GUIDELINES TO DRIVE ENVIRONMENTAL IMPROVEMENTS FOR MOBILE DEVICES BASED ON ECO RATING STATISTICS

V2

November 20th 2025

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1. Purpose of this environmental guide for mobile devices

In 2024 the Eco Rating Consortium published for the first time a statistical report[1] and a best practices guidance, based on the experience gathered by the Initiative so far. That past report included the assessment of 80.000 data points from 550 different smartphones that were launched between 2021 and 2024. In this 2025 report, we have included the newly assessed 200 models that were launched until September 2025. Why is that report being updated? We believe that device manufacturers and all distributors should play an important role in achieving the STBi target of becoming Net Zero. With that purpose in mind, the entire life cycle must be considered as a whole.

Thanks to this extensive evaluation of mobile phone devices, we have built a substantial statistics database. This allows identifying the most relevant environmental impact areas and provides targeted guidance for reducing the ecological footprint of smartphones for all device manufacturers, as well as their sub-suppliers across the entire supply chain (e.g., chipset and battery providers, including raw material suppliers, assembly factories, and logistics companies) on how to minimize the environmental impact of the smartphones they deploy.

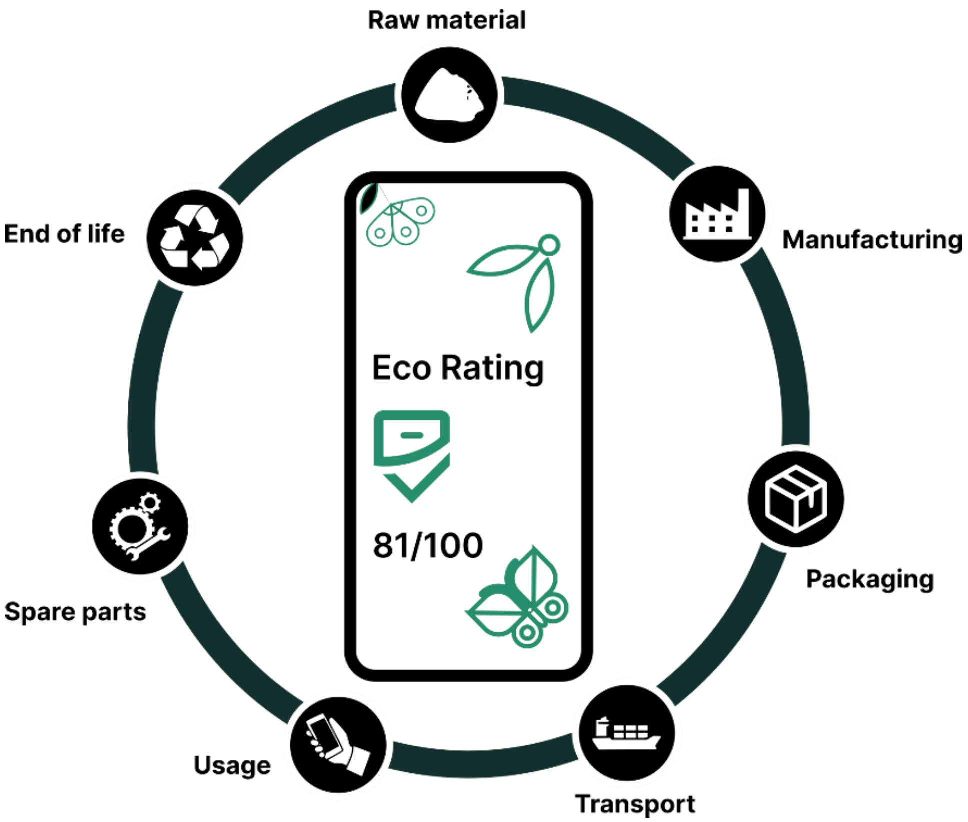
As a consequence, considering this regulatory background and Eco Rating's long experience, a robust database offering valuable insights into the sustainability of assessed smartphone devices was established. From this data, the most significant aspects related to material efficiency and life cycle performance can be identified. This understanding provides a clear perspective on how the transition to more Energy Efficient and circular devices can be achieved through Eco Design strategies.

The aim of the updated 2025 report is to present an evaluation of the key stabilization aspects compared to the 2024 report. This allows us to identify which environmental aspects are being widely considered by most manufacturers, as well as those that are only being contemplated by a few. Areas where only a small number of manufacturers have begun to take action, while the majority have not, are regarded as environmental opportunities for the industry.

[1] *https://www.ecoratingdevices.com/EcoRating_Statistics_and_best%20Practices_Guideline_V1.pdf*

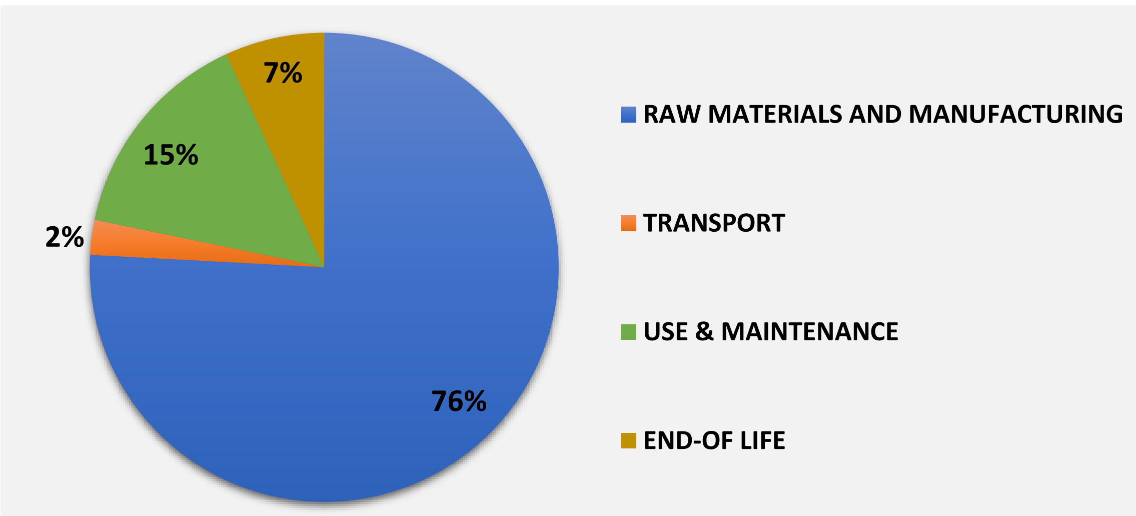
2. Environmental statistics

Looking at the main environmental aspects of the life cycle of an average device, we can conclude that the most relevant life cycle stage of this kind of product is the raw materials acquisition and manufacturing step, being responsible for more than 76% of the life cycle environmental impacts.



Cradle-to-grave life cycle for a mobile phone

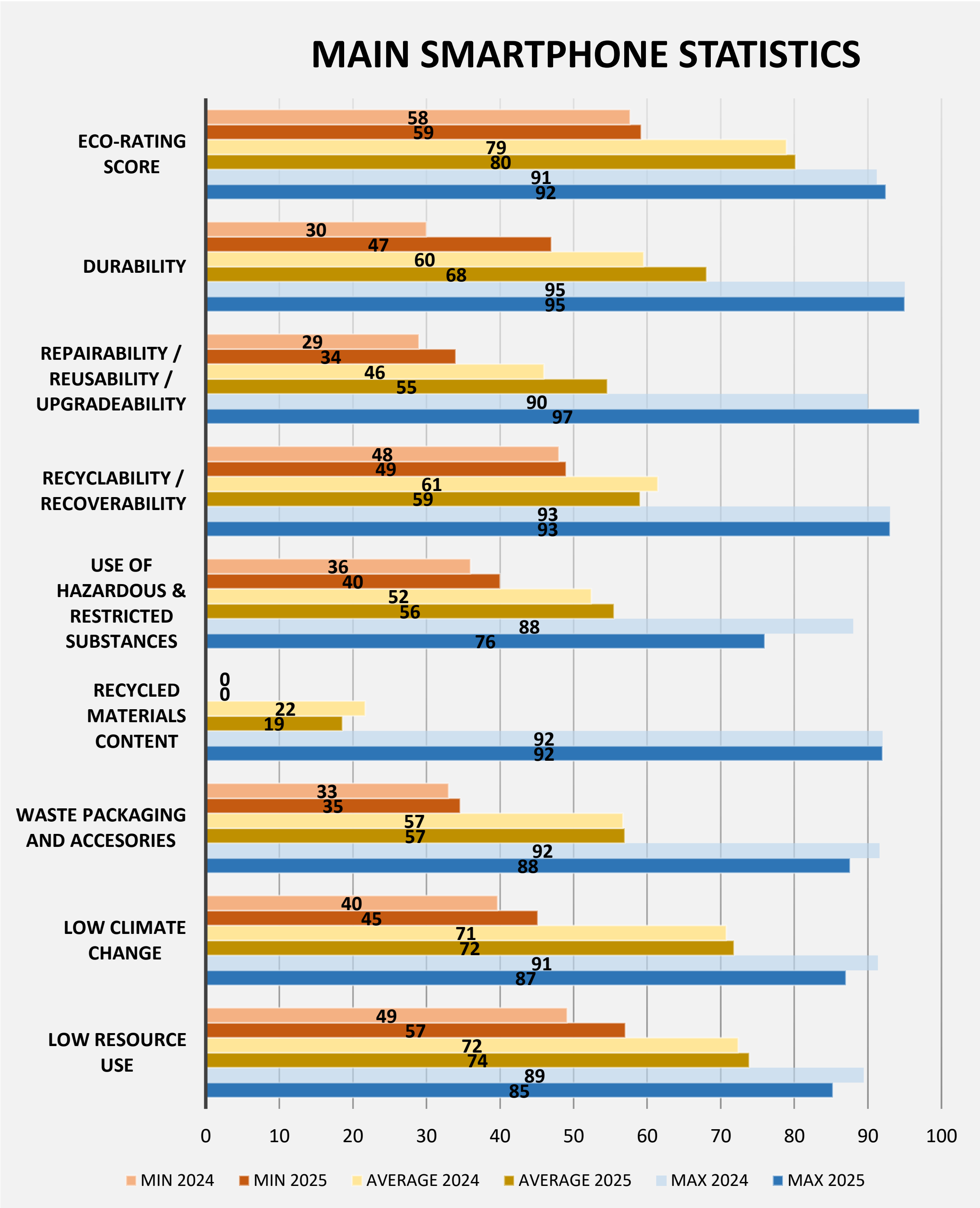
As in the previous report, the factors that contribute most to this stage are the manufacture of integrated circuits, the consumption of scarce metals such as gold and cobalt, as well as the display manufacturing.



Average life cycle profile of the Eco Rating score for a smartphone

Use and maintenance remain being also one of the most relevant aspects of the device life cycle, mostly related to the electricity consumption of the device and the need for component reinvestment during the service life of the device. Furthermore, the use and maintenance stage has increased by 2% its contribution to the overall score, regarding the previous report. End-of-life stage of the device is also relevant, but in this case in a positive way, as take-back programmes and recycled devices can be a source for recovered materials.

From the perspective of the final Eco Rating score, we can see that the overall average score for the devices evaluated is now 80 points, one point above the average value specified in the previous statistics report, with most of the devices evaluated (95%) falling in the middle of the scale, between 70 and 92 points.



Main Smartphone Statistics 2024 vs 2025

The previous graph shows the main statistics for the smartphones set in the overall Eco Rating score and in all the material efficiency sub-scores. The minimum score obtained was 59 and the maximum was 92. No device achieved a score of 100 in any of the categories evaluated.

In addition, the statistical values of the devices from the previous report have been included in the graph, showing the evolution of the main statistics for the evaluated devices. Overall, the total Eco Rating score for the devices evaluated has improved very slightly (from 79 to 80).

However, if we consider the values related to durability, we can see an improvement of +8 points compared to the previous 2024 report, mainly due to a clear improvement in the water protection levels, but also due to a better battery life and connector lifetime identified in the newly evaluated devices.

Similarly happens with the questions related to repairability category, which have improved by +9 points compared to the values of the previous report, boosted by the improvement in the period of time of available spare parts and components. Therefore, in overall terms, a positive trend can be identified.

Eco Rating bases its environmental evaluation in a combination of 16 life cycle assessment categories and 6 material efficiency parameters. Sections 2.1 and 2.2 aim to provide more detailed statistical information on the performance of the evaluated devices in all these concepts.

ENVIRONMENTAL IMPACT CATEGORIES			
Climate change	Ozone depletion	Ionising radiation	Land use
Water scarcity	Respiratory inorganics	Photochemical ozone formation	Eutrophication freshwater
Eutrophication marine	Eutrophication terrestrial	Human toxicity, cancer	Human toxicity, non-cancer
Ecotoxicity, freshwater	Resource use, energy carriers	Resource use, minerals and metals	Acidification terrestrial & freshwater

CIRCULAR ECONOMY / MATERIAL EFFICIENCY CRITERIA		
Durability	Repairability / Reusability / Upgradeability	Recyclability and recoverability
Use of hazardous &restricted substances	Recycled materials content	Waste packaging and accessories

2.1. Material efficiency statistics

For each aspect in the Material Efficiency section, several questions from the Eco Rating method have to be scored giving a result ranging from 0 to 5 for each aspect. The relevance of each aspect in the Materials Efficiency Section to the key Environmental Impact Categories are:

MATERIAL EFFICIENCY SECTION	RELEVANCE TOWARDS OVERALL ENVIRONMENTAL IMPACT
DURABILITY	High
REPARABILITY	High
RECYCLABILITY	Medium
USE OF HAZARDOUS AND RESTRICTED SUBSTANCES	Low
RENEWABLE MATERIALS	Low
PACKAGING	Low

Relevance of Material Efficiency aspects in the final Eco Rating score

It is important to note that having a lower relevance in the final score does not mean that the aspect itself is not important to the sustainability of the mobile device. All the assessed aspects have their relevance, but when looking to the overall life cycle approach of the mobile device, some aspects have higher influence than others.

Specifically for the material efficiency section, the following table shows the minimum, maximum and average performance in the sample of evaluated devices. In addition to that, the material efficiency statistics from the previous report have been included as well for each question, in order to see the trend for the material efficiency questions.

Those percentages in dark blue cells correspond to the values from the 2024 version of the statistics report. If the results obtained are compared with the data compiled from the previous report, we can conclude that the average values obtained for the questions on durability and repairability have generally increased, while a slight decrease can be noted in some of the questions related to recyclability & recoverability, use of renewable materials and packaging & accessories.

Legend

2025	X%
2024	Y%

Guidelines to drive environmental improvements for mobile devices

SECTION	QUESTION		SCORE 0	2025	2024	SCORE 1	2025	2024	SCORE 2	2025	2024	SCORE 3	2025	2024	SCORE 4	2025	2024	SCORE 5	2025	2024
DURABILITY	DUR-01	Guarantee period	< 2 years	10%	1%	2 years	**46%**	46%	-	-	-	3 years	42%	**51%**	-	-	-	> 3 years	1%	1%
	DUR-02	Dust protection	< IP4x	0%	1%	IP4x	1%	3%	-	-	-	IP5x	47%	**73%**	-	-	-	IP6x	**52%**	23%
	DUR-03	Water Protection	< IPx3	18%	40%	IPx3	8%	16%	IPx4	31%	**26%**	IPx5	7%	1%	IPx6	0%	0%	IP ≥ IPx7	**37%**	17%
	DUR-04	Drop resistance	x < 45 cm	0%	0%	45 ≤ x < 75 cm	0%	0%	75 ≤ x < 100 cm	0%	1%	100 ≤ x < 120 cm	**58%**	**63%**	120 ≤ x < 150 cm	20%	17%	x ≥ 150 cm	22%	19%
	DUR-05	Battery life	x < 400 cycles	0%	0%	400 ≤ x < 600 cycles	0%	7%	600 ≤ x < 800 cycles	2%	1%	800 ≤ x < 1000 cycles	16%	**37%**	1000 ≤ x < 1200 cycles	**47%**	33%	x ≥ 1200 cycles	36%	22%
	DUR-06	Charge Connector lifetime	x < 10,000 times	0%	0%	10,000 ≤ x < 20,000 times	39%	**53%**	-	-	-	20,000 ≤ x < 30,000 times	5%	12%	-	-	-	x ≥ 30,000 times	**57%**	35%
REPARABILITY, REUSABILITY & UPGRADABILITY	REP-00	Support of security patches	< 2 years	6%	2%	2 years	7%	15%	3 years	**30%**	**38%**	4 years	23%	28%	5 years	11%	16%	> 5 years	23%	1%
	REP-01	Support of operating systems	< 2 years	13%	8%	2 years	**33%**	**50%**	3 years	24%	28%	4 years	15%	9%	5 years	7%	4%	> 5 years	9%	1%
	REP-02	Availability of spare parts	< 4 years	1%	**41%**	4 years	23%	23%	5 years	**51%**	29%	6 years	1%	7%	7 years	21%	0%	> 7 years	4%	0%
	REP-03	Secure data deletion	No information provided	0%	0%	Only in In-box paper (e.g. user guide)	0%	0%	-	-	-	In the manufacturer web-page or digitally in the device	33%	49%	-	-	-	In the manufacturer web-page and digitally in the device	**67%**	**51%**
	REP-04	Secure transfer of data	No information provided	0%	0%	Only in In-box paper (e.g. user guide)	0%	1%	-	-	-	In the manufacturer web-page or digitally in the device	35%	47%	-	-	-	In the manufacturer web-page and digitally in the device	**65%**	**51%**
	REP-05	Disassembly depth of prioritary parts	*Average of DIS questions	0%	0%	*Average of DIS questions	0%	0%	*Average of DIS questions	27%	11%	*Average of DIS questions	**43%**	**45%**	*Average of DIS questions	30%	42%	*Average of DIS questions	0%	1%
	REP-06	Fasteners of prioritary parts	*Average of FAS questions	0%	0%	*Average of FAS questions	3%	6%	*Average of FAS questions	**58%**	**42%**	*Average of FAS questions	30%	33%	*Average of FAS questions	8%	19%	*Average of FAS questions	1%	0%

