidate List.
- **Google** also restricts phthalates for all materials and specifies 26 single substances for this group that comprises the four phthalates restricted under RoHS, the further phthalates restricted under REACH Annex XVII and the phthalats recognized as SVHC listed in the REACH Candidate List and additional phthalates such as e.g. DEP.
- **LG Electronics** again lists 'Other phthalates(except DEHP, DBP, BBP, DIBP)' under 'Level B-I substances (voluntary use reduction substances)' and further details that 'LG Electronics can phase out Level B-I substance of each product group according to the phase out program of the relevant business unit.' A countecheck of the prodcuts in the EPEAT registry shows that at least certain mobile phones of LG Electronics that the phthalates recognized as SVHCs (REACH Candidate list substances) are restricted e.g. in LM-Q720PS[180] or LM-V450VM[181].
- **Samsung:** lists the four phthalates as class I and according to 'Table 2. Banned and restricted substances' additionally bans 'Phthalates other than listed in Class I', referring to ANNEX XVII of REACH Regulation (EC) No 1907/2006, CA Proposition 65 and US CPSC Public Law 110-314. These following so called 'class II phthalates are listed in number 28 from Annex 3: Diisononyl phthalate(DINP), Di-isodecyl phthalate(DIDP), Di-n-octyl phthalate(DnOP), Di-n-hexyl phthalate(DnHP), Bis(2-methoxyethyl) phthalate(DMEP), Di-iso-pentyl phthalate(DIPP), n-Pentyl-isopentyl phthalate(nPIPP), Di-n-pentyl phthalate(DnPP). Furthermore, Phthalates are listed in *'Table 3 Voluntary phase-out of substances'* on *'Class III: Substances which are voluntary phase-out due to the potentially negative effectsto the environment or health'.* For *'Mobile phones Tablets and (including accessories and (including accessories and chargers)'*, the phase-out started January 2010; as phase-out date January 2011 is indiacted in this Table 3.

[180] https://epeat.sourcemap.com/products/5d1690137201aa1a5b22e1fb and https://epeat.sourcemap.com/products/5d168fd07201aa1a5b22e1df

[181] https://epeat.sourcemap.com/products/5d168f247201aa1a5b22e1c3

4.4.8. Conclusion and outlook

4.4.8.1. Computers

Due to the amendment of the RoHS Directive on the list of restricted substances, the four phthalates DEHP, DBP, BBP and DiBP do not further have to be addressed by GPP criteria.

The restriction of halogenated flame retardants in plastics in the draft Ecodesign regulation for electronic displays should further be considered for GPP criteria, also with regards to provide harmonized approaches for substance restrictions. It still needs to be worked out how this requirement should be formulated and addressed, e.g. as a technical specification in the best case or as an award criterion, and which verification procedure is most appropriate.

The analysis of the voluntary approaches reveals that REACH Candidate List substances, halogens and plasticizers as groups of substances could be considered for restrictions:

- A ban of the REACH Candidate List substances is covered by the ecolabel schemes EPEAT as an optional criterion, TÜV and Blue Angel. As from the companies Apple bans the REACH Candidate List susbtances and Lenovo states eliminate REACH Candidate list susbtances by end of 2020. Thus there are approaches achieving the ban of REACH Candidate List substances. A restrictio of the REACH Candidate List substances might be suitable for an award criterion.
- A restriction of halogentated flame retardants, is contained in all four ecolabel schemes analysed and also in some companies restrictions. According to the companies' lists, a ban of halogenated flame retardants is applied by Apple, Dell, HP and – for some produtcts- by Samsung. Thus, the restriction of halogenated flame retardants is quite stronlgy supported and further supports the restriction suggested in the draft Ecodesign regulation for electronic displays. The restriction would apply to plastic parts with a weight of greater then 25g.
- As for the restriction of phthalates, two ecolable schemes, adress platicizers, TÜV bans of a larger set of phthalate plasticisers ('DEHP, DBP, BBP, DINP, DIDP, DNOP + SVHC Phthalates') and TCO refers to use plasticisers from the TCO Accepted Substance List where two phthalates not recognized as SVHCs are listed. Also most companies adress further phthalates besides the four restricted udner RoHS; however there is no consensus on a concrete set of substances e.g. the REACH Annex XVII phthalates DINP, DIDP and DNOP. A potential ban of phthalates by GPP criteria might rather be covered by an award criterion.

4.4.8.2. Smartphones

The legal background is the same as for computers. Due to the amendment of the RoHS Directive on the list of restricted substances, the four phthalates DEHP, DBP, BBP and DiBP do not further have to be addressed by GPP criteria.

The analysis of ecolabel schemes as well as approaches of front running companies show that compared to computers, restriction of halogenated substances and phthalates are addressed more often.

This supports the proposal already formulated for computers, that the restriction of halogenated flame retardants in plastics in the draft Ecodesign regulation for electronic displays should further be considered for GPP criteria, also with regards to provide harmonized approaches for substance restrictions. It still needs to be worked out how this requirement should be formulated and addressed, e.g. as a technical specification in the best case or as an award criterion, and which verification procedure is most appropriate.

