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Revision of the European Ecolabel Criteria for Personal, Notebook and Tablet Computers

TECHNICAL REPORT
Summary of the final criteria proposals

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Abstract

Revision of the European Ecolabel Criteria for Personal, Notebook and Tablet Computers

This technical report provide the background information for the revision of the EU Ecolabel criteria for Personal and Notebook Computers. The study has been carried out by the Joint Research Centre with technical support from the Oeko-Institut. The work has been developed for the European Commission's Directorate General for the Environment. The main purpose of this report is to provide a summary of the technical background and rationale for each criterion proposal. This document is complemented and supported by the preliminary and technical background reports, which consists of a series of task reports published during 2013-2014 and addressing:

- Scope and definitions (Task 1 report),
- Market analysis (Task 2 report),
- Technical analysis (Task 3 report),
- Improvement potential (Task 4 report),
- Technical background report with criteria proposals (Task 5 report).

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1. INTRODUCTION

1.1 Background to the revision process

This document is intended to provide the background information for the revision of the Ecolabel criteria for Personal and Notebook Computers. The study has been carried out by the Joint Research Centre's Institute for Prospective Technological Studies (JRC-IPTS) with technical support from the Oeko-Institut. The work is being developed for the European Commission's Directorate General for the Environment.

The main purpose of this document is to provide a summary of the technical background and rationale for each criterion proposal. This document is complemented and supported by the preliminary and technical background reports, which consists of a series of task reports[1] addressing:

- Scope and definitions (Task 1 report),
- Market analysis (Task 2 report),
- Technical analysis (Task 3 report),
- Improvement potential (Task 4 report),
- Technical background report with criteria proposals (Task 5 report).

Furthermore, during the course of the revision process two general questionnaires on the scope and improvement potential as well as queries specific to certain criteria were sent out to selected stakeholders. The target groups were industry, Member States, NGOs and research institutions. The specific information, views and suggestions arising from questions about the scope, improvement potential and criteria revision were reflected mainly in the Task 1 and Task 4 reports and taken into consideration as far as possible in the proposals for the criteria revision.

The technical background report with criteria proposals (Task 5 report) is the document used to record the stakeholder consultation process and related follow-up

[1] The previous Task 1-5 reports and further information can be downloaded from: http://susproc.jrc.ec.europa.eu/computers/stakeholders.html

research in support of the criteria proposals. Revision of the Task 5 report has taken place according to the following timeline:

- The first draft version of the technical report (Task 5) formed the basis for the first Ad-Hoc Working Group (AHWG) meeting which took place in October 2013.
- The second revision of this technical report brought together the scientific arguments for the proposed revisions and new criteria as the basis for further stakeholder discussion at the second AHWG meeting taking place in May 2014.
- Following the AHWG2 a third revision was made, with the revised proposals having been presented to the EU Ecolabelling Board in November 2014.
- A fourth revision was made to accompany the proposed criteria that were the subject of Inter Services Consultation within the Commission during February and March 2015 before presentation of the final criteria proposal to the EU Ecolabelling Board in April 2015.
- Voting by the EU Ecolabel Regulatory Committee was delayed until adoption of Energy Star v6.1 in the EU, which took place in July 2015.
- The final criteria with amendments agreed at the April EUEB meeting were then represented for Inter Services Consultation during October 2015.

For each of the criteria summarised in this document, boxes are provided highlighting the current criteria, the final proposal and a summary rationale. A summary is also provided of the technical rationale for the proposed criterion, based on the stakeholder feedback and follow-up research carried out.

1.2 The current scope of the EU Ecolabel criteria for Desktop and Notebook computers

Currently, two separate sets of Ecolabel criteria exist for personal computers (Commission Decision 2011/337/EU) and notebook computers (Commission

Decision 2011/330/EU). They consist of fifteen and fourteen criteria for personal and notebook computers respectively which are listed in Table 1.1.

Table 1.1: Current Ecolabel criteria for Personal and Notebook Computers according to Commission Decisions 2011/337/EU and 2011/330/EU

Current EU ecolabel criteria for "Personal Computers"	Current EU ecolabel criteria for "Notebook Computers"
Criterion 1 – Energy savings	Criterion 1 – Energy savings
Criterion 2 – Power management	Criterion 2 – Power management
Criterion 3 – Internal power supplies	---
Criterion 4 – Mercury in fluorescent lamps	Criterion 3 – Mercury in fluorescent lamps
Criterion 5 – Hazardous substances and mixtures	Criterion 4 – Hazardous substances and mixtures
Criterion 6 – Substances listed in accordance with Article 59(1) of Regulation (EC) No 1907/2006	Criterion 5 – Substances listed in accordance with Article 59(1) of Regulation (EC) No 1907/2006
Criterion 7 – Plastic parts	Criterion 6 – Plastic parts
Criterion 8 – Noise	Criterion 7 – Noise
Criterion 9 – Recycled content	Criterion 8 – Recycled content
Criterion 10 – User instructions	Criterion 9 – User instructions
Criterion 11 – User reparability	Criterion 10 – User reparability
Criterion 12 – Design for disassembly	Criterion 11 – Design for disassembly
Criterion 13 – Lifetime extension	Criterion 12 – Lifetime extension
Criterion 14 – Packaging	Criterion 13 – Packaging
Criterion 15 – Information appearing on Ecolabel	Criterion 14 – Information appearing on Ecolabel

The revised Ecolabel criteria document is proposed as covering both product groups; thus common criteria proposals for both personal computers and notebook computers have been developed, with differentiation made between technical product characteristics where necessary.