Legend: 2025 X% / 2024 Y%

Guidelines to drive environmental improvements for mobile devices

SECTION	QUESTION		SCORE 0	2025	2024	SCORE 1	2025	2024	SCORE 2	2025	2024	SCORE 3	2025	2024	SCORE 4	2025	2024	SCORE 5	2025	2024
REPARABILITY, REUSABILITY & UPGRADABILITY	REP-07	Tools needed for prioritary parts	*Average of TOO questions	0%	0%	*Average of TOO questions	0%	0%	*Average of TOO questions	13%	17%	*Average of TOO questions	**55%**	**66%**	*Average of TOO questions	32%	17%	*Average of TOO questions	0%	1%
	REP-08	Information on reparability, reusability, upgradability	-	-	-	Available only to manufacturer-authorized repair service providers	**48%**	**56%**	-	-	-	Available to independent repair service providers	31%	25%	-	-	-	Available to general public	20%	19%
	DIS-01	Battery disassembly	x > 10 steps	0%	0%	10 ≥ x > 7 steps	20%	2%	7 ≥ x > 5 steps	20%	24%	5 ≥ x > 3 steps	**39%**	**43%**	3 ≥ x > 1 steps	20%	26%	x = 1 step	1%	6%
	DIS-02	Screen disassembly	x > 20 steps	0%	0%	20 ≥ x > 15 steps	26%	22%	15 ≥ x > 10 steps	23%	22%	10 ≥ x > 5 steps	**31%**	**38%**	5 ≥ x > 2 steps	20%	18%	x ≤ 2 steps	0%	1%
	DIS-03	Back Covers disassembly	x > 10 steps	0%	0%	10 ≥ x > 7 steps	0%	0%	7 ≥ x > 5 steps	0%	0%	5 ≥ x > 3 steps	10%	3%	3 ≥ x > 1 steps	**58%**	**56%**	x = 1 step	32%	41%
	FAS-01	Battery fasteners	-	-	-	Removable fasteners, non-easily accessible	16%	15%	Removable fasteners, easily accessible	**53%**	48%	Reusable fasteners, non-easily accessible	18%	**14%**	Reusable fasteners, easily accessible	12%	24%	The same reusable fastener type, easily accessible, for the three parts	1%	0%
	FAS-02	Screen fasteners	-	-	-	Removable fasteners, non-easily accessible	14%	16%	Removable fasteners, easily accessible	**46%**	35%	Reusable fasteners, non-easily accessible	31%	27%	Reusable fasteners, easily accessible	8%	22%	The same reusable fastener type, easily accessible, for the three parts	1%	0%
	FAS-03	Back Covers fasteners	-	-	-	Removable fasteners, non-easily accessible	0%	3%	Removable fasteners, easily accessible	**61%**	**52%**	Reusable fasteners, non-easily accessible	7%	5%	Reusable fasteners, easily accessible	31%	40%	The same reusable fastener type, easily accessible, for the three parts	1%	0%
	TOO-01	Battery tools	-	-	-	Feasible with proprietary tools	0%	0%	Feasible with other commercially available tools	13%	13%	Feasible with common tools	**59%**	**69%**	Feasible with set of tools that is supplied with the product or spare part	11%	6%	Tools not needed	17%	13%
	TOO-02	Screen tools	-	-	-	Feasible with proprietary tools	0%	10%	Feasible with other commercially available tools	15%	12%	Feasible with common tools	**68%**	**76%**	Feasible with set of tools that is supplied with the product or spare part	17%	3%	Tools not needed	0%	0%
	TOO-03	Back Covers tools	-	-	-	Feasible with proprietary tools	0%	3%	Feasible with other commercially available tools	14%	13%	Feasible with common tools	**68%**	**68%**	Feasible with set of tools that is supplied with the product or spare part	16%	3%	Tools not needed	3%	12%

Legend		
	2025	X%
	2024	Y%

SECTION	QUESTION		SCORE 0	2025	2024	SCORE 1	2025	2024	SCORE 2	2025	2024	SCORE 3	2025	2024	SCORE 4	2025	2024	SCORE 5	2025	2024
RECYCLABILITY & RECOVERABILITY	REC-00	Voluntary take-back programmes	Device is not collected	5%	6%	This device is collected and the components are recycled to gain rare metals and minerals back into circularity	**49%**	30%	-	-	-	This device is collected to reuse the components that are still in good condition as spare parts	12%	15%	-	-	-	This device is collected to be repaired and refurbished, and offered as a 2nd hand device with new warranty period	33%	**50%**
	REC-01	Take-back programmes. % of countries	x < 10 %	0%	1%	10 ≤ x < 20 %	0%	1%	20 ≤ x < 40 %	16%	13%	40 ≤ x < 60 %	**40%**	**42%**	60 ≤ x < 80 %	31%	16%	80 ≤ x ≤ 100 %	14%	28%
	REC-02	Conditions of take-back programmes	No information provided	0%	1%	Only in In-box paper	1%	1%	-	-	-	In the manufacturer web-page or digitally in the device (e.g. in menu “general info”)	**66%**	**78%**	-	-	-	In the manufacturer web-page and digitally in the device	33%	21%
	REC-03	Disassembly of parts that require selective treatment	x > 25 steps	0%	0%	25 ≥ x > 20 steps	0%	0%	20 ≥ x > 15 steps	30%	10%	15 ≥ x > 10 steps	31%	27%	10 ≥ x > 5 steps	**36%**	**58%**	x ≤ 5 steps	3%	4%
	REC-04	Disassembly of parts containing precious/critical raw materials	x > 35 steps	0%	0%	35 ≥ x > 25 steps	2%	2%	25 ≥ x > 15 steps	**48%**	26%	15 ≥ x > 10 steps	17%	24%	10 ≥ x > 5 steps	32%	**44%**	x ≤ 5 steps	1%	3%
	REC-05	Additional information to recyclers on precious/critical raw materials, recyclable materials	No information available	14%	3%	Available to recyclers (delivery under demand)	**81%**	**81%**	-	-	-	Available to recyclers in the company web-site (after registration)	3%	7%	-	-	-	Free available to general public in the company web-site	3%	8%
	REC-06	Marking of plastic parts	No minimum weight set for the device	35%	31%	weight ≥ 25 gr	4%	14%	-	-	-	weight ≥ 10 gr	7%	7%	-	-	-	weight ≥ 5 gr	**54%**	**48%**
	REC-07	Polymer compatibility in plastic parts	The incompatible polymers (or formulations) used in the same plastic part cannot be dismantled easily	0%	0%	The incompatible polymers (or formulations) used in the same plastic part can be dismantled easily (without tools)	7%	2%	-	-	-	The polymers (or formulations) used in the same plastic part are compatible polymers for recycling with the others	**84%**	**76%**	-	-	-	The same polymer (or formulation) is used in the plastic part	8%	22%

Legend

2025	X%
2024	Y%

Guidelines to drive environmental improvements for mobile devices

SECTION	QUESTION		SCORE 0			SCORE 1			SCORE 2			SCORE 3			SCORE 4			SCORE 5		
				2025	2024		2025	2024		2025	2024		2025	2024		2025	2024		2025	2024
RECYCLABILITY & RECOVERABILITY	REC-08	Polymers purity in plastic formulation	The % of additives in the formulation does not allow the easy separation of the plastic from the pure polymer when recycling together	9%	10%	The % of additives in the formulation allows the easy separation of the plastic from the pure polymer when recycling together	7%	14%	-	-	-	The percentage of additives in the formulation does not compromise the recycling of the plastic together with pure polymer	**84%**	**74%**	-	-	-	Use of pure polymer (without additives)	1%	2%
RECYCLABILITY & RECOVERABILITY	REC-09	Recyclability rate of the product	x < 50 %	0%	0%	50 ≤ x < 60 %	0%	0%	60 ≤ x < 70 %	8%	**35%**	70 ≤ x < 80 %	30%	**22%**	80 ≤ x < 90 %	41%	23%	90% ≤ x	22%	19%
USE OF HAZARDOUS AND RESTRICTED SUBSTANCES	HAZ-01	Halogen free	No specific device parts are halogen free	0%	0%	Plastic parts (e.g. housing)	4%	7%	Plastic parts + cables/wires	0%	1%	Plastic parts + cables/wires + printed circuit boards	0%	**0%**	Complete product (all components and materials)	0%	4%	Complete product + External accessories (e.g. earphones, cables and external power suppliers)	**96%**	**88%**
USE OF HAZARDOUS AND RESTRICTED SUBSTANCES	HAZ-02	RoHS Directive	The product does not fulfil the EU RoHS Directive requirements in all the markets	0%	0%	The product fulfils the EU RoHS Directive requirements in all the markets (even in those not obliged by law).	29%	43%	-	-	-	Product exceeds the exceptions of Annex III of RoHS Directive by date (achieved at least 1 year in advance of the exp. date) or by lower content (at least 20% lower than the allowed concent.)	**69%**	**53%**	-	-	-	The product does not use any application exempted in Annex III of RoHS Directive	3%	4%
USE OF HAZARDOUS AND RESTRICTED SUBSTANCES	HAZ-03	Hazardous substances in the product - REACH Annex XIV	The product does not fulfil the EU REACh Regulation Article 33 for Substances of very high concern (Candidate list) in all the markets	0%	0%	The product fulfils the EU REACh Regulation Art. 33 for Substances of very high concern (Candidate list) in all the markets (even in those not obliged by law)	**95%**	**92%**	-	-	-	The product and accessories do not include any Substance of very high concern (Candidate list) of REACH Regulation above the limit of 0,1% by weight	5%	7%	-	-	-	The product and accessories do not include any substance with a hazard statement acc. to Part 3 (Health Hazards) of the GHS System (or the CLP Regulation) above the limit of 1000 ppm	0%	1%

Legend 2025 X% 2024 Y%

SECTION		QUESTION	SCORE 0	2025	2024	SCORE 1	2025	2024	SCORE 2	2025	2024	SCORE 3	2025	2024	SCORE 4	2025	2024	SCORE 5	2025	2024
USE OF HAZARDOUS AND RESTRICTED SUBSTANCES	HAZ-04	Hazardous substances in the product - REACH Annex XVII	The product does not fulfil the EU REACh Regulation Article 67 for restrictions of substances in Annex XVII in all the markets	0%	0%	The product fulfils the EU REACh Regulation Art. 67 for restrictions of substances in Annex XVII in all the markets (even in those not obliged by law).	31%	37%	-	-	-	The product and accessories do not use any substance of the Annex XVII of REACh Regulation	**69%**	**63%**	-	-	-	The product and accessories do not use any substance with a hazard statement according to Part 3 (Health Hazards) of the GHS System (or the CLP Reg.)	0%	1%
	HAZ-05	Hazardous substances in the battery	The product does not fulfil the EU Battery Directive in all the markets	0%	0%	The product fulfils the EU Battery Directive in all the markets (even in those not obliged by law).	1%	3%	-	-	-	The product exceeds the req. of EU Battery Directive in at least a 50% (no more than 10 ppm Cd and 3 ppm Hg)	23%	10%	-	-	-	Battery cells do not contain cadmium and mercury above 1 ppm	**76%**	**86%**
	HAZ-06	Hazardous Substances Management System	The company does not use any Standard to monitor the hazardous substances included and used in the product, across the supply chain	0%	24%	The company uses the IEC 62474 Standard (or similar) to monitor the hazardous substances included and used in the product, in all the supply chain	30%	25%	-	-	-	The company has programmes to substitute the hazardous substances included or used in the product which are covered by IEC 62474 Standard (exceeding legal requirements)	**42%**	**33%**	-	-	-	The company has programmes to substitute the hazardous substances included in the product which have a hazard statement according to Part 3 (Health Hazards) of the GHS System (or the CLP Regulation)	28%	17%
USE OF RECYCLED / RENEWABLE MATERIALS	REN-01	% of recycled material in covers	x = 0 %	**83%**	**76%**	0 < x < 15 %	11%	12%	15 ≤ x < 30 %	2%	1%	30 ≤ x < 45 %	1%	3%	45 ≤ x < 60 %	2%	4%	60% ≤ x	1%	5%
	REN-02	% of recycled material in structural parts	x = 0 %	**65%**	**61%**	0 < x < 15 %	25%	25%	15 ≤ x < 30 %	1%	4%	30 ≤ x < 45 %	1%	7%	45 ≤ x < 60 %	1%	1%	60% ≤ x	8%	2%
	REN-03	% of bio-based / bio-degradable plastic	x = 0 %	**77%**	**74%**	0 < x < 5 %	19%	16%	5 ≤ x < 10 %	1%	2%	10 ≤ x < 15 %	4%	4%	15 ≤ x < 20 %	0%	2%	20% ≤ x	0%	1%
	REN-04	% of recycled material in packaging elements	x = 0 %	1%	3%	0 < x < 60 %	33%	**42%**	60 ≤ x < 70 %	**43%**	26%	70 ≤ x < 80 %	16%	9%	80 ≤ x < 90 %	5%	6%	90% ≤ x	2%	14%

SECTION	QUESTION		SCORE 0	2025	2024	SCORE 1	2025	2024	SCORE 2	2025	2024	SCORE 3	2025	2024	SCORE 4	2025	2024	SCORE 5	2025	2024
PACKAGING & ACCESSORIES	PAC-01	Quantity of plastic used in packaging	Plastic materials are normally used in packaging	0%	0%	Minimum amount of plastic elements are used beside cover foils and plastic bags for devices and accessories	10%	5%	-	-	-	Only cover foils and plastic bags for devices and accessories	24%	40%	-	-	-	No plastic material used in packaging at all	**66%**	**55%**
	PAC-02	Volume of packaging material per volume of product	x > 90 %	0%	0%	90% ≥ x > 80 %	**33%**	**33%**	80% ≥ x > 70 %	16%	11%	70% ≥ x > 60 %	17%	23%	60% ≥ x > 50 %	18%	10%	50 % ≥ x	16%	23%
	PAC-03	% of packaging materials certified by FSC/PEFC systems	x = 0 %	**67%**	**67%**	0 < x < 50 %	11%	7%	50 ≤ x < 60 %	1%	1%	60 ≤ x < 70 %	2%	1%	70 ≤ x < 80 %	4%	0%	80% ≤ x	16%	24%
	PAC-04	User manual and other documentation in paper (in-box)	The paper used for the user manual and other documentation is not FSC/PEFC certified	**82%**	**69%**	The paper used for the user manual and other documentation is FSC/PEFC certified	5%	10%	-	0%	-	Not additional documentation in paper (except user manual which is FSC/PEFC certified)	4%	6%	-	0%	-	When it is not legally required, there is not included a paper user manual in-box	8%	15%
	PAC-05	Accessories (charger) included with the product (in-box)	The accessory is not part of the company voluntary “Take-back" programme of the device	0%	0%	The accessory is part of the company voluntary “Take-back" programme of the device	0%	3%	-	-	-	The charge has such a technical characteristic and a universal connector that could be used on models on models from other brands	44%	**69%**	-	-	-	The product (in-box) does not include this accessory. In the user guide there is a written compliance statement which charger from older devices can be re-used.	**56%**	28%
	PAC-06	Accessories (cable) included with the product (in-box)	The accessory is not part of the company voluntary “Take-back" programme of the device	0%	0%	The accessory is part of the company voluntary “Take-back" programme of the device	0%	3%	-	-	-	The cable has a universal connector and could be used for charge and data transfer on models from other brands	**98%**	**94%**	-	-	-	The product (in-box) does not include this accessory	2%	3%
	PAC-07	Accessories (headset) included with the product (in-box)	The accessory is not part of the company voluntary “Take-back" programme of the device	0%	0%	The accessory is part of the company voluntary “Take-back" programme of the device	0%	0%	-	-	-	The accessory has universal connector and could be used on models from other brands	10%	22%	-	-	-	The product (in-box) does not include this accessory	**90%**	**78%**

A more detailed analysis was conducted on the evolution of these material efficiency statistics. Here we compare the average statistics for devices assessed up to December 2022, between January 2023 and April 2024, and those assessed between May 2024 and September 2025. This comparison allows us to identify some trends in specific material efficiency issues. The most relevant trends are summarised in the table below, where it can be seen the result evolution comparing values from 2024 to the present. It shows the ones having a change over ±15%.

SECTION	QUESTION		2022 AVRG.	2024 AVRG.	2025 AVRG.	EVOLUTION
DURABILITY	DUR-02	Dust protection	3,01	3,37	4,03	+20%
	DUR-03	Water Protection	1,79	1,56	2,74	+76%
	DUR-05	Battery life	2,98	3,63	4,17	+15%
	DUR-06	Charge Connector lifetime	1,54	2,65	3,36	+27%
REPARABILITY, REUSABILITY & UPGRADABILITY	REP-00	Support of security patches	-	2,44	2,96	+21%
	REP-01	Period of time of regular updated support of operating systems	-	1,53	1,97	+29%
	REP-02	Period of time of available spare parts and components.	-	1,02	2,30	+125%
	DIS-01	Disassembly steps for the battery	2,70	3,09	2,60	-16%
RECYCLABILITY & RECOVERABILITY	REC-00	Existence of a company voluntary take-back programme	-	3,24	2,52	-22%
	REC-05	Additional information to recyclers on precious/critical raw materials, recyclable materials	1,17	1,44	1,04	-28%
	REC -09	Recyclability rate	3,78	3,26	3,77	+15%
USE OF HAZARDOUS AND RESTRICTED SUBSTANCES	HAZ-06	Hazardous Substances Management System	3,16	2,12	2,97	+40%
USE OF RECYCLED / RENEWABLE MATERIALS	REN-01	Percentage of recycled material	-	0,63	0,29	-54%
	REN-03	Percentage of bio-based used in plastic parts	-	0,48	0,32	-34%
PACKAGING & ACCESSORIES	PAC-03	% of packaging materials certified by FSC/PEFC systems	2,11	1,34	1,13	-16%
	PAC-04	User manual and other documentation in paper (in-box)	1,87	1,06	0,59	-43%
	PAC-05	Accessories (charger) included with the product (in-box)	3,29	3,51	4,11	+17%

Most relevant trends in the material efficiency section

The values in the table above indicate an overall positive trend. The ***durability*** section shows a positive evolution, related to improvements in aspects related to water and dust protection, enhancement of the battery life and the charging connector lifetime in the latest models evaluated.

With regard to ***repairability***, there is also a clear positive trend towards the improvement in the time taken to periodically update operating systems, security patches and in the period of time of available spare parts and components available, fostered by the latest European Regulation. On the other hand, the number of steps required to remove the battery from devices in most manufacturers has increased, meaning that this aspect has slightly decreased in its score since the last report. In the ***recyclability*** and ***recoverability*** section, opposite trends were found. The existence of in-company voluntary take-back programmes and the content of additional information to recyclers on precious/critical raw materials has decreased, while the recyclability rate has increased a 15% compared to the values registered in 2024.