The analysis of the voluntary approaches supports the proposals summarized for computers that REACH Candidate List substances, halogens and plasticizers as groups of substances could be considered for restrictions:

- A ban of the REACH Candidate List substances is covered by the ecolabel schemes EPEAT as an optional criterion, TÜV and Blue Angel. As from the companies Apple bans the REACH Candidate List susbtances. Thus there are approaches achieving the ban of REACH Candidate List substances. A restriction of the REACH Candidate List substances might be suitable for an award criterion.
- A restriction of halogentated flame retardants, is contained in all four ecolabel schemes analysed and also in the companies restrictions. According to the companies' lists, a ban of halogenated flame retardants is applied by Apple, Google and for smartphones also by LG Electronics and Samsung. Thus, the restriction of halogenated flame retardants is for smartphnoes even stronger supported and further supports the restriction suggested in the draft Ecodesign regulation for electronic displays.

  It has to be kept in mind that for smartphones or a leighter weight of 5 grams as stipulated by TCO or not weight value should be given.
- As for the restriction of phthalates, three ecolable schemes, adress platicizers, EPEAT UL 110 restricts the phthalates on the Candidate List of Substances of Very High Concern (SVHC); TÜV bans of a larger set of phthalate plasticisers ('DEHP, DBP, BBP, DINP, DIDP, DNOP + SVHC Phthalates') and TCO refers to use plasticisers from the TCO Accepted Substance List where two phthalates not recognized as SVHCs are listed. Also most companies adress further phthalates besides the four restricted udner RoHS; however there is no consensus on a concrete set of substances e.g. the REACH Annex XVII phthalates DINP, DIDP and DNOP. However, a ban of phthalates by GPP criteria might covered by e.g. an award criterion is strongly supported by the company approaches.

5. ANNEXES

5.1. Results of the analyses of NAP GPP: EU GPP criteria for ICT equipment

The following six Member States have indicated that they do not currently have a valid NAP GPP: Estonia, Greece, Hungary, Luxembourg, Romania, and Slovenia. Source: http://ec.europa.eu/environment/gpp/pdf/GPP_NAPs_June_2018.pdf

Table 61: Detailed overview of the results of EU GPP criteria for ICT equipment in NAP GPP

Country	Are GPP criteria developed at the national level (Y/N)?	For which product groups have national GPP criteria been developed	For which product groups are GPP criteria currently under development	For which product groups are EU GPP criteria recommended	TCO/LCC TOOLS DEVELOPED/USED
Austria	yes	IT equipment	-	-	TCO Tool for IT equipment
Belgium	Yes, most of the cases the EU GPP criteria are the start of the discussion at national level with the stakeholders.	PCs, laptops, monitors, mobile phones	-	In general: If national criteria exist, often based on the EU GPP criteria and discussed with the national stakeholders, the national criteria are recommended.	No specific tool (only) for ICT but general tools, available for all services: - Best practices comparison (2015) - Ethical and sustainable procurement pilot projects (2015) - Ecological and social/ethical label database (2015)
Bulgaria		Energy efficiency criteria for office IT equipment			
Croatia	Yes; GPP criteria for the priority product groups in NAP GPP are based on EU GPP Criteria. Other additional criteria have not been developed	GPP criteria for all priority product groups are based on EU GPP Criteria	None	telecommunication services and mobile telephony services, office IT equipment	LCC tools have not been developed on national level. NAP GPP contains an overview of several LCC tools and guides as well as an recommendation for the use of SMART SPP application
Cyprus				Office equipment,	
Czech Republic	In preparation; they are based on EC GPP core criteria	IT office equipment	IT		
Denmark	Yes, but for the most part the EU GPP criteria is com-mu-nicated to the	Electricity using products		For the product groups where there is no national guidance	computers, displays, servers, storage, large network equipment, small network equipment,

Country	Are GPP criteria developed at the national level (Y/N)?	For which product groups have national GPP criteria been developed	For which product groups are GPP criteria currently under development	For which product groups are EU GPP criteria recommended	TCO/LCC TOOLS DEVELOPED/USED
	procurers				
Finland	YES	energy related products		EU GPP criteria are used as a basis for national guidelines and criteria.	
France	Yes	Computers (general guidelines)			Joint task force aiming at establishing precise criteria for LCC (for now focus on CO2 emissions from wood building materials)
Germany	Yes	Ccomputer			German Environment Agency: 1. General LCC-tool; 2. Product group specific LCC-tool (product groups: PC, multifunction device, monitor, data processing centre, floor coverings, refrigerator, dishwasher) Berliner Energieagentur: LCC-tool for the product groups lighting, vehicles, household appliances, IT and green energy ICLEI / Öko-Institut: General LCC-tool for a variety of products Zentralverband Elektrotechnik- und Elektronikindustrie e.V.: the LCC-tool is most suitable for the development of larger projects, for example sewage treatment plants
Ireland	No		Office IT Equipment	IT equipment	None at present
Italy	Yes. EU GPP criteria and Ecolabel criteria are the main reference documents.	personal, notebook and tablet computers	personal, notebook and tablet computers		
Latvia	YES			Office IT equipment	
Lithuania	Yes	mobile phones and mobile phone chargers			
Malta	NO			computers and monitors	