Furthermore, within the parallel revision processes for EU Ecolabel criteria for televisions and computers it has been discussed[2] to remove the product subcategory "computer display" from the current scope of the Ecolabel criteria for personal

[2] There is increasingly a functionality overlap between computer displays and television sets placed on the EU market. Computer displays are being used to watch content normally only viewed on televisions and television sets are increasingly enabled for web browsing. In the current review process of the EU Ecodesign and Energy Labelling Regulations for televisions, the discussion paper (presented and discussed with stakeholders at the Consultation Forum meeting of 8 October 2012) proposed to change the scope from solely "televisions" to "electronic displays", including television sets, television monitors, and external computer displays.

computers and move it to a revised scope of Ecolabel criteria for “Electronic Displays”, subsuming television sets, television monitors and external computer displays. Thus, the following sections highlight the revised criteria proposals but exclude specific requirements for computer displays, which are considered and presented within the Technical Report and Criteria Proposals for Televisions.

1.3 The 'hot spot' environmental impacts associated with the product group

The technical analysis of LCA studies on desktop and notebook computers (cf. Task 3 report) revealed that especially for computer products with a short life time, such as notebook PCs or tablet PCs, the manufacturing phase has more significant environmental impacts compared to the use phase.

Within the manufacturing phase of desktop PCs, the motherboard and other Printed Wiring Boards of the desktop unit, the power supply, CD ROM and the hard disk drive (HDD) are mainly responsible for the environmental impacts (see Figure 1.3.1). Further, the LCD panel and PWB of the display are the main contributors at component level (see Figure 1.3.2).

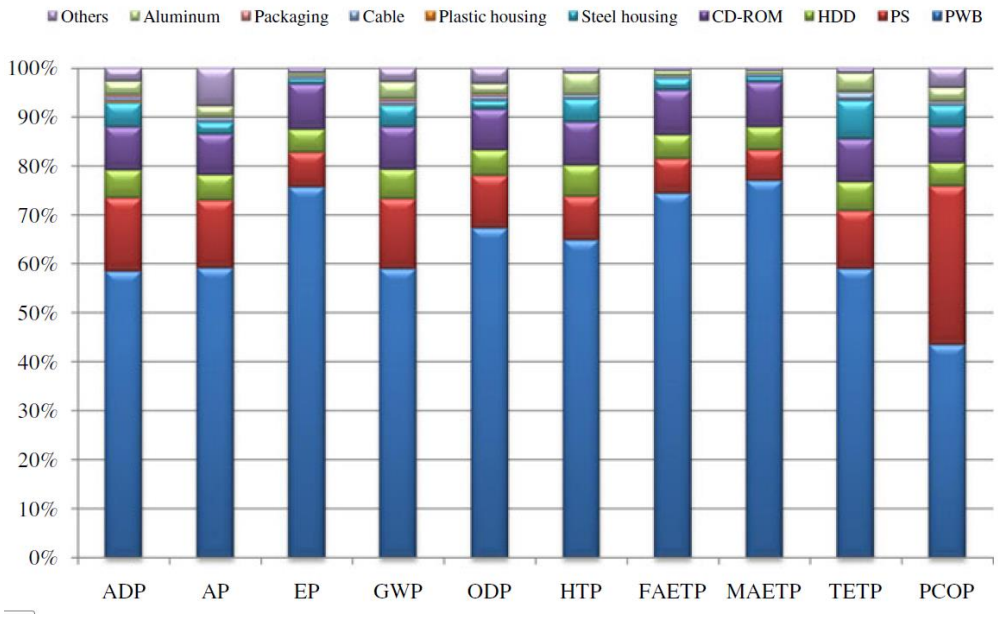

Figure 1.3.1: Desktop unit: Main contributors to environmental impacts of the manufacturing phase at component level (Source: Song et al 2013)