In addition, there is a noticeable improvement in the ***hazardous Substances*** Management System. However, questions such as the percentage of recycled material and percentage of bio-based used in plastic parts included in the use of **recycled/renewable materials** section have worsened compared to the values provided in the previous report, where the values were already very low. Therefore, special attention should be paid by the manufacturers in this chapter of the device design.

Finally, the use of **accessories** included with the product are achieving better scores, meaning that less accessories are being provided with the handset, while user manual and other documentation in paper has significantly worsened compared to previous values.

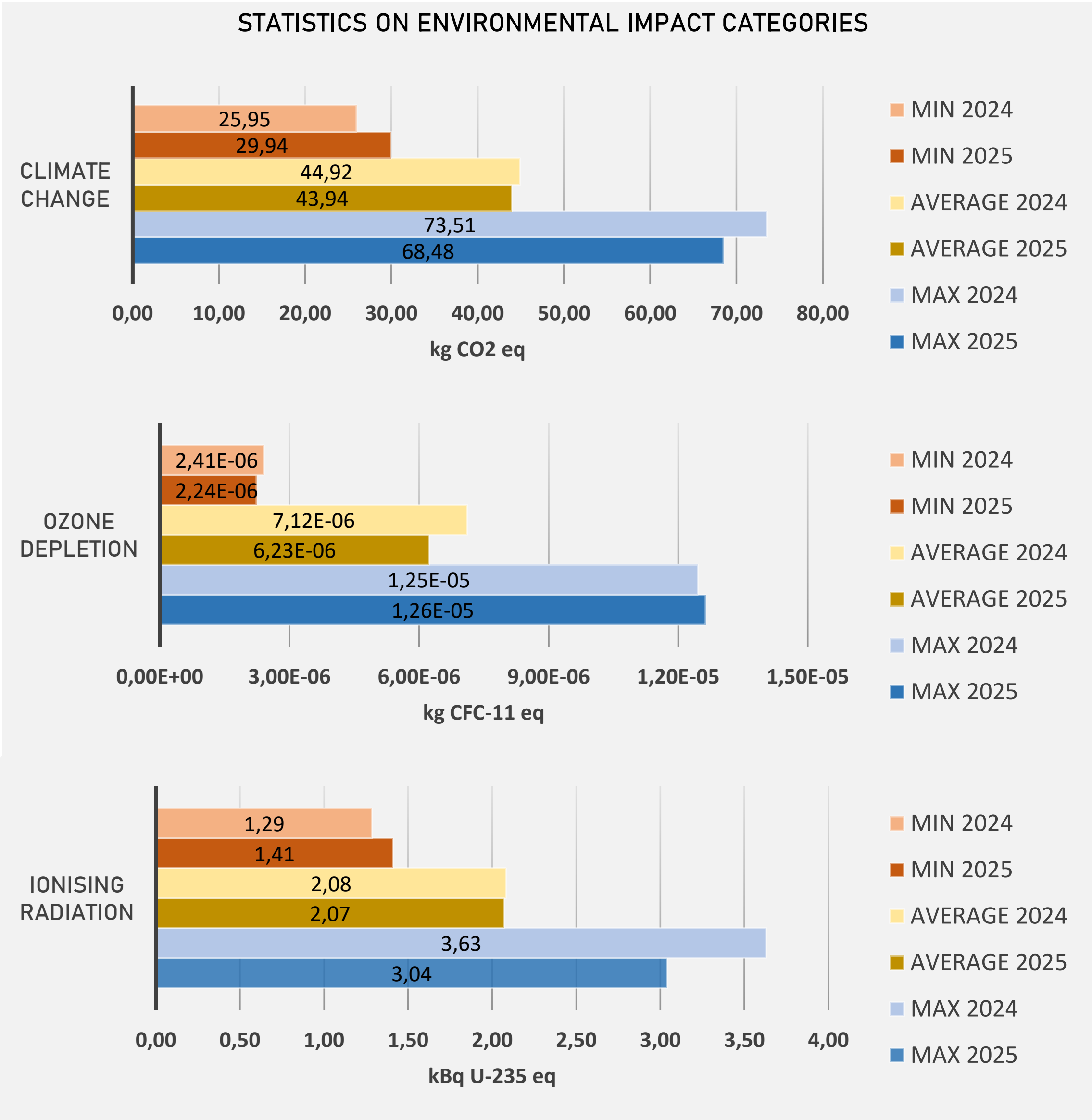
2.2. Life cycle assessment statistics

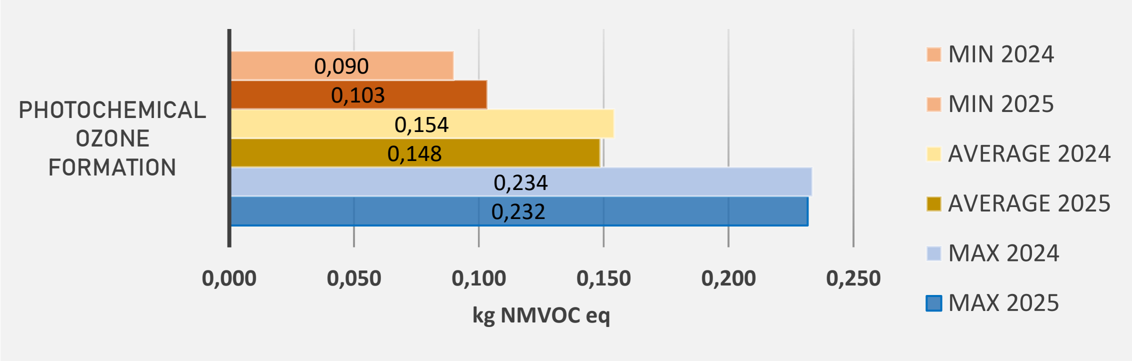
About the Life Cycle Assessment related section and aspects, the following table indicates the relevance of each parameter to the overall final Eco Rating score:

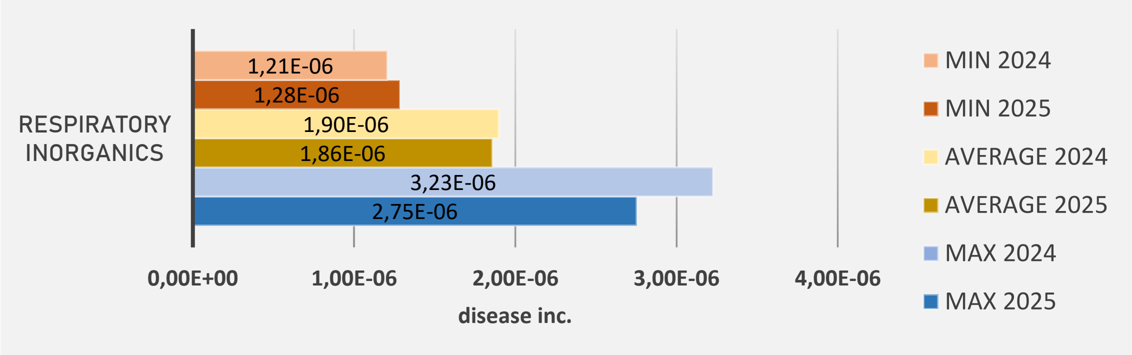
LIFE CYCLE ASSESSMENT SECTION	RELEVANCE TOWARDS OVERALL ENVIRONMENTAL IMPACT
Scarce materials	High
Integrated circuits manufacturing	High
Use and maintenance	High
Display manufacturing	High
Charger manufacturing	Medium
End-of-life	Medium
Printed circuit manufacturing	Medium
Battery manufacturing	Medium
Camera manufacturing	Low
Transport stage	Low
Device assembly	Low
Packaging and other accessories	Low
Cover manufacturing	Low

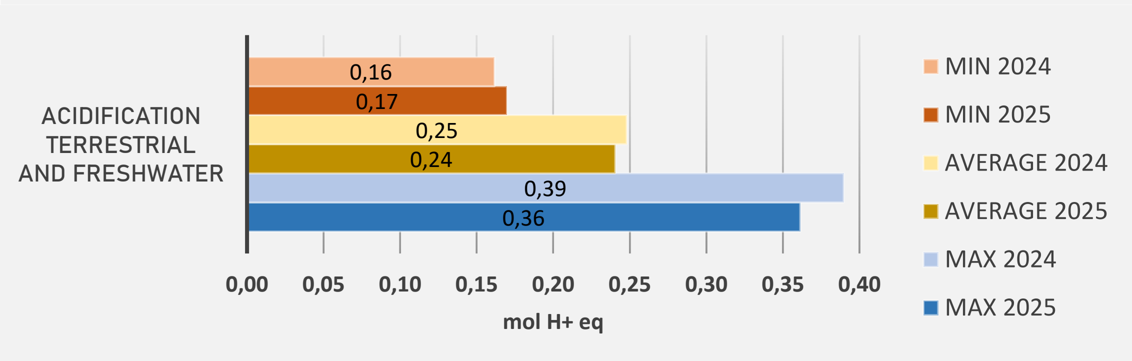
Relevance of Life cycle assessment aspects in the final Eco Rating score

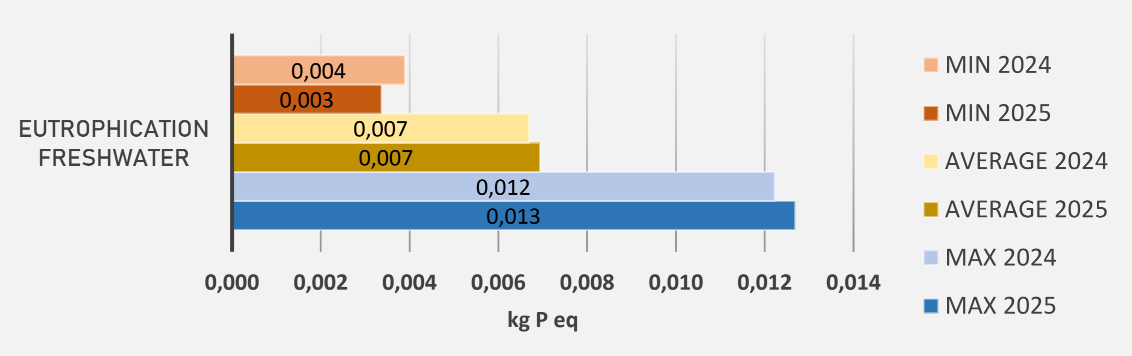
Previous to the obtention of the final Eco Rating score, the simplified life cycle assessment conducted in the Eco Rating tool evaluates 16 environmental concerns individually. The following graphs show the average statistical performance of the evaluated smartphones in 13 of these categories, considering the functional unit evaluated which is “enable access for 1 hour daily calling and enable 1 hour web browsing and 1 hour video watching daily for 4 years”.

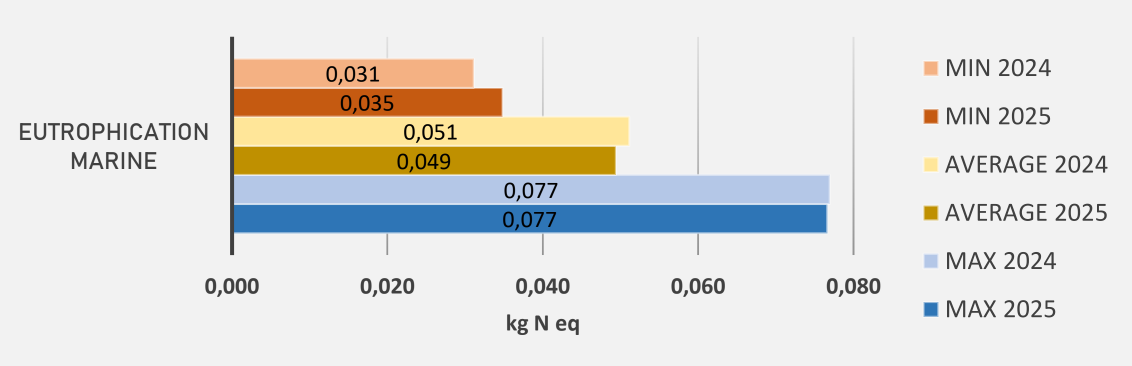


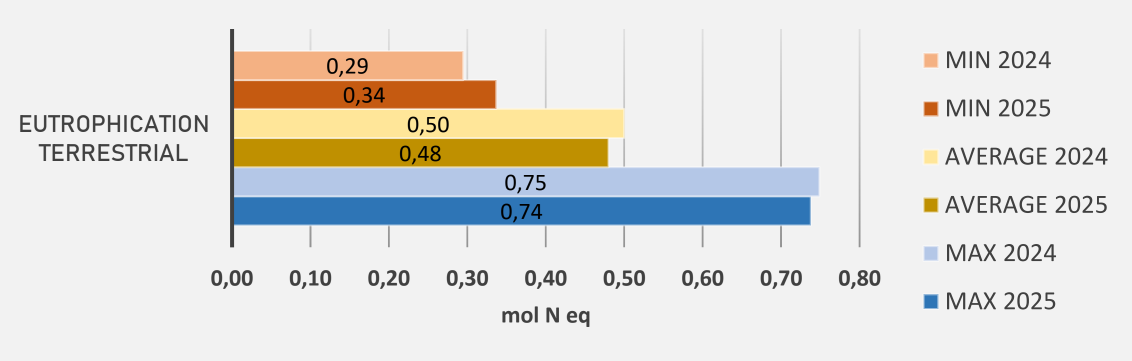

PHOTOCHEMICAL OZONE FORMATION
0,090
0,103
0,154
0,148
0,234
0,232
0,000
0,050
0,100
0,150
0,200
0,250
kg NMVOC eq
MIN 2024
MIN 2025
AVERAGE 2024
AVERAGE 2025
MAX 2024
MAX 2025

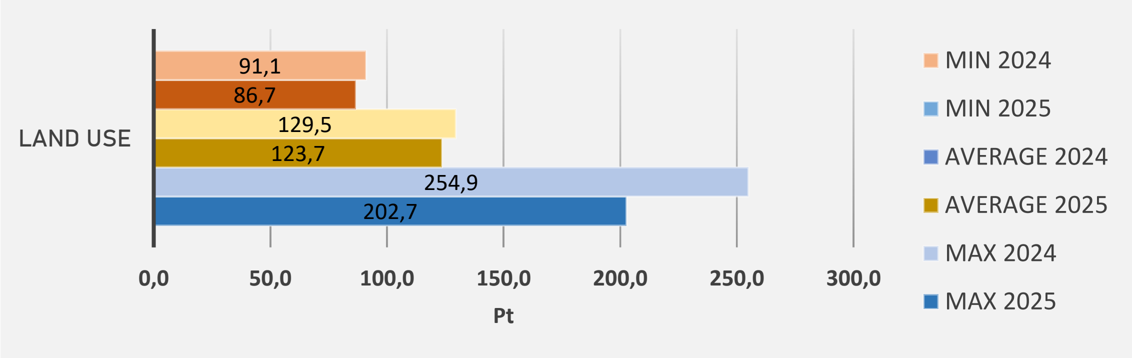

RESPIRATORY INORGANICS
1,21E-06
1,28E-06
1,90E-06
1,86E-06
3,23E-06
2,75E-06
0,00E+00
1,00E-06
2,00E-06
3,00E-06
4,00E-06
disease inc.
MIN 2024
MIN 2025
AVERAGE 2024
AVERAGE 2025
MAX 2024
MAX 2025

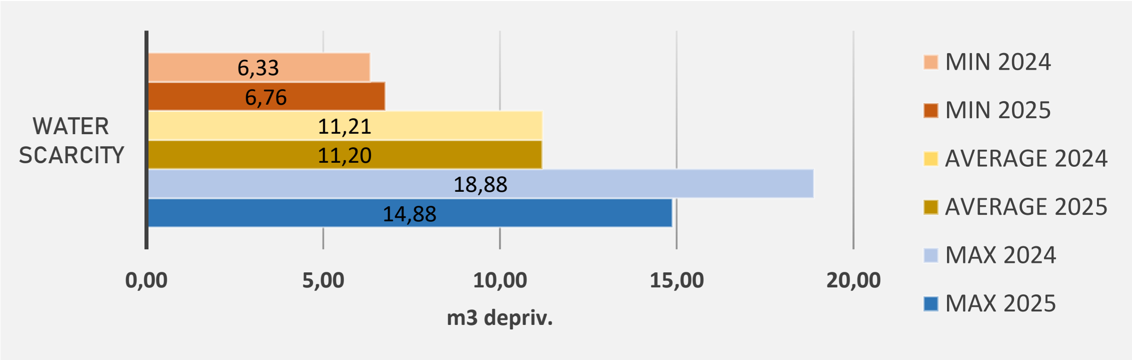

ACIDIFICATION TERRESTRIAL AND FRESHWATER
0,16
0,17
0,25
0,24
0,39
0,36
0,00
0,05
0,10
0,15
0,20
0,25
0,30
0,35
0,40
mol H+ eq
MIN 2024
MIN 2025
AVERAGE 2024
AVERAGE 2025
MAX 2024
MAX 2025

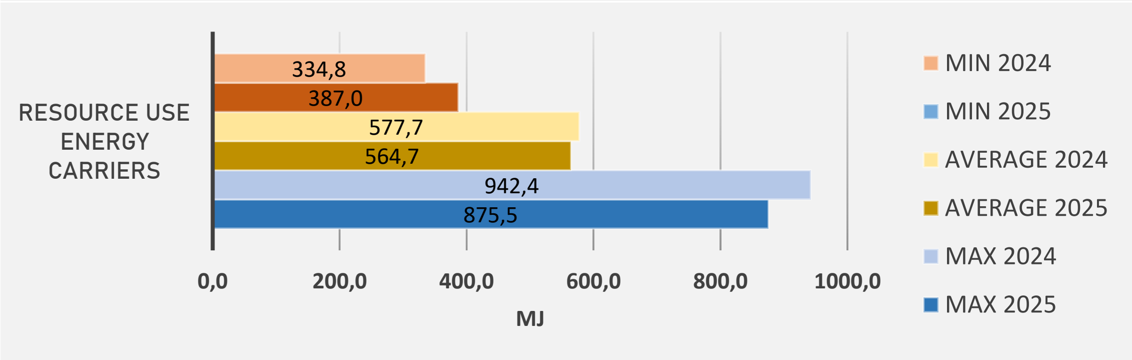

EUTROPHICATION FRESHWATER
0,004
0,003
0,007
0,007
0,012
0,013
0,000
0,002
0,004
0,006
0,008
0,010
0,012
0,014
kg P eq
MIN 2024
MIN 2025
AVERAGE 2024
AVERAGE 2025
MAX 2024
MAX 2025