Country	Are GPP criteria developed at the national level (Y/N)?	For which product groups have national GPP criteria been developed	For which product groups are GPP criteria currently under development	For which product groups are EU GPP criteria recommended	TCO/LCC TOOLS DEVELOPED/USED
The Netherlands	Yes	IT equipment, ICT services			
Poland	No				
Portugal	YES - ENCPE 2020 foresees the definition of environmental criteria for twenty-one priority categories of goods and services.		Office IT equipment	Office IT equipment	
Slovakia	No, Slovak NAP for GPP applies for 12 product groups which are based on EU GPP criteria.			Computer and monitors	None
Spain	Yes	office equipment			
Sweden	Yes	IT and Telecom	Computers and screens	Computers and screens	General LCC tool
United Kingdom	Yes	office ICT			

Source: Own compilation

5.2. Results of the analyses of NAP GPP: Monitoring activities

The following six Member States have indicated that they do not currently have a valid NAP GPP: Estonia, Greece, Hungary, Luxembourg, Romania, and Slovenia.

Table 62: Detailed overview of the results of monitoring activities in NAP GPP

Countries	MONITORING
Austria	Federal level – a voluntary monitoring system was developed and tested. Due to a small degree of participation and a lack of data, the monitoring activities were put aside for the moment.
Belgium	National: A first set of test-questionnaires to the federal services was sent out in March 2010. Since the Circular of 2014, several paths for structural monitoring are discussed and some are implemented: (1) reporting of strategies on SPP in the federal departments by reports of the Commission of Sustainable Development (destined to the government and the federal parliament), (2) monitoring by the federal accounting system FEDCOM, (3) monitoring of the products bought via central procurement, (4) monitoring by the database on the publication of the national tender documents etc. Flanders Region Pilot ongoing + decision to roll out electronical system from 2017 to monitor and manage tenders Brussels Region yearly monitoring of the GPP. Every 3 years, results (based on the 3 yearly monitoring) are compared with the targets. Walloon Region monitoring questionnaire on GPP was sent out in 2012. A working group on the monitoring of SPP has been set up in 2015.
Bulgaria	Monitoring of the implementation of the NAP shows that targets have not been achieved but there are positive results for GPP criteria implementation on paper
Croatia	Monitoring was conducted by the use of on-line forms survey in 2016 and through official Electronic Public Procurement Advertisement since 2015 on annual basis
Cyprus	There is continuous monitoring from the Department of Environment, using questionnaires, letters and direct contact with the public authorities. Cyprus is about to apply for financing through Interreg Europe programme a project for GPP Monitoring System. For more information and / or interest to be part of the project please contact to ngeorgiou@environment.moa.gov.cy
Czech Republic	Ministry of the Environment will collects data about GPP on the central level by statements of procurement of 'Green responsible products' which are will be sent by other bodies by 2018. Other data are obtained from 'Information system on public contracts' which was modified according this goal.
Denmark	A study published in 2016 aims to provide an overview of the status of green public procurement in Denmark (in 2013). Furthermore, the aim is to examine the possibility of continued monitoring of the government's, regions' and municipalities' awareness of environmental considerations in connection with public procurement
Finland	Monitoring by examining tender calls and by questionnaire in 2012 and 2017. Around half of the municipalities considered sustainability goals in their procurement strategy or other procurement instructions. Sustainability goals are often set at a fairly general level and only around one fourth of the municipalities had defined more detailed sustainability criteria in their procurement strategy or instructions.
France	Several tools have been developed by the SPP national action plan to evaluate and monitor SPP : « éco-responsibility » indicators, administrative audits, studies etc…. The 2008 PM guidelines on « Etat exemplaire » (public authorities leading by example) contains 12 (out of 20) SPP targets. The other targets relate to environmental management, training etc…These guidelines are equipped with a strong monitoring system. Each sectoral target factsheet contains indicators that ministries have to regularly fill in. Every Ministry must report yearly on the progress towards the targets and the indicators. A budget-neutral financial 'bonus-malus' (reward-penalty) system is introduced in 2010 to reward the well-performing ministries and penalise the bad ones.
Germany	Ongoing study: 'Elektronische Vergabestatistik' on Monitoring Public Procurement by the

Countries	MONITORING
	Federal Ministry of Economic Affairs and Energy Monitoring of the sixth measure of the 'Action Programme Sustainability' by The Federal Government (on March 30 2015) (http://www.bundesregierung.de/Webs/Breg/DE/Themen/Nachhaltigkeitsstrategie/5-Berichte/Ma%C3%9Fnahmenprogramm/_node.html)
Ireland	No monitoring is currently underway. Responsibility will be shared between the Dept of Communications, Climate Action and Environment, The Environmental Protection Agency and The Office of Government Procurement.
Italy	An electronic monitoring system is in place since 2010 but no useful data were collected by it. Legislative Decree 56/2017 states that the National Anticorruption Authority (ANAC) must monitor the application of Minimum Environmental Criteria. A specific cooperation with National Anticorruption Authority has been proposed by Ministry of environment on this topic.
Latvia	An Annual review. Contracts over and under EU limits Central level For all groups, where are applied GPP criteria Results from 2015: GPP proportion for all procurements are 19,2% in financial expression
Lithuania	The monitoring of GPP is performed and statistical data on conducted public procurement is accumulated by the Public Procurement Office. All contracting authorities shall submit a report on the procurement procedure to the Public Procurement Office and shall indicate in the reports if the GPP criteria were used during the procurement procedure. Annual reports on GPP progress of implementation.
Malta	Data is collected by means of a GPP report that CAs are obliged to submit on a weekly basis. In addition to this report, MESDC also undertakes a quality assurance exercise that compares the data collected in each ministry GPP weekly report with the tenders published on the EPPS system. This monitoring system collates information on a pre-publication basis and therefore only monitors tenders. In terms of monitoring all entities which fall within the remit of the National Procurement Regulations are monitored
The Netherlands	Results of GPP monitoring carried out in 2008: municipalities 44%, provinces 34% and central government 51% The most recent monitoring took place in 2010. The follow up is a policy evaluation, planned in fall of 2013
Poland	As regards the GPP monitoring, the Public procurement Office developed in 2016, a new monitoring method which is based on analysis of information delivered by contracting authorities in annual report on awarded contracts. The annual reports on awarded contracts are submitted by all the contracting authorities by means of an online form placed at the Public Procurement Office portal. A new standard form of annual report on awarded contracts, which each and individual contracting authority is obliged to submit to the Public Procurement Office, was adopted in Dec., 2016 by means of a regulation (a secondary legislation to the Public Procurement Law). A special table was added in order to identify all the possibilities of inclusion of environmental aspects as provided for in the 2016 amended Public Procurement Law (all these aspects are stipulated in the 2014 EU PP Directives). The Public Procurement Office of Poland shall then possess detailed information on all awarded contracts where some environmental considerations were found (in case of contracts awarded in 2016 – the information is narrowed to contracts awarded under 2016 amended Public Procurement Law).
Portugal	Monitoring is automatically obtained in Electronic Platforms for Public Procurement. The ENCPE 2020 foresees some indicators to evaluate its implementation: ICPE1 = number of tendering procedures considering environmental criteria × 100 / number of total tendering procedures CPE2 = value associated with tendering procedures considering environmental criteria established × 100 / value ICPE3 = number of contracts awarded including environmental criteria × 100 / total number of contracts ICPE4 = contract price of contracts including environmental criteria × 100 / contract price of all contracts.
Slovakia	On-line form survey. Annually. All contracts and purchases for product groups covered by the NAP for GPP. Central, regional and local level authorities. Product groups covered by NAP GPP. EU GPP criteria. Results from 2016 monitoring: Indicator 1 (% share of GPP in total public procurement in relation to the number of tenders): 3,5%, Indicator 2 (% share of GPP in total public procurement in relation to the value of tenders): 7,9%.
Spain	1. General Administration A monitoring of the NAP, through a questionnaire, has been conducted during 2010 and 2011. The results of these monitoring are avaliable at: http://www.marm.es/es/ministerio/planes-y-estrategias/plan-de-contratacion-publica-verde/default.aspx. Second report on the State of Green Public Procurement in the General

Countries	MONITORING
	Administration of the State: broad levels of compliance with targets and objectives set in the GPP NAP (2008-2015) 2. Autonomous Communities In the Basque Country, an annual monitoring on the state of implementation of the Government agreement is carried out. A specific pilot project based on the EU monitoring study with 7 public administrations was conducted in 2009. 3. Local Entities Barcelona is a pioneer city in monitoring its GPP achievements following the main indicators proposed by the CE on its 'Collection of statistical information on GPP in the EU'. 96% of the expenses and 71% of the tenders of the priority product groups include green criteria (paper, cleaning services, IT equipment, transport, furniture, electricity, food and catering services, textiles and gardening products and services). In addition, some of the economically most important contracts also include environmental clauses, such as the waste collection and urban cleaning services, traffic lights, outdoor lighting or fountain maintenance
Sweden	There is no general monitoring of the percentage of public procurement procedures incorporating green criteria out of the whole volume of procurement at national level. However, there are examples of studies limited in scope. For example, the National Agency for Public Procurement has carried out a minor study based on approximately 600 tender documents for 30 selected product groups. The result showed that 90 percent of the tender documents analyzed contained some form of environmental criterion, either criteria from the National Agency for Public Procurement or criteria developed by the contracting authority.
United Kingdom	Monitoring of compliance with Greening Government Commitments is done by the Cabinet Office through regular surveys which all relevant organisations must complete.