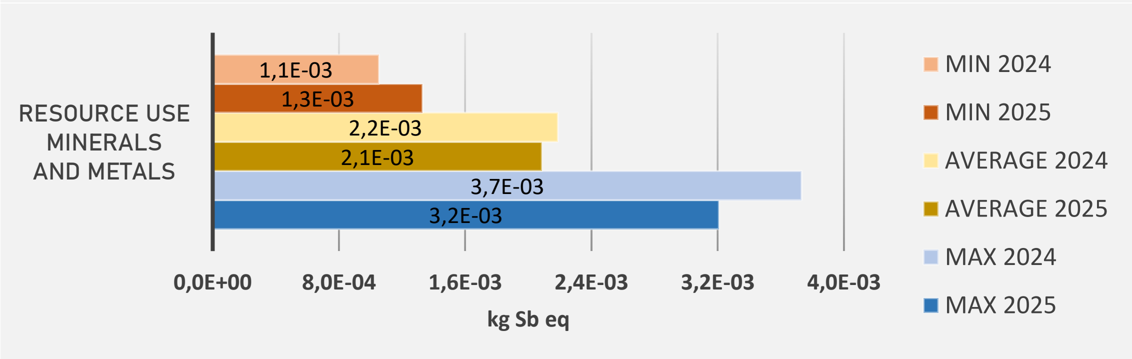

EUTROPHICATION MARINE
0,031
0,035
0,051
0,049
0,077
0,077
0,000
0,020
0,040
0,060
0,080
kg N eq
MIN 2024
MIN 2025
AVERAGE 2024
AVERAGE 2025
MAX 2024
MAX 2025


EUTROPHICATION TERRESTRIAL
0,29
0,34
0,50
0,48
0,75
0,74
0,00
0,10
0,20
0,30
0,40
0,50
0,60
0,70
0,80
mol N eq
MIN 2024
MIN 2025
AVERAGE 2024
AVERAGE 2025
MAX 2024
MAX 2025


LAND USE
91,1
86,7
129,5
123,7
254,9
202,7
0,0
50,0
100,0
150,0
200,0
250,0
300,0
Pt
MIN 2024
MIN 2025
AVERAGE 2024
AVERAGE 2025
MAX 2024
MAX 2025


WATER SCARCITY
6,33
6,76
11,21
11,20
18,88
14,88
0,00
5,00
10,00
15,00
20,00
m3 depriv.
MIN 2024
MIN 2025
AVERAGE 2024
AVERAGE 2025
MAX 2024
MAX 2025


RESOURCE USE ENERGY CARRIERS
334,8
387,0
577,7
564,7
942,4
875,5
0,0
200,0
400,0
600,0
800,0
1000,0
MJ
MIN 2024
MIN 2025
AVERAGE 2024
AVERAGE 2025
MAX 2024
MAX 2025


RESOURCE USE MINERALS AND METALS
1,1E-03
1,3E-03
2,2E-03
2,1E-03
3,7E-03
3,2E-03
0,0E+00
8,0E-04
1,6E-03
2,4E-03
3,2E-03
4,0E-03
kg Sb eq
MIN 2024
MIN 2025
AVERAGE 2024
AVERAGE 2025
MAX 2024
MAX 2025

In the following table, we can compare the most relevant trends in particular aspects of the life cycle assessment. The analysis is based on data extracted up to December 2022, between January 2023 and April 2024, and the current average values assessed up to September 2025. The most relevant trends are summarised in the table below, where it can be seen the result evolution comparing values from 2024 to the present. It shows the ones having a change over ±15%.

SECTION	QUESTION		2022 AVRG.	2024 AVRG.	2025 AVRG.	EVOLUTION
BASIC PARAMETERS	Internal storage	GB	143,5	203,8	284,7	**+40%**
	RAM memory	GB	6,3	7,0	8,4	**+19%**
	Charger weight	grams	83,5	81,8	53,4	**-35%**
	Accesories weight	grams	20,3	9,2	7,6	**-17%**
INTEGRATED CIRCUIT BOARD MANUFACTURING	Total silicon die	cm2	5,7	5,3	6,8	**+29%**
	RAM silicon die	cm2	1,2	1,3	1,8	**+42%**
	Storage silicon die	cm2	1,6	1,5	1,9	**+34%**
CAMERA	Selfie Resolution	MP	15,9	15,8	23,3	**+47%**
ASSEMBLY	Cardboard	grams	112,0	122,5	106,6	**-13%**
	Paper	grams	37,7	34,9	32,1	**-8%**
	Plastic film	grams	2,2	1,3	1,0	**-24%**
SCARCE MATERIAL	Tantalum content	mg	4,2	3,1	4,1	**+30%**
	Indium content	mg	2,9	0,9	1,4	**+55%**
	Cobalt content	mg	10.323	14.102	16.572	**+18%**
USE	Endurance talking	Minutes	1.903	1.920	2.284	**+19%**
	Endurance web browsing	Minutes	1.002	1.027	1.162	**+13%**
	Endurance video playing	Minutes	1.011	1.011	1.168	**+16%**

Most relevant trends in the life cycle assessment section

The table shows both positive and negative trends depending on the evaluated areas. Manufacturers are tending to make devices with greater memory and storage capacities, which does not have a direct effect on the final score, but it is true that this effect will indirectly influence several of the aspects discussed below. Furthermore, on other basic aspects of the device, a reduction on the average charger weight and on the average accessories weight included in the device package has been spotted. The reduction in the charger weight comes mostly from the vendors not including a charger at all in the packaging, more than from a real reduction in the charger weights.

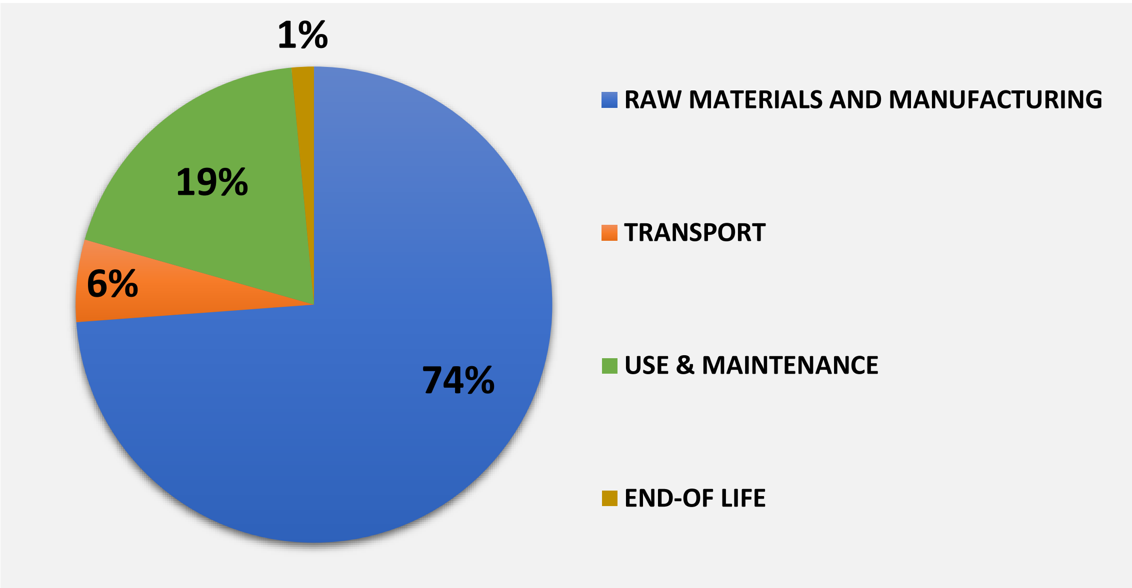
On the integrated circuits manufacturing, we can identify a general increase in the use of silicon, both for the RAM circuits, storage circuits and in the total value. This increase in the silicon content, is directly associated with the previously mentioned growing trend towards manufacturing devices with higher memory capacities. Contrary to this increase, there is a noticeable trend among manufacturers reducing the quantity of materials used in packaging, as can be seen in the values for cardboard, paper and plastic film.

The cobalt content has increased, mainly due to the increase in the average capacity of batteries, as well as tantalum and indium. It is important to note that the increase in the quantity of tantalum and indium is still below the 2022 levels. Finally, there is also a relevant increase of the average endurance of the device battery, when in the talking, web browsing and video playing modes, which is again considered as a positive trend related to the energy efficiency of smartphones.

2.2.1. Global warming potential related statistics

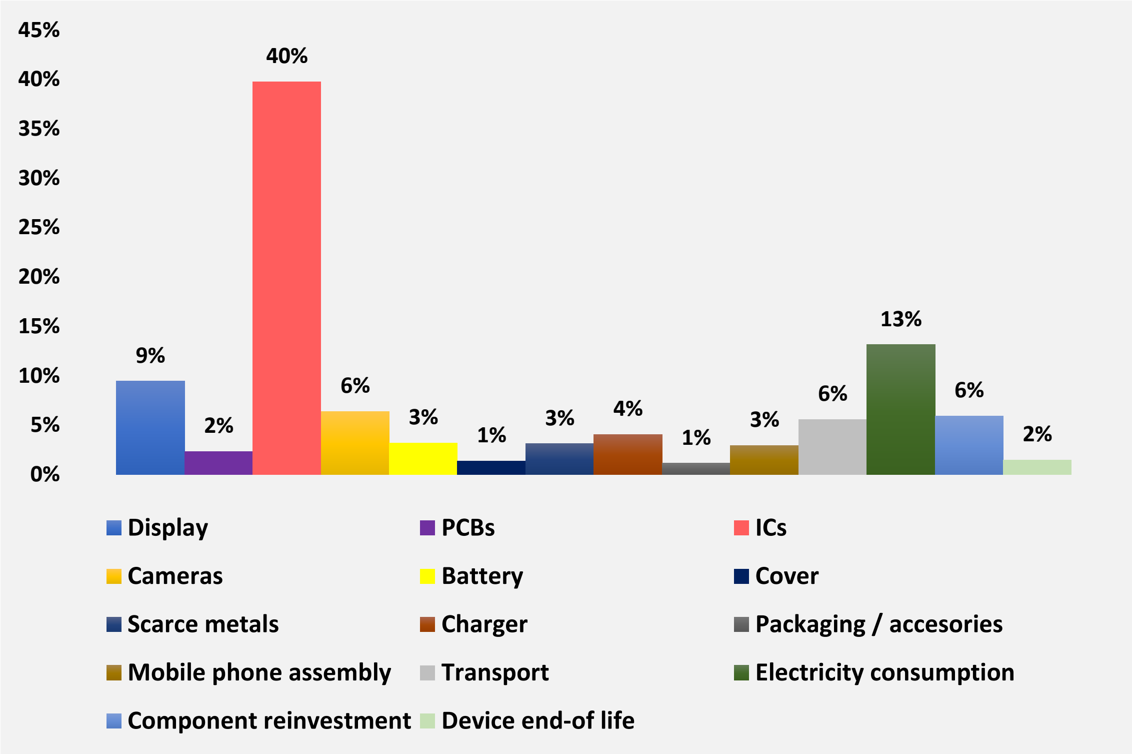
The global warming potential is currently one of the most significant environmental impact categories, especially considering the ongoing challenges associated with climate change. Evidence linking carbon emissions from human activities to rising global temperatures has encouraged a wide range of stakeholders to assess and reduce their carbon footprint.

According to the average life cycle profile for global warming potential evaluated so far by Eco Rating, the raw materials and manufacturing stage represents the primary contributor to this particular environmental impact. When comparing this chart to the one presented in the previous report, the values appear to be almost unchanged. Additionally, the overall profile closely resembles that of the total Eco Rating score.



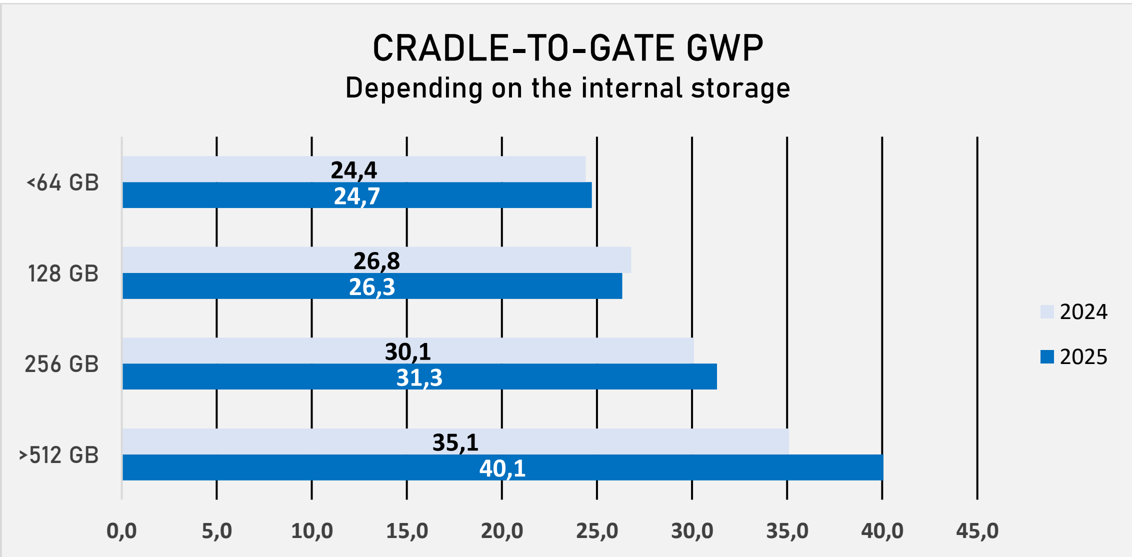
Average life cycle profile of the global warming potential for a smartphone

Within this stage, the integrated circuits manufacturing has a key role in the total carbon emissions, as can be evidenced in the following figure, which shows values corresponding to 2025:



Detailed average life cycle profile of the global warming potential for a smartphone

The production of silicon substrates for integrated circuits—ranging from the processing of quartz sand to the fabrication of the final chip—is a highly energy-intensive process. Consequently, the carbon footprint associated with semiconductor manufacturing constitutes a significant environmental impact factor within the smartphone supply chain, particularly in the context of climate change mitigation. Furthermore, a consistent correlation has been identified between devices with higher memory densities and an increased global warming potential (GWP), primarily attributed to the silicon processing stage. The following graph presents the average GWP of the assessed devices as a function of their internal storage capacity. Data from the previous assessment cycle (2024) are also included, indicating a continuing upward trend in storage capacity across product generations.



Cradle-to-gate global warming potential of smartphones, depending on their internal storage capacity

When considering Eco Design, it is crucial to focus on the semiconductor supply chain to lower emissions associated with energy use. Significant progress could be achieved by improving energy efficiency and expanding the use of renewable energy within this sector. In addition, promoting the development and adoption of low-silicon integrated circuits should be a key goal for the smartphone industry.

The findings of this report indicate that there remains considerable opportunity for the mobile phone industry to further improve product design with greater environmental responsibility.

3. Guideline for sustainable design of mobile phones

The widespread and growing adoption of mobile phones gives rise to several challenges:

- The functionality of these devices has progressively expanded over time, leading to increased demands on power, storage capacity, and raw materials for manufacturing. Certain materials, even in small quantities, raise global concerns due to their social, economic and geopolitical impacts (examples include critical raw materials like tantalum, gold, cobalt or tin).

- Upon reaching the end of their useful life mobile phones are commonly left “dormant” or unused at home. This represents a resource wastage that with appropriate processes, could be harnessed through reuse, recycling and recovery.

- The average lifespan of smartphones is between 3-5 years, as users tend to replace them. This replacement cycle is influenced by various factors, including:
  - User preference for a new model or software, unrelated to any malfunction of the device.
  - The accessibility of frequently damaged components, such as the screen, battery, and occasionally the back cover.
  - The availability of updated editions of the operating system, firmware, or software.
  - Considerations of repair cost and ease.
  - Decreased battery performance over time. Enhanced battery endurance results in better energy efficiency and performance, thanks to less frequent charging and an extended overall battery lifespan (measured by the total number of charging cycles).

Advanced technologies present new possibilities, especially in promoting sustainability and offering manufacturers several choices for a more sustainable mobile device design and more sustainable practices in their processes.

3.1. Materials Selection

Mobile phones consist of a very wide diversity of materials, that goes along a complex supply chain. For example, nearly half of the elements of the periodic table are present in Smartphones, and a mine or crude oil well is usually at the beginning of every supply chain followed by purification, chemical conversion into compounds that go into components, component manufacturing and finally assembly of mobile phones. Each of those steps produce inevitably an environmental impact and there are also some commercial and geostrategic notions (as when growing demand meets increasing scarcity and leads to increasing raw material prices which, in turn, will drive mobile phone prices up and put manufacturers’ profit margins under pressure). On top, some of the raw materials are only available from a very few mining countries which implies the risk of becoming unavailable when geopolitical tensions rise.

So, there are good reasons for the industry to strive replacing primary resources by secondary resources, and apply Circular Economy strategies along the supply chain for converting waste into new raw material[2]. We will list here some of the most relevant environmental aspects and best practices about material selection.

3.1.1. Selection of base and electronic materials, bearing in mind both intended use of the devices and the possibility for future software updates.

When selecting base materials and electronics hardware with an eye towards both the intended use of the devices and the potential for future software updates, it's essential to consider various general factors:

- Recyclability and Renewability: Choose materials that are recyclable or made from renewable sources to minimize environmental impact.
- Low Toxicity: Choose materials with low toxicity levels to ensure the safety of both users and the environment during manufacturing, usage, and disposal.
- Power Consumption:
    - Select electronics hardware with energy-efficient components to minimize power consumption during operation.
    - Look for components that comply with energy efficiency standards, such as Energy Star, to ensure they meet established criteria for environmental performance.
- Quality Materials: Choose robust and durable materials for construction to extend the lifespan of devices, reducing the need for frequent replacements and minimizing waste.
- Modularity: Consider designing devices with modular components to facilitate easy upgrades or repairs, allowing users to replace specific parts rather than the entire device.
- User-Friendly Design: Design devices with user-friendly interfaces and easy-to-access components, enabling users to perform upgrades or repairs without specialized knowledge.
- Availability of Spare Parts: Ensure that spare parts are readily available, promoting repairability and extending the lifespan of the product.
- Open Standards: Choose hardware components and materials that adhere to open standards, making it easier to implement future software updates and ensuring compatibility with evolving technologies.
- Compliance with Circular Economy Principles: Align material and hardware selection with circular economy principles, emphasizing reuse, recycling, and responsible end-of-life management.
- Conduct Lifecycle Assessments: Perform lifecycle assessments to evaluate the environmental impact of materials and hardware choices, considering factors from raw material extraction to disposal.

How this relates with the Eco Rating method and the Score:
- **Material Efficiency: REN-01, REN-02, REN-03, REN-04, HAZ-01, HAZ-02, HAZ-03 HAZ-04, HAZ-05, HAZ-06, REP-02, DUR-04, DUR-05, DUR-06**
- **LCA: Use stage, maintenance stage, increased service life of the device**

[2] *More aspects under Wasmus et al. https://www.businesschemistry.org/wp-content/uploads/2020/09/Wasmus_06_2019.pdf*

3.1.2. Use of secondary (recycled) plastics, substitution of fossil plastics by bio-based materials

A substantial portion of mobile phones consists of plastic (ca. 20-40% by weight depending on design). Battery covers, stiffening frames, displays and PCBA sheets are typical parts wherein synthetic polymers (plastic) are used. 400.3Mt of plastic has been produced world-wide in 2022 of which 90.6% have been of fossil origin[3]. Even if fossil plastic is recycled several times it will end up at one not so fine day as CO_2 as this is thermodynamically the most stable form of Carbon: fossil Carbon is converted into atmospheric CO_2. So fossil plastic is a major driver of global warming. Hence mobile phones must stop using fossil plastic. The strategy for alternatives must be to use Carbon that is already on the earth or in the atmosphere to create full circularity.

This can happen in 3 ways:

(i) Mechanically recycled plastic: Waste plastic is shredded and newly compounded to make it fit for different applications. The disadvantage is that additives from the previous use restrict the achievable properties so that compromises need to be made in mechanical properties and cosmetics. But still, mechanically recycled plastic is good for many applications as existing examples in the industry show (e. g. T-branded routers of the Smart series with 97% post-consumer recycled plastic).

(ii) Biobased plastic: Biological waste is chemically taken apart to synthesize monomers which are then polymerized. To be very clear, this biobased plastic has the same properties as fossil plastic including a full degree of freedom in compounding with additives as the molecular structure of the final product is identical. Only the origin of the Carbon atoms is different.

(iii) Chemcycled plastic: Here waste plastic is chemically decomposed (side node: some polymerization reactions are reversible upon application of heat) and monomers are synthesized from the reaction products. The monomers in turn are then polymerized. It is important to also note that the additives from the previous use are either decomposed to volatile reaction products or otherwise separated. Again here, the properties are identical to fossil plastic.

The manufacturers of mobile phones are requested to abstain from the use of fossil plastic. There are no good arguments to not use one of the above options. Those have also an ecological balance better by a factor of 5-10 than fossil plastic and will help to reduce the GHG emission during production.

How this relates with the Eco Rating method and the Score:

- **Material Efficiency: REN-01, REN-02, REN-03, REN-04**
- **LCA: -**

[3] https://de.statista.com/statistik/daten/studie/167099/umfrage/weltproduktion-von-kunststoff-seit-1950/

3.1.3. Use of secondary (recycled) metals

Another major material constituent of mobile phones are metals (ca. 40%). Here as well there is no good reason to not use metals from secondary sources. Likewise, secondary metal has a better eco-balance than primary metal and is thus another measure to drive down GHG emissions during mobile phone manufacturing. Some of the metals, particularly gold, have a worse eco-balance than other metals. These should not only be substituted by secondary sources but also the amount used in mobile phones should be reduced as much as technically possible.

There is a wide variety of metals and metal alloys used in mobile phones. From an ease of recycling perspective, it is desirable to reduce that diversity and focus on fewer metals and alloys to have fewer metallic elements in mobile phones, but these then in larger amounts. The authors don't see the necessity to have so many different metals and alloys in mobile phones if a solution is used that covers most of the mechanical requirements of parts in a mobile phone by just one multi-purpose metallic material.

How this relates with the Eco Rating method and the Score:
- **Material Efficiency: REN-01, REN-02**
- **LCA: Recycled source for scarce materials**

3.1.4. Avoid the use of harmful substances

Another consequence of material selection is the introduction of harmful substances. Some of these are legally regulated inside the European Union (such as the directives RoHS, REACH and POP) and some other jurisdictions. Adherence to those is mandatory and thus a basic hygiene factor that determines marketability in such jurisdictions.

There are some general materials that are considered hazardous that must be not used or at least limited in mobile devices manufacturing, as for example:
- Beryllium
- Antimony
- Polyvinyl Chlorides (PVC)
- Phthalates
- Brominated Fire Retardants (BFRs)
- Bisphenol A
- Triphenyl Phosphate (TPP)
- Halogenated Flame Retardants (HFRs)
- Other Halogenated Compounds

There are also some other specific harmful substances that are of some concern:

(i) Lead (Pb) in so far as exempted by Annex III RoHS

(ii) 1,3-Propanesultone which is a SVHC according to Annex XIV REACH and candidate list and is used as an electrolyte additive to increase the cycling robustness of Li ion batteries. Provided certain legal obligations are observed, this doesn't restrict marketability, but unfortunately this substance is a very potent carcinogen.

(iii) Barium-containing dielectrics in ceramic capacitors.

(iv) Antimony Trioxide for instance as a fining agent in glass.

(v) Halogenated flame retardants (except PBB or PBDE which is regulated inside the EU by the RoHS directive).

(vi) Some plasticizers such as the Phthalate class of compounds. RoHS controls only 4 members of this substance class even though the whole substance class is suspected to have the same effect on the endocrine system.

Finally, some materials are more due to include harmful materials and/or additives: for example:

- most plastic compositions require additives to make the plastic fit for a specific application. Several of these additives may be harmful. Hence, the formulation of the plastic needs to be carefully reviewed and should only contain the absolute minimum of additives that is necessary to achieve the specific purpose
- Frequently, mobile phones are coated or painted to achieve certain cosmetics or scratch resistance. Many of those coatings or paints contain organic solvents which, with a few exceptions, are all harmful and constitute a problem in relation to Supply Chain Due Diligence legislation as described above in spite of the fact that they are later eventually not present as such in the dried/hardened coating or painting. Use of such coatings and paintings with harmful solvents must be avoided. Instead, water-based coatings or paintings provide a viable alternative for many applications. In cases where that is not possible also solvent-free UV-hardening (in-situ polymerization triggered by UV light) coatings or lacquers might be used. But please note that the monomers before polymerization may be harmful and that concentrations of photo initiators beyond traces may remain in the polymer matrix that are also harmful.

Supply Chain Due Diligence legislation in some jurisdictions (such as the LkSG in Germany or a forthcoming EU directive. In the meantime, now the European Supply Chain Due Diligence Regulation has been agreed upon by the member states) adds a new dimension to the harmful substance content in mobile phones. Operators purchasing mobile phones are responsible for working conditions and environmental protection along the supply chain. This includes adequate handling of harmful substances which otherwise constitutes a substantial risk of damage to workers' health and environmental pollution.

Therefore, it should be in the interest of the whole industry to abolish harmful substances in the supply chain wherever that is possible. The Eco Rating consortium requests this from mobile phone manufacturers accordingly. There are substitutes for most of the above list available:

(i) Some of the exemptions for Lead are no longer technically required such as copper alloys containing up to 4% of Lead. Lead-free brasses are readily available on the market.

(iii) There are Barium-free compositions available as ceramic capacitors.

(iv) Antimony-free glass is available on the market.

(v) There are halogen-free flame retardants available that can achieve UL-94 V0, such as organic Phosphonates.

(vi) Esters of Terephthalic Acid and Adipic Acid are available as alternatives to Phthalates.

The gold standard though would be a system where the hazard statements according to the Globally Harmonized System for the classification and labelling of chemicals (GHS – here particularly chapters 3 and 4) are used to screen the ingredients of candidate components and chose components based on a minimization of the associated hazards.

How this relates with the Eco Rating method and the Score:

- **Material Efficiency: HAZ-01, HAZ-02, HAZ-03 HAZ-04, HAZ-05, HAZ-06**
- **LCA: -**

3.1.5. Exclusion of unnecessary accessories such as cables, low quality headsets and chargers or making them optional at purchase.

Reducing unnecessary accessories and making them optional at purchase in mobile devices is a sustainable practice that helps minimize electronic waste and encourages responsible consumption. Here are some guidelines for excluding or making optional accessories:

- Minimal Packaging: Design minimalistic packaging that only includes essential components, reducing overall packaging waste.
- Clearly Labeled Accessories: Clearly label and separate necessary accessories from optional ones to help users make informed choices.
- Digital Manuals: Provide digital manuals or instructional materials instead of printed versions to reduce paper consumption.
- Online Resources: Direct users to online resources for additional information and support, reducing the need for printed materials.
- Charger-Free Option: Consider offering mobile devices without a charger by default, allowing users to purchase chargers separately only if needed. Specifically for the European markets, this is legally mandatory regarding EU regulation 2022/2380.
- Universal Charging Standards: Promote the use of universal charging standards, ensuring compatibility with existing chargers and minimizing the need for new ones.
- High-Quality Cables: Include durable, high-quality cables that are less prone to wear and tear, reducing the frequency of replacements.
- Optional Cable Lengths: Offer optional cable lengths to accommodate different user preferences and reduce unnecessary cable clutter.
- Customizable Bundles: Allow users to customize their purchase by choosing which accessories they want, creating a more personalized and efficient buying process.
- Preference Surveys: Conduct surveys to understand user preferences for accessories and tailor product offerings accordingly.
- Trade-In Programs: Consider offering trade-in programs where users can exchange old accessories for discounts on new ones, promoting responsible disposal and reducing electronic waste.
- Retailer Education: Collaborate with retailers to educate customers about the environmental impact of accessories and the benefits of making conscious choices.
- In-Store Information: Provide in-store information about the environmental impact of accessories to raise awareness among consumers.

By implementing these guidelines, mobile device manufacturers can contribute to reducing electronic waste, promoting sustainable consumption patterns, and providing consumers with more flexibility in choosing the accessories that best meet their needs.

How this relates with the Eco Rating method and the Score:

- **Material Efficiency: PAC-05, PAC-06, PAC-07**
- **LCA: Charger manufacturing, other accessories manufacturing**

3.2. Design for durability

A longer use of the mobile device to distribute their environmental impacts onto a longer period is a supplemental strategy to reduce their total lifetime impacts. Such a length of usage principle has obvious technical prerequisites, as that a mobile phone should not become defective prematurely (due to deficient quality or inability to surmount foreseeable rough handling by the consumer). This puts durability as a key technical requirement into focus.

Durability must be designed from scratch into a mobile phone design. Development cycles of mobile phones are so short that durability cannot be empirically ensured by trial, error and redesign and anew going through that cycle. Such an approach would fail to yield an acceptable durability at launch and would result in a mobile device that is overly prone to defects in the field.

Instead, adequate durability must already be ensured before the first prototype is being built. The Finite Element (FE) method allows to digitally simulate the mechanical behavior and real durability tests should only serve to verify the FE model of the mobile phone.

According to the EN-45552:2020[4], the durability of a part or a product is the ability to function as required, under defined conditions of use, maintenance and repair, until a limiting state is reached.
The design for durability should promote a longer use of the mobile device to distribute their environmental impacts onto a longer period of time, reducing their total lifetime impacts. If the product last longer, it is not needed to produce a new device to substitute it.

There are different strategies to increase the durability of the product, some of them based on technical requirements, but others based on management and information schemes.

3.2.1. Increase the durability of materials and components

Such a length of usage principle has obvious technical prerequisites, as that a mobile phone should not become defective prematurely (due to deficient quality or inability to surmount foreseeable rough handling by the consumer). This puts durability as a key technical requirement into focus.

The aspects that could be improved from a technical perspective are:

- Use of more durable materials. When possible, use materials with lower wear or scratch, especially in the external parts of the device (housing, display, etc.).
- Increase the degree of protection provided by enclosures (against water and dust ingress), that means increase the IP code when possible. Consider that this strategy of increasing the device sealing could affect the capability of the device to be disassembled for repair.
- Increase the resistance to accidental drops. One of the main reasons of device substitutions is the damage produced to the device after a drop (affecting the covers, display, etc.). Actions to increase this resistance will prevent this premature substitution

[4] *EN-45552:2020.- General method for the assessment of the durability of energy-related products*

(for example toughened and strengthened glass panels, more resistance plastics in covers, etc.).

- Increase the battery endurance. The capacity of Lithium-ion batteries inevitably decreases over time and with use. Battery durability is usually described by a battery's specific cycle life and calendar life. Cycle life denotes the number of charge/discharge cycles (amount of charge equivalent to the battery's initial capacity) the battery can withstand before its capacity decreases below a certain level (e.g. 80 % or 60 % of the initial capacity).

  If the battery endurance can't be improved to guarantee the desired durability, it should be facilitated its replacement.

- Increase the charge connector lifetime. The pug and unplug operation reduce the lifetime of the charge connector, limiting the durability of the device. Improving the endurance of this critical connector could increase the durability of the product.

  If the charge connector endurance can't be improved, it should be facilitated its replacement.

Durability must be designed from scratch into a mobile phone design. Development cycles of mobile phones are so short that durability cannot be empirically ensured by trial, error and redesign and anew going through that cycle. Such an approach would fail to yield an acceptable durability at launch and would result in a mobile device that is overly prone to defects in the field.

Instead, adequate durability must already be ensured before the first prototype is being built. The Finite Element (FE) method allows to digitally simulate the mechanical behaviour and real durability tests should only serve to verify the FE model of the mobile phone.

Some specific guidelines for durability increase of the device and his components (screen, battery…), most of them covered by the Regulation for ecodesign requirements for mobile devices and the Regulation regarding the energy labelling, are:

- Resistance to accidental drops: Resistance to 45 falls (35 for foldable devices un-extended state/15 extended)
- Level 4 on the Mohs hardness scale for scratch resistance
- Protection from dust and water: protection against ingress of solid foreign objects (>1mm) and splashing of water (IP44)
- At least 800 cycles of battery endurance, ensure an 80% remaining capacity
- Optional charging feature that terminates the charging process automatically when the battery is charged to 80%, and the default feature one (once the battery is fully charged there is no further charging power supplied unless the charge drops below 95%).
- Make security updates, corrective updates or functionality updates available, for 5 years from the end of placement in the market
- Marking of plastic components heavier than 50g, to help recyclability and reuse of plastic parts

Eco Rating Score relationship:
- **Material Efficiency: DUR-02, DUR-03, DUR-04, DUR-05, DUR-06**
- **LCA: Increased service life of the device**

3.2.2. Management and information aspects

A part of technical improvements, the durability of the device can be promoted by some management and information aspects, such as:

- Increase the guarantee period of the device (if possible beyond the legal requirements).

  This strategy will favour that the user will use this guarantee period to repair the device (avoiding the purchasing of another one) and increasing its durability.

  The user should be fully aware of its guarantee rights, how to use them, etc.

- Availability of software, firmware and operating systems regular updates.

  These updates are as important as the physical elements of a smartphone to ensure a longer life of the device and to reduce phone replacement rates.

  Software updates and in particular security updates of operating systems (OS) are crucial for the functionality and data security of a smartphone, and they should be provided in a regular basis and during a minimum period of time after the date of placement on the market of the last unit (the mentioned ecodesign Regulation (EU) 2023/1670 fixes this period to at least 5 years).

Eco Rating Score relationship:
- **Material Efficiency: DUR-01, REP-00 and REP-01**
- **LCA: Increased service life of the device**

3.3. Design for repairability / upgradeability

Next to durability in priority for longevity is reparability, which is the availability of products to be repaired, that is, to be submitted to a process of returning a faulty product to a condition where it can fulfil its intended use (EN 45554:2020).

Real-life experience clearly shows that even the most robust design may one day become defective. In order to prevent a repair from becoming a lifetime-ending event it must be a proposition attractive in price and convenience for the consumer. While attraction with regards to convenience is a matter of the business proposition with which the repair is offered, the price is governed by certain technical prerequisites. One of the key cost drivers is the labour time that goes into the repair. The faster and easier the repair, the lower the cost gets. This in turn has immediate implications for the hardware design.

It is also obvious that repairs are only possible as long as spare parts are available, so spare parts availability should be mandatory (and will be as stated in Regulation (EU) 2023/1670) for at least a period of 7 years after the latest placement on the market).

Some generic guidelines for repairability / upgradeability increase of the device and his components (screen, battery…), most of them covered by the Regulation for ecodesign requirements for mobile devices and the Regulation regarding the energy labelling, are:

- Guarantee the availability of spare parts:
    - To professional repairers: battery, cameras, audio connectors, charging ports, buttons, microphone, speakers, hinge assembly parts….
    - To end users: battery, back cover, protective foils, chargers, sim and memory trays…
- Access to repair and maintenance information
- limit the maximum delivery time of spare parts (5 working days during the first 5 years after the date of end of placement on the market, or 10 working days during the remaining years)
- Provide information on the price of spare parts, until at least 7 years after the end of placement in the market
- Provide information on the requirements for preparation for reuse: ensure that devices:
    - Encrypts by default the user data stored in the internal storage of the device
    - Include a software function that resets the device to its factory settings and erases securely by default the encryption key and generates a new one
    - Records the following data from the battery management system for end-users: data of manufacturing of the battery, data of first use, number of full charge/discharge cycles, general state of "health"
- Reduce the disassemble requirements:
    - removable, resupplied or reusable fasteners
    - no tools needed or generalist tools
- Provide the end user the reparability score (as stated in the Regulation regarding the energy labelling) in a clear and transparent way.

Following, some more specific guidelines are described.