Source: http://ec.europa.eu/environment/gpp/pdf/GPP_NAPs_June_2018.pdf

5.3. List of search terms and keywords used for the analyses of tender documents

Table 63: Detailed overview of the search terms and key words used for the analyses of tender documents

German		Englisch		French		Italian		Spanish	
Search terms	**Key words**	**Search terms**	**Key words**	**Search terms**	**Key words**	**Search terms**	**Key words**	**Search terms**	**Key words**
GPP	Green Public Procurement	GPP	Green Public Procurement	GPP	Marchés publics écologiques	GPP	Appalti pubblici verdi	GPP	Contratación pública ecológica
Energy Star		Energy Star		Energy Star		Energy Star		Energy Star	
TCO		TCO		TCO		TCO		TCO	
EPEAT	EPEAT Gold	EPEAT	EPEAT Gold	EPEAT	EPEAT Gold	EPEAT	EPEAT Gold	EPEAT	EPEAT Gold
Blauer Engel		Blue Angel		Ange Bleu		Angelo blu		Ángel Azul	
Nordic Swan		Nordic Swan		Nordic Swan		Nordic Swan		Nordic Swan	
Umweltzeichen	Europäisches Umweltzeichen	Ecolabel	EU ecolabel	Ecolabel	EU ecolabel	marchio ecologico		etiqueta ecológica	
Energie	Energieverbrauch, energieeffizient, Energieeffizienz, energiesparend	energy	energy-efficient, energy efficiency, energy demand, energy consumption, using less energy, Energy criteria, Minimum Energy performance	énergie	consommation d'énergie, l'efficacité énergétique, l'efficience énergétique, consomme moins d'énergie, Critères relatifs à l'énergie, Performances énergétiques minimales	energ	consumo energetico, minore consumo energetico, Criteri energetici, Prestazione energetica minima, efficienza energetica	energ	consumo de energía, eficiencia energética, energéticamente eficiente, consumen menos energía, Criterios energéticos
Umwelt	umweltfreundlich, umweltverträglich, Umweltkriterien, Umweltauswirkungen	environment	environmentally friendly, environmentally sound, environmental criteria, environmental	environnement	respectueux de l'environnement, critères environnementaux	ambient	criteri ambientali, impatti ambientali	ambient	los criterios medioambientales , Medio ambiente

German		Englisch		French		Italian		Spanish	
Search terms	**Key words**	**Search terms**	**Key words**	**Search terms**	**Key words**	**Search terms**	**Key words**	**Search terms**	**Key words**
			impacts						
Nachhaltig	Nachhaltige Beschaffung, nachhaltige Entwicklung, Nachhaltigkeitskriterien	sustainable	sustainable, sustainable procurement, sustainable development	durab	développement durable, durabilité, critères de durabilité, achat responsable, achat durable	sostenib	più ampia sostenibilità	sostenib	una mayor sostenibilidad
Recycl	Recycling, recyclierbar, recycelt, Recyclingmaterial, Recyclingfähigkeit	recycl	recycling, recyclable, recycled, recycled material	recycl	recyclage, recyclable recyclé, matériau recyclé,	ricicl	riciclo	recicl	reciclado
Verpackung	Verpackungsmaterial	packaging	packaging material, packing material	emballage		imballaggio		empaquetado	
repar	reparierbar, Reparatur, reparierfähige Gestaltung	repair	repairable, repair, Design for repairability	répara	réparable, Conception en vue de la réparabilité	ripar	Progettazione per la riparabilità	reparación	Diseño pensado en la posibilidad de reparación
Austausch	Einfacher Austausch von Akkumulatoren / Akku / wiederaufladbare Batterien, wechselbar	replacement	Ease of replacement for rechargeable batteries	remplacement	Facilité de remplacement des batteries rechargeables	sostituzione	Facilità di sostituzione delle batterie ricaricabili	sustitución	Facilidad de sustitución de las baterías recargables
Lebensdauer	Verlängerung der Produktlebensdauer	product life	Product lifetime extension	durée de vie	durée de vie, vie du produit, Prolongement de la durée de vie du produit	vita	durata di vita, Prolungamento della durata di vita	vida	la vida útil del producto, Prolongación de la vida útil del producto
langlebig	Langlebigkeit	longevity	increased longevity	longévité	accroître la longévité des	longevità	maggior longevità dei	longevidad	una mayor longevidad de sus

German		Englisch		French		Italian		Spanish	
Search terms	**Key words**	**Search terms**	**Key words**	**Search terms**	**Key words**	**Search terms**	**Key words**	**Search terms**	**Key words**
					produits		prodotti		productos
Ersatzteil	Längerfristige Verfügbarkeit von Ersatzteilen	spare parts	Continued availability of spare parts	pièces détachées	Disponibilité permanente des pièces détachées	pezzi di ricambio	Disponibilità costante dei pezzi di ricambio	piezas de recambio	Disponibilidad continua de piezas de recambio
End of Life		end of life		fin de vie		fine del ciclo di vita		término de la vida útil	
Wiederverwendung		re-use		réutilisation		riutilizzo		reutilización	
gefährliche Stoffe	Kriterien für gefährliche Stoffe	Hazardous substances	Hazardous Substances criteria	substances dangereuses	substances dangereuses, Critères relatifs aux substances dangereuses	sostanze pericolose	Criteri per le sostanze pericolose	sustancias peligrosas	Criterios de sustancias peligrosas
REACH	REACH Kandidatenliste	REACH	REACH Candidate List substances	REACH	la liste des substances candidates en vertu du règlement REACH,	REACH	sostanze candidate REACH	REACH	lista de sustancias candidatas de REACH, sustancia candidata a ser incluida en la lista de REACH
SVHC	= Liste von Stoffen mit besonders besorgniserregenden Eigenschaften	SVHC		SVHC	substances extrêmement préoccupantes (SVHC).	SVHC	sostanze classificate come sostanze estremamente preoccupanti (SVHC)	SEP	sustancias extremadamente preocupantes (SEP).
substances of very high concern		substances of very high concern		substances extrêmement préoccupantes		sostanze classificate come		sustancias extremadamente preocupantes	
Flammschutz-mittel		flame retardant		retardateurs de flamme		ritardanti di fiamma		materiales ignífugs	
Weichmacher		plasticizer, plastizisers		Plastifiants		Plastificanti		Plastificantes	

Source: Own compilation

5.4. Results of the analysis of tenders by search term: Number of hits per tender, differentiated by country

Number of tenders analysed per country: AT: 5, BE: 8, DE: 31, ES: 29, FR: 15, IT: 5, UK: 7

Table 64: Results of the analysis of GPP tenders by search term: Number of hits per tender, differentiated by country

Number of hits in tender	Austria	Belgium	France	Germany	Italy	Spain	United Kingdom	Total
0	1	2	1	1	0	2	1	12
1	0	0	1	1	1	4	0	6
2	0	0	0	2	1	2	1	5
3	0	1	1	0	0	2	0	4
4	2	0	1	6	0	6	1	16
5	1	3	2	3	1	2	4	16
6	0	1	4	5	0	3	0	13
7	1	0	2	1	1	1	0	6
8	0	1	3	3	1	2	0	8
9	0	0	0	1	0	4	0	5
10	0	0	0	3	0	0	0	4
11	0	0	0	2	0	1	0	2
12	0	0	0	2	0	0	0	2
13	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0
16	0	0	0	1	0	0	0	1
17-30	0	0	0	0	0	0	0	0

Source: Own compilation

5.5. Results of the analysis of tenders by search term: Number of hits per search term, differentiated by country

Number of tenders analysed per country: AT: 5, BE: 8, DE: 31, ES: 29, FR: 15, IT: 5, UK: 7

Table 65: Results of the analysis of EU GPP tenders: Number of hits per search term, differentiated by country

Englisch	Austria	Belgium	France	Germany	Italy	Spain	United Kingdom	Total
GPP	0	0	0	0	0	0	0	0
Energy Star	2	2	2	14	0	5	0	25
TCO	0	2	1	9	0	2	0	14
EPEAT	1	1	1	3	0	1	0	7
Blue Angel	0	0	0	8	0	0	0	8
Nordic Swan	0	0	0	0	0	1	0	1
Ecolabel	0	1	2	2	0	4	0	9
Energy	3	1	6	23	4	13	0	50
environment	2	5	12	26	4	23	6	78
Sustainable	0	0	8	7	2	10	0	27
Recycle	0	3	8	15	3	9	0	38
Packaging	4	5	12	21	1	1	0	44
Repair	3	5	9	15	4	21	0	57
replacement	3	4	11	23	2	19	4	66
product life	0	0	0	10	2	17	5	34
Longevity	0	1	0	0	0	0	0	1
spare parts	2	1	4	12	0	0	0	19
end of life	0	0	0	1	1	0	5	7
re-use	0	0	3	7	0	5	2	17
Hazardous substances	0	0	1	6	0	5	0	12
REACH	0	1	0	1	0	0	4	6
SHV	0	0	0	0	0	0	0	0
substances of very high concern	0	0	0	0	0	0	0	0
flame retardant	0	0	0	2	0	0	0	2
plasticizer, plastizisers	0	0	0	1	0	0	0	1

Source: Own compilation

5.6. RoHS Directive: Example for narrowing the scope of an RoHS exemption by further specifying the application

Table 66: Exemption 9 (b) before the last review in 2015 (first row; which is still valid for category 8 and 9 equipment) and after the last review as 9(b)-(I)