3.3.1. Selection of mechanical fasteners

The type of mechanical fasteners has a direct influence in the dismantling time and therefore in the repairability potential of the device.
The standard EN 45554:2020[5] differentiate between the following fastener types, depending on their reversibility and the reusability:

- Reusable (Class A): An original fastening system that can be completely reused, or any elements of the fastening system that cannot be reused are supplied with the new part for the repair, reuse or upgrade process.
- Removable (Class B): An original fastening system that is not reusable, but can be removed without causing damage or leaving residue which precludes reassembly (in case of repair or upgrade) or reuse of the removed part (in case of reuse) for the repair, reuse or upgrade process.
- Neither removable nor reusable (Class C): An original fastening system that is not removable and not reusable, as defined above, for the repair, reuse or upgrade process.

For example, gluing joints are very difficult to open if access to the interior of a mobile phone for repair is required. Opening those usually requires the application of heat and special tools (such as suction cups or similar). It is both time consuming for the repair technician and bears the risk of collateral damage when attempting to open the mobile phone.
So, the preference are reusable fasteners, following by removable fasteners and finally this type of fasteners neither removable nor reusable.
Other aspects to be considered are:

- Number of fasteners (reduce as much as possible the number of fasteners)
- Uniformity in fastener type (use the same type of fastener to reduce the time needed to change the required tool)
- Accessibility to the fastener (facilitate the access and identification to the fastener, with enough space to use the required tool. If fasteners or connectors are not visible, the disassembly sequence can require further steps to locate them or finding disassembly instructions.)

For example, if screws are used, those should be of uniform size to avoid the need of tool changes to reduce the repair time even further.

How this relates with the Eco Rating method and the Score:

- **Material Efficiency: FAS-01, FAS-02, FAS-03, REP-06**
- **LCA: Increased service life of the device**

[5] EN 45554:2020.- General methods for the assessment of the ability to repair, reuse and upgrade energy-related products

3.3.2. Selection of electrical contacts

Following a similar criterion of reusable and movable fasteners, electrical contacts should preferably be provided by plug and socket type of connectors. Soldering joints should be avoided as unsoldering is more time consuming and requires afterwards manual soldering to complete the repairs. Manual soldering bears the risk of failed repairs by cold soldering joints particularly when the repair technician trembles in the wrong moment.

How this relates with the Eco Rating method and the Score:
- **Material Efficiency: FAS-01, FAS-02, FAS-03, REP-06**
- **LCA: Increased service life of the device**

3.3.3. Selection of required tools

The required tools to disassembly the product or its parts have also an influence on the repairability potential of the product.
According to the Regulation (EU) 2023/1669, the tools could be classified as follow:

- ‘Basic tools’ means a screwdriver for slotted heads, a screwdriver for cross recess screws, a screwdriver for hexalobular recess heads, a hexagon socket key, a combination wrench, combination pliers, combination pliers for wire stripping and terminal crimping, half round nose pliers, diagonal cutters, multigrip pliers, locking pliers, a prying lever, tweezers, magnifying glass, a spudger and a pick.
- ‘Commercially available tool’ means a tool that is available for purchase by the general public and is neither a basic tool nor a proprietary tool;
- ‘Proprietary tool’ means a tool that is not available for purchase by the general public or for which any applicable patents are not available to licence under fair, reasonable and non-discriminatory terms;

The preference order is the following:
1. No tools needed
2. Basic tools needed
3. Supply the required set of tools (or offer to be supplied at no additional cost) with the spare part.
4. Supply the required set of tools (or offer to be supplied at no additional cost) with the product.
5. Commercially available tools needed

How this relates with the Eco Rating method and the Score:
- **Material Efficiency: TOO-01, TOO-02, TOO-03, REP-07**
- **LCA: Increased service life of the device**

3.3.4. Reduce disassembly depth

Some components are more likely to fail or to break than others. These are namely the battery and the display and should therefore be the easiest ones to access.
Access should be able just by opening of 1-2 electrical and/or mechanical connectors.

According to EN 45554:2020, the disassembly depth is the number of steps required to remove a part from a product, without damaging the product. A step can be defined as an operation that finishes with the removal of a part, and/or with a change of tool.
The analysis of disassembly depth is fundamental to assess the effort required to access and/or replace priority parts. The number of disassembly steps could be influenced by:

- The disassembly sequence (i.e. parts to be removed before arriving to the priority part and its fasteners/connectors). A modular design can facilitate this sequence.
- The number and type of used fasteners and connectors
- The accessibility and easy identification of these fasteners and connectors
- The number of tools needed

Some components are more likely to fail or to break than others. The Regulation (EU) 2023/1669 considers that the following priority parts regarding repairability potential:

- the battery.
- the display assembly.
- the back cover or back cover assembly.
- the front-facing camera assembly.
- the rear-facing camera assembly.
- the external charging port.
- the mechanical button.
- the main microphone(s).
- the speaker.
- the hinge assembly or the mechanical display folding mechanism.

The number of disassembly steps vary from each priority part, and range from lower than 2 to more than 15 steps.

Other aspects that can influence the time needed for the part/product disassembly are:
- Availability of disassembly or repairability manuals or information to various targeted groups.
- Skill level of the person who performs the disassembly and repair. This comprises the ability to identify and localize the fault, to access the faulty part within the product, handle the tools safely and manage any risk to the product, the environment and the operator. As a consequence, certain repair operations can only be feasible for certain skill level categories.
- Working environment required to perform the repair, reuse, upgrade process; which is influenced by safety provisions and equipment requirements.

How this relates with the Eco Rating method and the Score:
- **Material Efficiency: DIS-01, DIS-02, DIS-03, REP-05, REP-08**
- **LCA: Increased service life of the device**

3.3.5. Spare parts availability

The availability of spare parts, especially for those parts with highest failure rate, is a paramount parameter to ensure that a repair/upgrade process can take place.
In order to ensure that devices are able to be effectively repaired, the price of spare parts should be reasonable and should not discourage repair.
The user should know the spare parts that are available, their cost and how to purchase them.

The Regulation (EU) 2023/1670 indicates which spare parts should be available for professional repairers and end-user. It specifies that:

From 20 June 2025 or from one month after the date of placement on the market, whichever is later, manufacturers, importers or authorised representatives shall make available to professional repairers at least the following spare parts, including required fasteners, if not reusable, until at least 7 years after the date of end of placement on the market, when present:

(i) battery or batteries;
(ii) front-facing camera assembly;
(iii) rear-facing camera assembly;
(iv) external audio connector(s);
(v) external charging port(s);
(vi) mechanical button(s);
(vii) main microphone(s);
(viii) speaker(s);
(ix) hinge assembly;
(x) mechanical display folding mechanism.

From 20 June 2025 or from one month after the date of placement on the market, whichever is later manufacturers, importers or authorised representatives shall make available to professional repairers and end- users at least the following spare parts, including required fasteners, if not reusable, until at least 7 years after the date of end of placement on the market:

(a) battery or batteries;
(b) back cover or back cover assembly, if to be fully removed for replacement of the battery;
(c) protective foil for foldable displays;
(d) display assembly;
(e) charger, unless the device complies with Article 3(4) of Directive 2014/53/EU(1);
(f) SIM tray and memory card tray, if there is an external slot for a SIM tray or memory card tray.

How this relates with the Eco Rating method and the Score:

- **Material Efficiency: REP-02**
- **LCA: Increased service life of the device**

3.4. Design for recyclability

We understand by recyclability as the availability of the product and its parts to be recycled, that is, to be submitted to a recovery operation of any kind, by which waste materials are reprocessed into products, materials or substances whether for the original or other purposes excluding energy recovery (EN 45555:2019).The design characteristics of the product can facilitate selected recycling and recovery processes, for example marking the plastics parts in order to facilitate their identification. The design characteristics of the product can facilitate selected recycling and recovery processes, for example marking the plastics parts in order to facilitate their identification.

These design characteristics should be consistent with the established end-of-life scenario for the products and its parts, favouring the selected recycling/recovering processes.

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The design characteristics of the product can facilitate selected recycling and recovery processes, for example marking the plastics parts in order to facilitate their identification.
These design characteristics should be consistent with the established end-of-life scenario for the products and its parts, favouring the selected recycling/recovering processes.

3.4.1. Increase the recyclability of materials and components

There are some design related aspects that affect the recyclability/recoverability potential of the product, such as:

- Content of regulated substances, mixtures and components that have to be removed during the depollution process, previous to the recycling process. These substances and components are regulated by the WEEE Directive (Directive 2012/19/EU).

  The design characteristics are mainly related to reduce the content of these substances in the product and to facilitate the identification of the parts that contains these substances.

- Ability to access and remove the parts that require selective treatment, depending on joining techniques used, parts to be disassembled before arriving to the targeted parts, etc.

- Compatibility of the materials with the established recycling processes, and the availability to undo joints (including screws, glue, snaps, etc.) to separate and to sort targeted materials or the possibility to recycle them together (materials compatibility for recycling).

- Ability to access and remove parts containing Critical Raw Materials (CRM) and other Valuable Materials from the product.

- Availability to access and remove parts that reduce the recyclability potential, based on the established end-of-life scenario (for example plastics using certain flame retardants).

- Marking of relevant parts to improve the sorting and recycling of the device and targeted parts, for example plastics parts, parts with CRM or valuable materials, parts containing halogenated substances or hazardous substances, etc. The Regulation (EU) 2023/1670 requires that plastics components heavier than 50 gr shall be marked by specifying the type of polymer with the appropriate standard symbols or abbreviated terms, from 20 June 2025.

In general, design features that enhance reparability (please refer to previous section 4.3) will also improve the aspect of the ability to access and remove the parts for recycling.

How this relates with the Eco Rating method and the Score:
- **Material Efficiency: REC-03, REC-04, REC-06, REC-07, REC-08, REC-09**
- **LCA: End-of-life stage**

3.4.2. Management and information aspects

There are also management and information aspects that could increase the recyclability potential of the product, such as:

- Provision of additional information to recyclers:
  To provide information on disassembly process and location of battery and other valuable components is essential for a safe and efficient recycling. This information could include:
    - General information on the product;
    - Content of dangerous components/substances used (as a minimum the ones mentioned in Annex VII of the WEEE Directive, see section 3.1): provision of a short description and photo, and the place where these are usually found in the appliance. For this purpose, note that the entry of the product at the SCIP database at the ECHA could also serve to this purpose.
    - Dismantling instructions: these could include exploded diagrams of the device, indicating the opening mechanism and required tools; in case of clips, this should include information related to the direction the housing should be opened;
    - How to recognize special models and specific dismantling instructions for them;
    - Advice on collection (separate/mixed) and on logistics.

Additional relevant information could include also:

- Information on batteries which cannot be removed without the use of (advanced) tools).
- Personal protection equipment needed for handling,
- Risks for workers when the waste is not properly dismantled,
- Advice on possibilities to sort the components or substances (when different treatment is possible for different types)
- Advice on available treatment techniques

- Provision of additional information to end-user, about the optimum recycling scenario for the product, and how to proceed to discard the product in a correct way (collection points, etc.).
- Existence of take-back systems, to return the product without an additional cost for the end-user. Once collected, the products should be redirect according to the established end-of-life scenario.

How this relates with the Eco Rating method and the Score:
- **Material Efficiency: REC-00, REC-01, REC-02, REC-05**
- **LCA: End-of-life stage**

3.5. Supply Chain Transparency

Creating and overseeing the supply chain of a company within the mobile phone industry poses unique challenges; short product lifecycles, swiftly advancing technology, interconnected global distribution networks, growing product diversity, elevated levels of demand and supply uncertainty…. Present difficulties for supply chain management in this sector. As competition intensifies and profit margins diminish, effective supply chain management practices become increasingly crucial for companies vying in this industry, being the sustainability one of the most relevant aspects to take into account.

3.5.1. Avoid material of conflict or critical raw materials

Mobile devices contain a diverse range of materials, often incorporating rare and critical materials. Out of the 17 rare earth metals, 16 are usually present in smartphones, yet none are presently reclaimed. In particular in relation to rare earth elements there are only a very few mineable deposits which create a critical strategic dependance on those countries where these mines or deposits are situated. Only recycling is a way out of such a critical strategic dependance. Additionally, along with other electronic devices, mobile devices may require the use of the so-called conflict minerals (tungsten, tantalum, tin, and gold).

In regions characterized by political instability and where these metals are sourced, sales can potentially fund armed groups, contribute to forced labor and other human rights violations, and support corruption and money laundering. While cobalt is not categorized under the conflict minerals definition, its inclusion in the production of lithium batteries for mobiles and other devices raises significant concerns, with well-documented human rights and safety risks associated with its extraction. This is also relevant for Supply Chain Due Diligence Acts applicable in various jurisdictions. Network operators operating under such legislation are prohibited from tolerating such human rights violations and must intervene when becoming aware of such violations. Beside that legal aspect, such violations bear also the risk of reputational damage when becoming public which is a risk both for network operators and mobile phone manufacturers.

That’s why ensuring the responsible sourcing of critical raw materials (CRM), conflict minerals (3TG), and extending to high-risk minerals like copper, cobalt, and lithium is imperative. In the EU, the new Conflict Minerals Regulation came into force in 2021, helping to ensure that the EU importers of 3TG as well as global and EU smelters and refiners will meet the international responsible sourcing standards.

So complete transparency regarding the materials used in mobile devices, including the utilization of secondary materials or those obtained through company take-back programs, is essential. This transparency should extend to providing a list for all minerals, along with details on due diligence efforts and compliance with third-party assessments.

Actively participating in industry initiatives focused on responsible sourcing of minerals and mining, with tangible measurable impacts, is vital. Here are some initiatives that could help developing an exhaust and traceable mineral and material responsibility plan:

- Responsible Cobalt Initiative (RCI)
- The Alliance for Responsible Mining (ARM)
- The Responsible Minerals Initiative (RMI)
- The Initiative for Responsible Mining Assurance (IRMA)

- Towards Sustainable Mining
- The Fairtrade Foundation
- The Better Sourcing Program
- ITSCI Programme

How this relates with the Eco Rating method and the Score:
- **Material Efficiency: REC-04, REC-05**
- **LCA: Scarce metals content**

3.5.2. Supplier Code of Conduct (ScoC)

A Supplier Code of Conduct outlines the ethical, social and environmental standards that an organization expects its suppliers to adhere to, as well as compliance with fundamental human rights.

Here's a summarized content outline of a typical Supplier Code of Conduct requirements:

- Compliance with Laws and Regulations: Suppliers must comply with all applicable laws and regulations in the regions where they operate.
- Fair Labor Practices: Suppliers are expected to uphold fair labor standards, including no forced labor, child labor, and adherence to minimum wage and working hour requirements.
- Non-Discrimination: Suppliers should promote a workplace free from discrimination, ensuring equal opportunities and fair treatment for all employees.
- Anti-Corruption: Suppliers must conduct business with integrity, avoiding any form of corruption, bribery, or unethical practices.
- Fair Competition: Commitment to fair competition practices and compliance with antitrust laws.
- Environmental Compliance: Suppliers are expected to comply with environmental laws and regulations, minimizing their impact on the environment.
- Resource Efficiency: Encouragement of resource efficiency, waste reduction, and sustainable practices.
- Workplace Safety: Suppliers must ensure a safe and healthy working environment, implementing proper safety measures and providing necessary training.
- Emergency Preparedness: Preparedness for emergencies and the implementation of health and safety protocols.
- Respect for Human Rights: Suppliers are required to respect and support human rights, addressing any human rights concerns within their operations.
- Product Quality: Suppliers are expected to deliver products and services that meet agreed-upon quality standards.
- Product Safety: Commitment to producing safe and reliable products, adhering to applicable safety standards.
- Data Security: Suppliers should handle any sensitive information, including personal data, with the utmost care and in compliance with privacy laws.
- Community Engagement and Social Responsibility: Encouragement of suppliers to engage positively with local communities, respecting cultural diversity and supporting community development initiatives.
- Monitoring and Reporting: Establishment of mechanisms for monitoring and reporting on the supplier's compliance with the Code of Conduct.

- Audits and Assessments: The right to conduct audits or assessments to ensure ongoing compliance.
- Continuous Improvement: Suppliers are encouraged to continuously improve their practices in line with evolving standards and best practices.
- Communication: Clear communication of the expectations outlined in the Code of Conduct to all relevant stakeholders.
- Training: Provision of necessary training to ensure awareness and understanding of the Code of Conduct.

This is under the explicit provision that applicable legislation does not require other or additional conducts which then take precedence. Manufacturers are strongly recommended to review applicable legislation in the jurisdiction of their home country in view of required or permissible conducts in their supply chain. Above recommendations can only supplement any such applicable legislation and only in so far as not contradicting applicable local legal requirements.

How this relates with the Eco Rating method and the Score:
- **Material Efficiency: -**
- **LCA: -**

3.5.3. Sustainability risk assessment

A Sustainability Risk Assessment is a process of evaluating and identifying potential environmental, social, and governance (ESG) risks associated with a business's operations, supply chain, and overall activities. The goal is to understand and manage these risks to ensure sustainable business practices, so a comprehensive Sustainability Risk Assessment enables organizations to proactively address potential challenges, enhance resilience, and demonstrate a commitment to responsible and sustainable business practices.

Please note that in some locations there might be specific legal requirements regarding these sustainability risk assessments. Manufacturers are strongly recommended to review first applicable legislation in the jurisdiction of their home country in view of risk assessment-related requirements. In those cases, applicable local legal requirements shall not be contradicted.

Here's a brief summary of the key components typically included in a Sustainability Risk Assessment:
- Definition of the scope of the assessment and the key internal and external stakeholders to be assessed, to gather insights and perspectives to understand the potential impacts and risks associated with the business's activities.
- Legal and Regulatory Compliance: Assess the compliance with relevant national and international laws and regulations related to environmental protection, labor rights, human rights, and other sustainability aspects.
- Identification of potential risks related to supply chain disruptions, ethical sourcing, and environmental impacts.
- Assess environmental risks, such as resource depletion, pollution, and climate change impacts, associated with the business's operations. Consider the potential effects on ecosystems, biodiversity, and natural resources.
- Evaluate social risks, including labor rights, worker conditions, and community relations. Identify potential risks related to employee health and safety, diversity and inclusion, and fair labor practices.
- Examine the business's adherence to ethical standards, anti-corruption policies, and fair competition practices.

- Evaluate risks associated with data security and privacy, ensuring compliance with applicable laws and regulations. Address concerns related to the responsible handling of customer and employee data.
- Assess the business's contribution to climate change and its vulnerability to climate-related risks. Consider the company's efforts to reduce greenhouse gas emissions and adapt to climate impacts.
- Develop and implement strategies to mitigate identified risks.
- Establish mechanisms for ongoing monitoring and management of sustainability risks.
- Communicate the findings of the sustainability risk assessment to internal and external stakeholders.

Manufacturers are strongly recommended to review any legally mandated supply chain risk assessment under the jurisdiction of their home countries. Above recommendations can only be supplemental to such local legal requirements and can only apply in so far as they are not contrary to such local legal requirements.

How this relates with the Eco Rating method and the Score:
- **Material Efficiency: -**
- **LCA: -**

3.5.4. Supplier sustainability information systems and audits

Supplier sustainability information systems, such as EcoVadis, Achilles, BSR (Business for Social Responsibility)…, play a crucial role in assessing and managing the sustainability performance of suppliers within a supply chain.

The primary goal of these systems is to evaluate and monitor the sustainability practices of suppliers to help companies make informed decisions and drive positive social, environmental, and ethical impacts across their supply chains. Usually, supplier sustainability information systems use a set of criteria to assess suppliers, covering various aspects of sustainability including environmental impact, labor practices, human rights, ethical business conduct, and supply chain management. They also often provide standardized frameworks or questionnaires based on international standards (e.g., Global Reporting Initiative, ISO 26000) to ensure consistency and comparability in assessing suppliers globally.

So, these systems facilitate the collection of relevant sustainability data from suppliers through surveys, assessments, and documentation, covering a wide range of topics such as energy consumption, emissions, labor practices, and community engagement…

There is also usually the involvement of third-party verification processes to enhance the credibility and reliability of the sustainability information provided by suppliers. This can include on-site audits or reviews by independent assessors.

Suppliers are often scored based on their sustainability performance, and benchmarking against industry peers helps companies understand how their suppliers compare in terms of sustainability practices, and enabling ongoing monitoring of supplier performance, allowing companies to track improvements over time and address emerging sustainability challenges.

Finally, they facilitate communication and collaboration between companies and suppliers by providing a platform for sharing best practices, setting improvement targets, and fostering a culture of sustainability. Companies can use the data gathered from these systems to generate comprehensive reports on their supply chain's sustainability performance, promoting transparency and accountability in corporate sustainability reporting, and some systems offer resources and guidance to help suppliers enhance their sustainability practices.

So, Supplier Sustainability Information Systems are instrumental in promoting sustainable practices across supply chains by providing a structured and standardized approach to assessing, monitoring, and improving the sustainability performance of suppliers.

How this relates with the Eco Rating method and the Score:
- **Material Efficiency: -**
- **LCA: -**

3.6. Manufacturing

Mobile device manufacturing involves various environmental aspects that can significantly impact the overall sustainability of the process. Addressing these environmental aspects requires a holistic approach that involves sustainable sourcing, energy-efficient manufacturing processes, waste reduction, responsible disposal practices, and a commitment to social and ethical standards throughout the mobile device supply chain.

Also, Mobile Network Operators (MNO) usually have ambitious scope 3 carbon emission reduction targets, and these aspects are one of the biggest levers to achieve those targets in terms of the mobile phone business. So, the support of the manufacturers is required for this information supply, and by the reduction of the environmental impacts for the "upstream" processes of the MNOs.

The main environmental aspects for manufacturing of the mobile device and his components are:

- The extraction of raw materials, such as metals (e.g., gold, silver, copper), minerals, and rare earth elements, for manufacturing components like circuit boards and batteries, that can lead to habitat destruction, soil erosion, and water pollution. This topic and guidelines are detailed in "4.1 Materials Selection".

- The energy-intensive nature of manufacturing processes, including the production of semiconductors, assembly, and testing, contributes to greenhouse gas emissions. The energy mix used in manufacturing facilities determines the overall carbon footprint so this is a crucial aspect to consider.

- The use of chemicals in various stages of manufacturing, including cleaning agents, solvents, and coatings, that can lead to environmental pollution if not properly managed. Efforts to minimize chemical usage and implement more sustainable alternatives are crucial. This topic and guidelines are detailed in "4.1 Materials Selection".

- Manufacturing processes often require substantial water usage for cooling, cleaning, and other purposes. Proper water management is essential to prevent depletion of local water resources and the release of pollutants into water bodies.

- The production of electronic devices generates significant amounts of waste, including defective products, excess materials, and by-products. Proper waste management practices, such as recycling and responsible disposal, are critical to mitigate environmental impact.

- The choice of packaging materials, such as plastics and cardboard, and the overall design of packaging contribute to resource consumption and waste generation. Sustainable packaging options and reduction initiatives are important considerations. This topic and guidelines are detailed in "4.10 Packaging".

- The transportation of raw materials, components, and finished products contributes to the carbon footprint. Optimizing transportation methods and using sustainable logistics practices help reduce environmental impact.

- While not strictly environmental, ethical considerations related to social and labor practices in manufacturing facilities are important. Ensuring fair labor conditions and respecting human rights contribute to a more sustainable overall impact.

The main generic guidelines for manufacturing of the mobile device and their components are:

- Reduce energy consumption, implementing energy-efficient technologies and practices in manufacturing processes to reduce overall energy demand. This includes upgrading machinery, optimizing production schedules, and improving energy management systems.
- Promote employee awareness and training on energy-efficient practices and encourage their involvement in energy-saving initiatives.
- Consumption of renewable energy
- Reduce water usage during manufacturing
- Avoid the use of harmful substances (This topic and guidelines are detailed in "4.1 Materials Selection").
- Reduce the amount of waste
- Optimizing transportation methods for lower carbon footprint

Following, some more specific guidelines are described.

3.6.1. Consumption of renewable energy in manufacturing

The consumption of renewable energy in the manufacturing of products is a key strategy for reducing the environmental impact of industrial processes.

Setting clear renewable energy goals is a key aspect, identifying the percentage of renewable energy to be used in manufacturing operations. It is recommended to develop a timeline for achieving these targets to guide the transition and to conduct Energy Audits to assess current energy consumption patterns and identify opportunities for integrating renewable energy sources. This analysis helps in understanding the energy needs and potential areas for improvement.

The installation of on-site renewable energy systems, such as solar panels or wind turbines, helps generate clean energy directly at manufacturing facilities, offsetting electricity consumption from conventional sources.

The contraction of Power Purchase Agreements (PPAs), Guaranties of Origin (GoO) or Renewable Energy Certificates (REC), helps to certify that electricity is coming from renewable sources. These allow companies to buy electricity directly from renewable sources, promoting the growth of renewable energy infrastructure.

Also, engaging with Green Energy Providers helps to prioritize renewable energy sources, committed to reducing their carbon footprint and supporting sustainable energy practices.

How this relates with the Eco Rating method and the Score:
- **Material Efficiency: -**
- **LCA: Device assembly stage**

3.6.2. Reduce water usage in manufacturing

Reducing water usage during manufacturing is also a critical aspect of sustainable and responsible industrial practices.

Conducting a comprehensive water audit to identify areas of high-water usage and potential inefficiencies are a good start. This analysis serves as a foundation for targeted water reduction strategies and for implementing Water-Efficient Technologies, as:

- use of high-efficiency machinery and closed-loop systems
- water recycling technologies to minimize water waste.
- Optimize cooling systems to reduce water consumption. Implement technologies like air cooling or closed-circuit cooling towers to minimize the need for continuous water replenishment.
- Implement water reuse and recycling systems to treat and reuse water within the manufacturing process. This reduces the demand for fresh water and minimizes wastewater generation.
- Modify manufacturing processes to require less water. Consider alternative methods or technologies that achieve the same results with reduced water usage.
- Implement Dry Processing Techniques where feasible. Dry processes generally require less water and can be more energy-efficient.
- Install water-saving devices, such as low-flow faucets and sensors, in restrooms and other facilities. These measures can significantly reduce water consumption in non-production areas.
- Train employees on the importance of water conservation and provide guidelines on best practices for water-efficient behaviors. Engage employees in the effort to reduce water usage.
- Fix Leaks and Address Water Loss: regularly inspect and promptly repair leaks in equipment and pipelines. Unaddressed leaks can result in substantial water wastage over time.
- Utilize rainwater harvesting systems to collect and store rainwater for non-potable uses, such as cooling processes and landscape irrigation.
- implement Smart Water Management Systems by integration of sensors and real-time monitoring to optimize water usage. These systems can identify and address inefficiencies promptly.
- Establish a continuous improvement cycle by monitoring water usage regularly and seeking ongoing opportunities to enhance efficiency. Regularly review and update water reduction goals based on performance and technological advancements.

How this relates with the Eco Rating method and the Score:
- **Material Efficiency: -**
- **LCA: -**

3.6.3. Reduce waste generation

Waste reduction helps conserve natural resources by minimizing the extraction of raw materials. This is particularly critical for non-renewable resources that are finite in supply. Also, the disposal and improper management of manufacturing waste contribute to pollution of air, water, and soil.

From the upstream point of view of materials, the production of goods from raw materials requires energy. By reducing waste, manufacturers can lower the overall energy consumption associated with the extraction, processing and transportation of materials.

Resource Circularity also helps to waste reduction with the principles of a circular economy, emphasizing the reuse, recycling, and repurposing of materials. This approach contributes to a more sustainable and regenerative economic model, as waste reduction leads to improved material efficiency, which directly translates into cost savings for manufacturers. Minimizing waste reduces the need to purchase and process excess raw materials and a proper waste management and reduction can lead to lower costs associated with waste disposal, landfill fees, and compliance with environmental regulations.

To reduce waste generation, some principles are:

- Choose materials with high recyclability, recycled content, and lower environmental impact. Work closely with suppliers to ensure the use of these materials.
- Adopt lean manufacturing principles to optimize production processes, minimize overproduction, and reduce unnecessary inventory. This helps in preventing excess waste generation. Optimizing the production planning to align with actual demand, avoiding overproduction and excess inventory that may lead to waste also helps to reduce waste and unnecessary processes and costs.
- Establish programs for the reuse and recycling of manufacturing by-products and waste materials. Explore opportunities to repurpose waste within the manufacturing process or collaborate with external partners for recycling initiatives.
- Implement closed-loop systems where possible, allowing materials to be recovered and reused within the manufacturing process. This can significantly reduce the need for virgin resources.
- Collaborate with suppliers who prioritize waste reduction and sustainability. Encourage suppliers to adopt responsible practices and provide materials in packaging that aligns with waste reduction goals.
- Minimize packaging materials by involving suppliers in the use of less and unnecessary packaging. Consider alternative packaging options and materials.
- Train employees on waste reduction practices and the importance of responsible waste management. Empower employees to identify and implement waste reduction initiatives within their areas of responsibility.
- Set ambitious zero-waste targets for manufacturing operations. Work towards the goal of sending minimal waste to landfills and actively seek alternative disposal methods, such as composting or waste-to-energy solutions.

How this relates with the Eco Rating method and the Score:

- **Material Efficiency: -**
- **LCA: -**

3.6.4. Optimize transportation methods for a lower carbon footprint

The combustion of fossil fuels in transportation vehicles releases large amounts of greenhouse gases (GHGs) into the atmosphere. The primary GHG emitted is carbon dioxide (CO2), but other pollutants like methane (CH4) and nitrous oxide (N2O) are also released.
28% of last year greenhouse gas emissions in the European Community came from transportation.

Some strategies to reduce the carbon footprint and impact from transportation:

- Combine multiple shipments into a single, larger shipment whenever possible, consolidating shipments and reducing the number of trips, optimizing transport efficiency and lowering emissions per unit of cargo.
- Prioritize the use of more energy-efficient and environmentally sustainable transportation modes, such as rail or sea freight, for long-distance shipments. These modes typically have lower carbon emissions compared to road or air transport.
- Transition to sustainable fuels, such as biodiesel, green H_2 or electric vehicles, to power transportation fleets. These alternatives can significantly reduce the carbon footprint of transportation.
- Upgrade the transportation fleet to include energy-efficient vehicles with improved fuel efficiency or electric/hybrid options. Modern technologies can significantly lower emissions compared to older, less efficient vehicles.
- Utilize route optimization software to plan the most efficient routes, minimizing distance traveled, and reducing fuel consumption. Dynamic routing can consider real-time traffic and weather conditions.
- Integrate different modes of transportation (e.g., combining trucking with rail or sea transport) to create more efficient and sustainable supply chain solutions. Intermodal transport can optimize costs and reduce emissions.
- Collaborate with other businesses or suppliers to share transportation resources. Sharing cargo space through collaborative shipping can optimize vehicle capacity and reduce the number of trips.
- Optimize last-mile delivery by using electric vehicles, bicycles, or other low-emission modes for short-distance transportation within urban areas. This reduces congestion and emissions in densely populated areas.
- Adopt just-in-time logistics practices to minimize inventory storage and reduce the need for frequent, large shipments. JIT reduces transportation-related emissions by aligning deliveries closely with production needs.
- Use telematics and Internet of Things (IoT) technologies to monitor and analyze vehicle performance, driver behavior, and fuel efficiency. Data-driven insights can lead to more informed decisions for optimizing transportation.
- Consider participating in carbon offset programs or investing in initiatives that contribute to environmental conservation or renewable energy projects to offset the unavoidable emissions. This must be the last option for carbon reduction, as “real” reduction and minimization must be first encouraged.
- Collaborate with suppliers to prioritize more sustainable transportation modes, as the ones explained above.

How this relates with the Eco Rating method and the Score:

- **Material Efficiency: -**
- **LCA: Transport stage**

3.6.5. Semiconductors and microchips manufacturing

According to statistics gathered by the Eco Rating device initiative during these years, semiconductors and microchips manufacturing have a mayor contribution to the environmental impact of raw materials and manufacturing of mobile devices, so finding ways to reduce this impact is crucial.

First of all, it is essential to understand where those emission are coming from, because their production is high energy intensive and consists, slightly simplified, of the following steps:

- Reduction of Silicon Dioxide (Quartz) to elementary Silicon at high temperature using graphite anodes (a process that also yields carbon as a reaction product).
- Purification to solar Silicon via Trichlorosilane, also at significant temperature.
- Growth of single crystals out of molten Silicon through high temperature process.
- Cutting the single crystal ingot into wafers, doping and etching the electronic structures into the wafer and then cutting the wafer into single microchips.
- Completing the microchip by making the electrical contacts and embedding it into the package.

Some of these steps are made under ultra cleanroom conditions, whose operation can be very resource demanding.

Different authors see the way to achieve the environmental impact reduction of semiconductors and microchips manufacturing mainly in 3 approaches:

- Making the involved chemical processes more energy efficient and finding other chemical processes that need less energy (lower reaction enthalpies involved).
- Replace fossil energy sources consumption by renewable energy.
- Replace fossil Carbon (Graphite) by green Hydrogen to avoid the emission of carbon as a reaction product.

This of course needs efforts in a wider supply chain but is worthwhile as progress will mean a huge leap forward in emission reduction for mobile phones.

Related to this, it is also worth to mention that there is a trend in the industry towards larger memory configurations. Given the very big impact of semiconductors, the Eco Rating initiative members are worried that this could create a rebound effect devouring or even over-compensating emission reduction achievements in other areas. The industry should do everything conceivable to avoid such a rebound effect.

How this relates with the Eco Rating method and the Score:

- **Material Efficiency: -**
- **LCA: Integrated circuits manufacturing**

3.7. Energy efficiency of the device

Electricity consumption during the device usage, can be considered as a substantial environmental hot-spot along the life cycle of this kind of product. Unlike the manufacturing stage, which occurs just one time during the device service life, energy consumption for battery charging is an aspect that will occur repeatedly throughout the lifetime of this electronic equipment.

It is well known that the constantly increasing electricity demands from society worldwide, are entailing relevant problems towards nature. Although great efforts are being made towards the renewability and decarbonization of the energy generation sector, concerns about the increase in the greenhouse gases emission, or about the fossil materials depletion, are still present. This is particularly significant considering the reliance on fossil fuels for electricity generation in many regions. There is a risk that increasing electricity demand outpaces progress made in decarbonization and energy efficiency which needs to be managed.

By enhancing energy efficiency, less energy is required to operate any device, which directly reduces the overall carbon footprint associated with the asset use. Therefore, energy efficiency in mobile phone devices plays a significant role in reducing use stage related environmental impacts. The energy efficiency related benefits are more important when talking about smartphones, as they require a higher amount of energy when compared to feature phones, designed to accomplish simpler tasks.

The main optimized power consumption measures in a mobile phone device, can be structured in three separate areas, that are detailed in the following sections. These are hardware related measures, software related measures and improvement of the charging process.

3.7.1. Hardware related energy efficiency measures

A mobile phone device can be conceived as the conjunction of several separate physical components, or hardware. These components require, in general, consuming electricity to accomplish the task they were designed for. Obviously, using more efficient hardware components, that perform their tasks consuming less power, will always be a good design option.

Hardware component manufacturers are continuously trying to improve the energy performance of the parts they made, so that the use of highly efficient hardware components, is sometimes linked to avoiding using older parts when designing the device. Benchmarking the power efficiency of the different hardware options being considered during the hardware design stage, should be a must when trying to enhance the overall energy efficiency.

Power efficiency is the ratio of the useful work performed by a system, compared to the energy consumed by it. For mobile applications, the power efficiency is a measure of how well the battery resources are being managed.

This benchmarking of hardware components is especially important when talking about the main energy consumers in a mobile phone device, which are usually related to the following items.

- Processor and System-on-Chip (SoC): The CPU (Central Processing Unit) and SoC, are major energy consumers in a smartphone. Using energy-efficient processors, shortening the electrical pathways and optimizing the CPU architecture can significantly reduce overall power consumption.

- Graphics Processing Unit (GPU): In the same way, the graphics processing unit installed in the device can also be a relevant energy consumer. The GPU is a specialized circuit designed to accelerate the image output in a frame buffer intended for output to a display. In this case, the GPU consumption is more dependent on the user profile. For example, smartphones used for gaming, may require increased energy consumption for this component, due to high quality graphics.
- Display Technology: Display technology accounts for a significant portion of a smartphone's power consumption. Using energy-efficient display technologies such as OLED (Organic Light-Emitting Diode) or AMOLED (Active Matrix Organic Light-Emitting Diode) can help reducing power consumption compared to traditional LCD displays.
- Efficient Radio Frequency (RF) Design: Optimizing the design of RF components such as antennas, can reduce power consumption during wireless communication, including cellular, Wi-Fi, and Bluetooth connections. The consumption related to connectivity is a constant among all user types and will also depend on the network types available.