Exemption Wording	Expiry Date	Explanation
9(b) Lead in bearing shells and bushes for refrigerant containing compressors for heating, ventilation, air conditioning and refrigeration (HVACR) applications	Applies to categories 8, 9 and 11; expires on: 21 July 2023 for category 8 in vitro diagnostic medical devices, 21 July 2024 for category 9 industrial monitor-ing and control instruments and for category 11, 21 July 2021 for other subcategories of categories 8 and 9.	This is the former wording that is still valid for the categories 8, 9 and 11 (8 - medical devices, 9 - monitoring and control instruments including industrial monitoring and control instruments; 11 - other EEE not covered by any of the categories above) because of different maximum validity periods specified in Article4(2)
9(b)-(I) Lead in bearing shells and bushes for refrigerant-containing hermetic scroll compressors with a stated electrical power input equal or below 9 kW for heating, ventilation, air conditioning and refrigeration (HVACR) applications	Applies to category 1; expires on 21 July 2019.'	The further specification of the application is underlined

Source: Compilation from RoHS Annex III and own explanation

5.7. REACH Regulation: Restrictions of REACH Annex XVII mentioned in the report

- Entry 6 on Asbestos fibres: [182] The manufacture, placing on the market and use of these fibres and of articles and mixtures containing these fibres added intentionally is prohibited.
- Entry 20 on Organostannic compounds: [183] Tri-substituted organostannic compounds, Dibutyltin (DBT) compounds, Dioctyltin (DOT) compounds
- Entry 24 on Monomethyl-tetrachlorodiphenyl methane, Trade name: Ugilec 141: [184] Shall not be placed on the market, or used, as a substance or in mixtures; articles containing the substance shall not be placed on the market.
- Entry 25 on Monomethyl-dichloro-diphenyl methane, Trade name: Ugilec 121, Ugilec U21: [185] Shall not be placed on the market, or used, as a substance or in mixtures; articles containing the substance shall not be placed on the market.
- Entry 26 on Monomethyl-dibromo-diphenyl methane bromobenzylbromotoluene, mixture of isomers (DBBT): [186] hall not be placed on the market, or used, as a substance or in mixtures; articles containing the substance shall not be placed on the market.
- Entry 27 on Nickel: [187] in any post assemblies which are inserted into pierced ears and other pierced parts of the human body unless the rate of nickel release from such post assemblies is less than 0,2 µg/cm²/week (migration limit); (b) in articles intended to come into direct and prolonged contact with the skin such as jewellery and textile accessories (migration limit 0,5 µg/cm²/week).
- Entry 43 on Azocolourants and Azodyes: [188] shall not be used, in textile and leather articles which may come into direct and prolonged contact with the human skin or oral cavity, …. where the substance or the mixture is intended for colouring textile and leather articles.
- Entry 46 on Nonylphenol and Nonylphenol ethoxylates: [189] used in cleaning and textile washing processes but also metal working (the restriction excepts where uses in controlled closed systems where the washing liquid is recycled or incinerated).
- Entry 50 on Polycyclic-aromatic hydrocarbons(PAH): [190] Articles shall not be placed on the market for supply to the general public, if any of their rubber or plastic components

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[182] ANNEX XVII TO REACH–Conditions of restriction Entry 6: https://echa.europa.eu/documents/10162/574c30dd-398d-b3ff-cc67-e7e843c2b243

[183] ANNEX XVII TO REACH–Conditions of restriction Entry 20: https://echa.europa.eu/documents/10162/7bd363a8-da41-460f-838d-3326b3fb7bd4

[184] ANNEX XVII TO REACH–Conditions of restriction Entry 24: https://echa.europa.eu/documents/10162/1d81010a-17e1-4026-b01c-70f647c7356b

[185] ANNEX XVII TO REACH–Conditions of restriction Entry 25: https://echa.europa.eu/documents/10162/08960286-ad89-47b1-a538-7f4c8d7d9074

[186] ANNEX XVII TO REACH–Conditions of restriction Entry 26: https://echa.europa.eu/documents/10162/47ff2539-e5fc-48e4-9136-1ded27dda4fc

[187] ANNEX XVII TO REACH–Conditions of restriction Entry 27: https://echa.europa.eu/documents/10162/7851171d-53e9-455a-8bb8-7ca22e89ad87

[188] ANNEX XVII TO REACH–Conditions of restriction Entry 43: https://echa.europa.eu/documents/10162/6f65910f-f80b-41c3-9c15-026731e4c03d

[189] ANNEX XVII TO REACH–Conditions of restriction Entry 46: https://echa.europa.eu/documents/10162/b91a8a69-f38e-4a35-ab7d-e475e5926988

that come into direct as well as prolonged or short-term repetitive contact with the human skin or the oral cavity, under normal or reasonably foreseeable conditions of use, contain more than 1 mg/kg (0,0001 % by weight of this component) of any of the listed PAHs. Such articles include amongst others:

- sport equipment such as bicycles, golf clubs, racquets
- household utensils, trolleys, walking frames
- tools for domestic use
- clothing, footwear, gloves and sportswear
- watch-straps, wrist-bands, masks, head-bands

Also toys, including activity toys, and childcare articles, shall not be placed on the market, if any of their rubber or plastic components that come into direct as well as prolonged or short term repetitive contact with the human skin or the oral cavity, under normal or reasonably foreseeable conditions of use, contain more than 0,5 mg/kg (0,00005 % by weight of this component) of any of the listed PAHs.

- Entry 52 on the restriction of the phthalates DINP, DIDP and DNOP in plasticised material for toys and childcare articles which can be placed in the mouth by children.[191] [192]

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[190] ANNEX XVII TO REACH–Conditions of restriction Entry 50: https://echa.europa.eu/documents/10162/176064a8-0896-4124-87e1-75cdf2008d59

[191] ANNEX XVII TO REACH–Conditions of restriction Entry 52: https://echa.europa.eu/documents/10162/57096439-2ddd-4f14-b832-85181a09f595

[192] The four phthalates restricted under RoHS are also restricted by entry 51 of REACH Annex XVII also covering the application in toys.

5.8. POP Regulation

Table 67: Entries for SCCP and HBCD in Annex I to Regulation (EC) No 850/2004

Substance	Specific Exemption on intermediate use or other specifications
'Alkanes C10-C13, chloro (short-chain chlorinated paraffins) (SCCPs)	1. By way of derogation, the production, placing on the market and use of substances or preparations containing SCCPs in concentrations lower than 1 % by weight or articles containing SCCPs in concentrations lower than 0,15 % by weight shall be allowed. 2. Use shall be allowed in respect of: (a) conveyor belts in the mining industry and dam sealants containing SCCPs already in use before or on 4 December 2015; and (b) articles containing SCCPs other than those referred to in (a) already in use before or on 10 July 2012. 3. Article 4(2) third and fourth subparagraphs shall apply to the articles referred to in point 2 above.
Hexabromocyclododecane 'Hexabromocyclododecane' means: hexabromocyclododecane, 1,2,5,6,9,10-hexabromocyclododecane and its main diastereoisomers: alpha-hexabromocyclododecane; beta-hexabromocyclododecane; and gamma-hexabromocyclododecane	1. For the purposes of this entry, Article 4(1)(b) shall apply to concentrations of hexabromocyclododecane equal to or below 100 mg/kg (0,01 % by weight) when it occurs in substances, preparations, articles or as constituents of the flame-retarded parts of articles, subject to review by the Commission by 22 March 2019. 2. The use of hexabromocyclododecane, whether on its own or in preparations, in the production of expanded polystyrene articles, and the production and placing on the market of hexabromocyclododecane for such use, shall be allowed provided that such use has been authorised in accordance with Title VII of Regulation (EC) No 1907/2006 of the European Parliament and of the Council(*), or is the subject of an application for authorisation submitted by 21 February 2014 where a decision on that application has yet to be taken. The placing on the market and use of hexabromocyclododecane, whether on its own or in preparations, in accordance with this paragraph shall only be allowed until 26 November 2019 or, if earlier, the date of expiry of the review period specified in an authorisation decision or the date of withdrawal of that authorisation pursuant to Title VII of Regulation (EC) No 1907/2006. The placing on the market and use in buildings of expanded polystyrene articles, that contain hexabromocyclododecane as a constituent of such articles and are produced in accordance with the exemption in this paragraph, shall be allowed until 6 months after the date of expiry of that exemption. Such articles already in use by that date may continue to be used. 3. Without prejudice to the exemption in paragraph 2, the placing on the market and use in buildings of expanded polystyrene articles and extruded polystyrene articles that contain hexabromocyclododecane as a constituent of such articles and are produced before or on 22 March 2016 shall be allowed until 22 June 2016. Paragraph 6 shall apply as if such articles were produced pursuant to the exemption in paragraph 2. 4. Articles that contain hexabromocyclododecane as a constituent of such articles and are already in use before or on 22 March 2016 may continue to be used and further placed on the market and paragraph 6 shall not apply. Article 4(2), third and fourth subparagraphs shall apply to such articles. 5. The placing on the market and use in buildings of imported expanded polystyrene articles that contain hexabromocyclododecane as a constituent of such articles shall be allowed until the date of expiry of the exemption in paragraph 2 and paragraph 6 shall apply as if such articles were produced pursuant to the exemption in paragraph 2. Such articles already in use by that date may continue to be used. 6. Without prejudice to the application of other Union provisions on the classification, packaging and labelling of substances and mixtures, expanded polystyrene, in which hexabromocyclododecane is used pursuant to the exemption in paragraph 2, must be identifiable by labelling or other means throughout its life cycle.

Source: Commission Regulation (EU) 2015/2030 of 13 November 2015 amending Regulation (EC) No 850/2004 of the European Parliament and of the Council on persistent organic pollutants as regards Annex I; Commission Regulation (EU) 2016/293 of 1 March 2016 amending Regulation (EC) No 850/2004 of the European Parliament and of the Council on persistent organic pollutants as regards Annex I