Apart from choosing more efficient hardware options, building the device taking into consideration the optimal thermal requirements of the components, is also a good practice to consider. Any heat generated within the device, can be harmful because it increases the ambient temperature and can negatively affect the efficiency and service life of the different electronic parts of the device during its functioning. Note that EN 62368 standard, can be useful to know the limits of the surface temperature.

- Thermal Management: Efficient thermal management systems and cooling techniques, can prevent overheating, which can lead to increased power consumption and reduced battery life. Cooling techniques can be broadly classified into active and passive. Passive cooling using heat sinks and spreaders, is physically built using thermal conductor materials such as aluminum or copper, facilitating the heat absorption and dissipation through air. On the contrary, some examples for active cooling experiences in smartphones have already been implemented, involving the use of liquid coolant being pumped through installed pipes to reach the whole system. Note that heat transport and dissipation can be calculated using the FE method, facilitating the optimization of the heat transfer within the device.

How this relates with the Eco Rating method and the Score:

- **Material Efficiency: -**
- **LCA: Use stage**

3.7.2. Software related energy efficiency measures

Using energy efficient hardware is paramount in this kind of devices, but is not the unique option when dealing with energy efficiency. Optimizing the smartphone's operating system and applications for energy efficiency can reduce unnecessary power consumption. This includes minimizing background processes, optimizing algorithms, and implementing power-saving features through the mobile phone software.

In general terms, a prerequisite when trying to design a device enhancing its energy performance based on software related measures, will be having adequate sensors installed, identifying the real-time use conditions. In addition to sensors, well-designed energy management systems are also a must, if energy efficiency for the system wants to be achieved. Some best practices in this, line include the following measures.

- Sensors Optimization: Optimizing the usage of sensors such as accelerometers, gyroscopes, and ambient light sensors can reduce unnecessary power consumption while still providing essential functionality.
- Battery Optimization: Efficient battery management systems, including hardware and software optimizations, can extend battery life and reduce power consumption during both active and idle states. The battery management system (BMS) is an important component of a lithium-ion battery that helps to regulate the battery's voltage and temperature to ensure optimal performance and safety. The operating temperature of a lithium-ion battery is an important factor in determining its performance, because high temperatures can cause the electrolyte to break down, reducing the battery's capacity and shortening its lifespan. A high-quality BMS can help to extend the overall cycle life of the battery.
- Low-Power Modes: Implementing low-power modes, such as standby or sleep modes, can reduce power consumption when the device is not in active use.
- Applications related power management: The power consumption of the components, will also rely on the demands from the applications being used. Software developers are able to design applications requiring minimal data in order to function. The performance of the pre-installed applications is becoming increasingly important in the long run. Energy efficiency can be obtained through an operative system capable of seeking low power options (brightness adjustment, automatic network search...) depending on specific user patterns.
- Power saving information to the user: Information about best energy management options and embedded power saving applications within the device, should always be provided to the mobile phone device user via the different information channels available (user manual, vendor website, digitally in the device menu).

How this relates with the Eco Rating method and the Score:
- **Material Efficiency: -**
- **LCA: Use stage**

3.7.3. Improving of the charging process

Apart from designing a device with low power requirements, as a result of selecting the most efficient hardware options and the appropriate energy management through its software, there is still another hidden energy consumer. We are referring to the battery charging process itself.

During the battery charging process, some unavoidable electricity losses occur resulting in a lower energy efficiency for this process. Usual loses associated to this process appear associated to the battery efficiency and to the charger efficiency.

Although some devices can be charged using wireless technologies, the most common battery charging technology used nowadays is using a charger component that is connected to the device using a wire. The output power of this charger can have a different value depending on the speed of the charging process. For example, a battery charged using a low-speed USB connector directly plugged in a computer USB port, will provide a power near 5 W, while fast charging modes of the latest high-end devices could provide considerably higher power.

- High power chargers: In general terms, it has to be noted that higher power chargers tend to get higher efficiencies, so that high power chargers are usually more efficient. In any case, the energy efficiency of the charger being provided to the final user of the device, should be considered and designed aiming to higher as possible values.
- Efficient Charging: The no-load power consumption of the power adapter should also be as low as practicable, meaning that including a charger that meets the maximum no-load power requirements and the maximum charging efficiency should be encouraged. Implementing fast charging technologies that are also energy-efficient can reduce charging times while minimizing wasted energy during the charging process.
- Durable and efficient batteries: These unavoidable losses during the charging process, appear more frequently when the battery charging requirements are more acute. Lithium-ion batteries suffer from degradation as time passes, and require being charged more often when degraded. Low quality and non-durable batteries will cause higher long term electricity losses. Therefore, the use of more efficient batteries should be encouraged.
- Reducing self-discharge rate of the battery: The self-discharge rate of a lithium-ion battery refers to the rate at which the battery discharges when not in use. This rate can vary between different types of lithium-ion batteries and can have an impact on the overall cycle life of the battery. This battery parameter should be considered when addressing the energy efficiency of this system, trying to reduce the non-usable energy during the battery life cycle.

How this relates with the Eco Rating method and the Score:

- **Material Efficiency: -**
- **LCA: Use stage**

3.8. End-of-life of the device

End-of-life considerations for mobile devices are crucial because inadequate disposal of electronic waste (e-waste), can result in the release of hazardous substances into the environment. Sustainable practices involve prolonging components' life cycle, reutilization of components, refurbishing, recycling or proper disposal to minimize e-waste impact.

Once the product is discarded by the user, it is able to enter into a return flow through which all or part of its total value, can be recovered into new products. After its first life, the handset or its parts can be partially transformed into refurbished products, new parts, materials or energy, useful for other products or processes.

The main idea would be to design the whole product facilitating and encouraging that most of its inherent value could be recovered for new product systems when its life reaches an end. This can only be achieved if during the design process, the hierarchy of the most added value alternatives is taken into consideration and the most efficient alternatives are fostered from this perspective. In this guide, the most relevant activities around this subject have been divided into three areas. Second life devices, parts and components recovery and encouraging sustainable management options. One of the options could be to group components inside a hardware design already with foresight to the recycling fraction to which the parts will belong at end-of-life.

3.8.1. Second life devices

When trying to reduce the harmful affection towards nature of any kind of product, designing long life goods has always been considered as one of the strategies with higher capabilities of reducing the product's life cycle environmental impacts. In this way, designing mobile phones is not an exception. Besides, when thinking about long life mobile phones, it is frequent to address just the durability of the product, but conversely, there are also relevant second user options for these electronic devices.

Fostering the second life use of smartphones is fundamental for sustainability, as it extends the lifespan of devices, reducing the demand of new materials and minimizing electronic waste. By promoting practices like refurbishment, remanufacturing, resale, or donation, valuable resources are conserved, mitigating manufacturing related environmental impacts.

Additionally, extending the usability of smartphones enables broader access to technology, supporting digital inclusion and reducing socioeconomic disparities. Embracing second life use not only benefits the environment but also contributes to a more equitable and sustainable future for all. Some of the strategies related to promoting second life of devices, are as follows.

- Manufacturer responsibility: It is possible to take responsibility for the end-of-life management of your products, by implementing take-back programs and offering incentives, discounts, or rewards for consumers who recycle their old smartphones through designated channels. Public awareness campaigns may be launched, to inform customers about the environmental and social benefits of getting their used phones in a take-back program, to encourage responsible disposal practices. Take back schemes can be producer-specific or collaborative between various industry actors.
- Deletion of personal data: A prerequisite for allowing second users for a device is the allowance for the secure deletion of the personal information from the first user.

Personal information such as photographs, videos, passwords or personal accounts, among others, can be stored unintentionally in the device. The smartphone design shall always ease this process, effectively informing the user about how to proceed and the tools to use for a secure data transfer and deletion without compromising the functionality of the device.

- Refurbishing: Recovered devices can be reintroduced in secondary markets for used devices. One advisable practice to reach this objective, is refurbishing, in which the damaged components of the product are repaired and the components that will soon become obsolete are preventively substituted. The device is returned to its original state.
- Remanufacturing: Remanufacturing is also a practice aimed at reintroducing used devices in secondary markets, but in this case the product gets to a state of equivalent or higher quality than the original product. The product is disassembled at the component level, inspected, repaired and finally reassembled using parts recovered from the original product or new parts if necessary. It includes an upgrade phase to improve the performance of the product over the original.

How this relates with the Eco Rating method and the Score:
- **Material Efficiency: REP-03, REP-04, REC-00, REC-01, REC-02**
- **LCA: End-of-life stage**

3.8.2. Parts and components recovery

Apart from the introduction of used devices in secondary markets, parts or components of the device as a whole can also be recovered through take-back programmes. These recovered parts and components can be reused for refurbished / remanufactured products, or as spare parts. In order to be able to recover these items, the mobile phone devices should be designed having in mind the ease of disassembly and repairability for the device. Otherwise, these strategies will not be economically feasible.

- Collection programs: Establish convenient used devices collection programs, habilitating recovery channels such as drop-off locations, trade-in programs, or mail-back services for used smartphones or parts. This may avoid unused phones ending up stored at home, without the ability of recovering their value.
- Modular design: Consider device design using modular components that can be easily disassembled and/or replaced, allowing for efficient recovery of individual parts. This modular design in smartphones prolongs device lifespan, reduces e-waste, and facilitates efficient recovery of complex components. In addition, modular smartphones offer the possibility of replacing broken modules, rather than the whole phone, as well as the possibility to update, upgrade or expand the phone and its features.
- Standardized components: Design using standardized components and fasteners, to simplify dismantling processes and enable interchangeability with components from other devices.
- Design for disassembly: Incorporate features such as easily accessible screws or snap-fit connections to facilitate disassembly during the dismantling process. In general terms, refer to chapter 4.3. of this guide, where the main design for disassembly options have already been described.

How this relates with the Eco Rating method and the Score:
- **Material Efficiency: REC-00, REC-01, REC-02, DIS-01, DIS-02, DIS-03, REP-05, FAS-01, FAS-02, FAS-03, REP-06, REP-08**
- **LCA: End-of-life stage**

3.8.3. Encouraging sustainable end-of-life options

Mobile phone devices contain valuable materials such as gold, silver, copper, and rare earth elements. When these devices or their main components reach the end of their useful life, facilitating their dismantling and recycling is a crucial strategy for the environment. Recycling not only conserves these precious resources but also reduces the environmental impact of mining and manufacturing new materials. Additionally, proper recycling prevents harmful substances from leaching into the environment when devices are disposed of improperly. Therefore, promoting efficient recycling processes for mobile phones ensures sustainability, resource conservation, and minimizes electronic waste pollution.

It has to be noted that from a full circular economy perspective, this kind of strategies are meant to deal with the materials when the device as a whole or complete components cannot be recovered. Please note that recovering components or complete phones should be always prioritized as sustainability strategies over recovering just materials for recycling.

From a device designer perspective, there are several ways to facilitate that smartphones and feature phones get properly dismantled after their use, increasing the options for these valuable material flows to reach an adequate recovery treatment. Please note that this section is closely related to chapter 4.4. of this guide, where the main "design for recyclability" options have been already described.

- Material selection: Prioritize the selection of easily recyclable materials over the non-recyclable ones. Implement clear labeling and identification of materials used in the phone to assist dismantlers/recyclers in sorting and separating different components in an adequate way. Avoid the use of hazardous substances.
- Foster materials compatibility and separation: Minimize the excessive use of adhesives and bonding agents that make it difficult to separate materials during recycling. In the situations where different materials are required to be bonded, check material compatibility tables, in which the materials that are incompatible for the same recycling process can be identified and avoided.
- User education: Use the different information channels available with the customer, as for example product documentation, manufacturer website and marketing campaigns, to educate about the importance of the recyclability of smartphones and responsible disposal practices.
- Cooperation with recyclers: Partner with recycling facilities and experts, to incorporate their insights into the design process and ensure compatibility of the device design with existing recycling technologies.

How this relates with the Eco Rating method and the Score:
- **Material Efficiency: REC-03, REC-04, REC-05, REC-06, REC-07, REC-08, REC-09, REP-08**
- **LCA: End-of-life stage**

3.9. Packaging

Last but not least, packaging is also one of the chapters that should be addressed when putting a mobile phone in the market. Design does not just affect the hardware and software elements of the device itself. By contrast, packaging elements are also carefully considered when commercializing any commodity, as they will represent a huge quantity of materials put in the market worldwide in the long term.

Different kind of material families are commonly used in smartphone packaging, as for example, cardboard or paperboard for boxes and inner packaging components, paper for user manuals or information sheets, plastic films to protect or wrap delicate parts, plastic bags to contain small pieces or different plastic components used as inner reinforcements.

Main sustainability strategies around this subject, are mostly related to reducing the material intensity required for the different packaging elements, choosing the most sustainable options when deciding which materials to use and paving the way for the effective recyclability of the packaging parts.

3.9.1. Reduction of the packaging material intensity

When looking into the packaging related environmental impacts, one of the main design strategies should be associated to reducing the quantity of materials used for packaging purposes, as most of the affection towards nature, is inherently linked to the consumption of raw materials.

Therefore, opting for lightweight, eco-friendly materials and efficient packaging design, not only conserves natural resources but also mitigates climate change, fostering a more sustainable approach to consumption while preserving ecosystems and biodiversity.

Some best practices in this line are:

- Reduced size / volume of the packaging: The primary purpose of every packaging is to contain and protect the product. This condition should be fulfilled by using the smallest possible size bundle. This will minimize the use of materials and therefore, reduce the environmental impact associated with the production of the packaging. Moreover, a reduced size packaging can have a positive influence towards the fuel consumption of transport means, as freight volumes are optimized in an easier way.
- Void space minimization: Depending on how the packaging design is approached, the gaps inside the box can be more or less optimized. One way to reduce the type of materials used, is to think about and take decisions on the arrangement of the different packed elements, looking for a minimization of void and empty spaces.
- Reduce unnecessary inbox pieces: Apart from the outer packaging, the different elements included in the box are usually split inside using separators or different kind of reinforcing pieces. To evaluate specific stress requirements of the packaging and discarding or lightening packaging parts that are not necessary, is a good design option.

How this relates with the Eco Rating method and the Score:

- **Material Efficiency: PAC-02, PAC-04**
- **LCA: Packaging manufacturing**

3.9.2. Use of sustainable packaging materials

Utilizing sustainable materials for packaging reduces dependence on finite resources, minimizes pollution, and curtails the ecological footprint of production and disposal. Eco-friendly packaging options should prioritize low impact materials, materials coming from environmental stewardship programs, reduce the use of hazardous substances and chemicals, or avoid using fossil origin materials. Best available options to cope with this objective are contained in the following best practices.

- Use of materials coming from a recycled origin: Most of the materials used for packaging purposes can include post-consumer material to some extent. In the situations where the use of these materials cannot be avoided, increasing the recycled fiber content in paper/cardboard materials or the percentage of plastic coming from a recycled source should be encouraged, as this secondary source materials have much less environmental impact when compared to their virgin origin alternatives.
- Use natural origin products from sustainable stewardship programs: When using natural origin materials such as paperboard, the designer should guarantee that these are coming from a sustainable source. For example, sustainable management schemes such as FSC or PEFC for forest-based products, assess the chain of custody for these materials and certify that the source for the materials is being managed in an appropriate way.
- Avoid the use of hazardous substances: During the packaging manufacturing, some environmentally hazardous substances may be used. The impact coming from the use of this chemicals should be reduced, using cleaner alternatives as for example chlorine-free bleach for paper packaging materials. Please note that legal requirements on the content of hazardous substances may affect the packaging, depending on the target market. Complying with those legally mandatory requirements, shall always be a must.
- Using eco-friendly inks and adhesives: Additional materials required for some packaging manufacturing stages. such as adhesives or inks, that improve the envelope aspect and enhance the user perception of the product, should also be selected carefully. Vegetable-based inks or solvent free inks, with low Volatile Organic Compound (VOC) associated emissions, may be more sustainable options when compared to conventional petroleum-based alternatives. Use of water-based or other environmentally friendly adhesives, is also a good alternative that should be explored from the packaging design perspective.
- Also avoid a glossy coating of the cardboard which is usually achieved by applying a thin layer of a polymer as this burdens recycling. A natural cardboard surface is more genuine sustainable and confers this message.

How this relates with the Eco Rating method and the Score:
- **Material Efficiency: REN-04, PAC-01, PAC-04**
- **LCA: Packaging manufacturing**

3.9.3. Promote packaging recyclability

Fostering recyclability in packaging promotes a circular economy, where materials are reused and repurposed rather than discarded. It reduces waste sent to landfills, conserves resources, and minimizes energy consumption and pollution associated with production. By designing packaging with recyclable materials, we contribute to a more sustainable future, preserving natural resources and mitigating environmental impacts.

Designing an eco-friendly packaging of the product from a circular economy perspective, should have into consideration some of the following measures.

- Elimination of non-recyclable materials: The packaging should not include non-recyclable plastics or composite materials, that are not capable of being reintroduced in the market after recycling. There are plenty of recyclable options in the market, so the full recyclability of the packaging elements should be seeked.
- Facilitate separation of materials: Minimize the use of glues, inks and labels, that could hinder the recyclability potential of the packaging, as some of these materials could not be effectively separated. Identify, to the possible extent, the different materials contained in the packaging and their most advisable recycling destination. This is particularly relevant for plastics, which should carry its corresponding material pictogram.
- Avoid mixing different material types: When designing the packaging elements, the use of as least materials as possible should be promoted. Sometimes users may dispose the packaging as a whole, not separating each material to its corresponding recycling destination. Reducing the number of different materials used and trying not to mix materials that are incompatible for the same recycling process, will reduce the materials that don’t reach a proper destination.
- Using biodegradable or compostable materials: To date, it is possible to use biodegradable or compostable materials for packaging purposes. These materials have the capacity to degrade if certain conditions are met, reducing the impacts caused in situations where these packaging elements do not reach an adequate end-of-life management option. Where biodegradable or compostable materials are used, the characteristics of these materials should be clearly identified directly on them, facilitating that they reach an adequate treatment option.

How this relates with the Eco Rating method and the Score:

- **Material Efficiency: REC-06**
- **LCA: Packaging manufacturing**

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