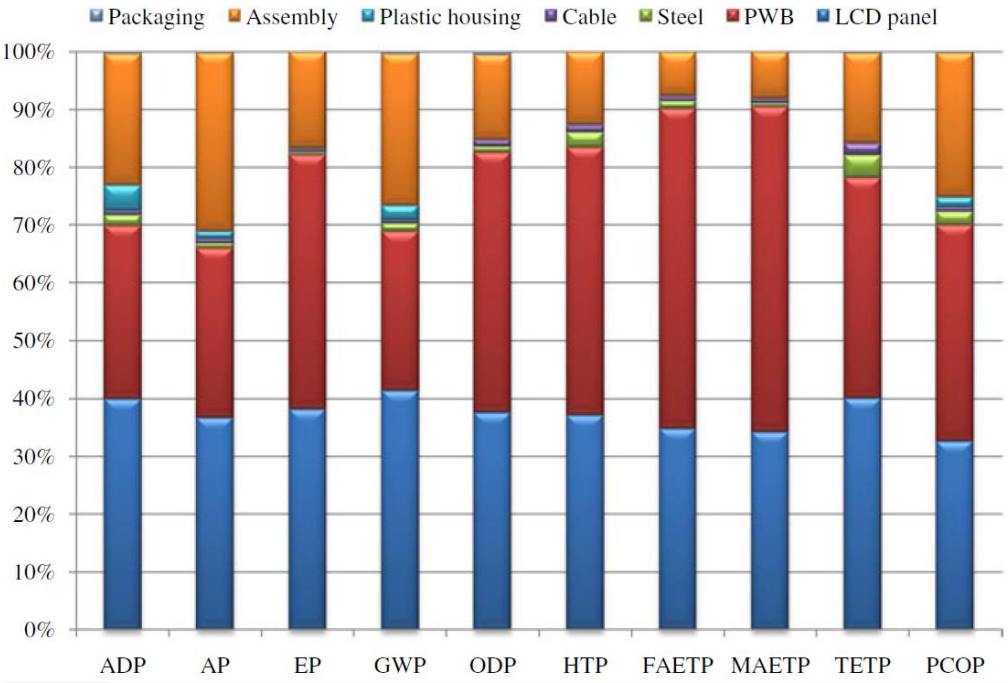

Figure 1.3.2: Display: Main contributors to environmental impacts of the manufacturing phase at component level (Source: Song et al 2013)

In relation to the manufacturing of notebooks, the production of the display and mainboard are the main contributors to environmental impacts, followed by battery production (see Table 1.2).

Table 1.2: Notebook: Main contributors to environmental impacts of the manufacturing phase at component level (Source: Ciroth & Franze 2011)

Environmental impacts	Major contributors		
	LCD display production	Mainboard production	Battery production
Climate change human health	√ (45%)	√ (23%)	Not relevant
Climate change ecosystem	√ (45%)	√ (23%)	Not relevant
Human Toxicity	√ (27%)	√ (52%)	√ (6%)
Particulate matter formation	√ (43%)	√ (27%)	Not relevant
Fossil Depletion	√ (45%)	√ (22%)	√ (3%)
Metal Depletion	√ (36%)	√ (37%)	√ (16%)

Many present debates on the environmental impacts attributable to ICT still focus strongly on the use phase of devices and infrastructures. Often insufficient attention

is given to the environmental impacts arising during the production phase. This is partly due to the poor availability of data on production processes.

ICT devices contain a great number of important metals such as gold, silver, platinum group metals, indium, tantalum, gallium etc. Most of these critical raw materials are concentrated in the following components of computers: Motherboard and other Printed Circuit Boards (silver, gold, palladium), display and background illumination (indium, gallium, etc.), and batteries (cobalt) which also correspond to the main contributing components of computers revealed from the LCA analyses as stated above. The availability and impacts relating to critical raw materials is the subject of policy analysis by the European Commission [3].

The extraction and processing of these metals is associated with major material requirements, appropriation of land and consumption of energy, and it causes severe environmental impacts. For instance, in many places around the world the mining of gold and silver incurs high ecological and social costs. Broad-scale excavation of rock, energy-intensive commination, cyanide leaching and amalgamation with mercury are just a few typical causes of the far-reaching impacts on people and the environment (Prakash et al. 2011a). Prakash and Manhart (2010) have found that the primary production of the quantities of gold, silver, palladium, copper and iron used for a single desktop PC generates emissions of around 23 kg CO_{2e}. Recovery techniques for these metals, such as the use of mercury to recover gold from electroscrap, also generate major adverse effects for people and the environment (Prakash & Manhart 2010).

The technical analysis of LCA studies (see Task 3) also revealed that the environmental impacts of the manufacturing phase of computer products can be reduced, if the end-of-life (EoL) treatment is managed more resource efficiently, since the secondary resources from recycling contribute to the avoidance of primary production. Within the EoL, sound management of toxic substances during recycling processes has been modelled to result in a ca.75% reduction of impacts.

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[3] European Commission, *Defining critical raw materials*, http://ec.europa.eu/enterprise/policies/raw-materials/critical/index_en.htm

The scope for the direct influence of ecolabel criteria on the production of single computer components appears to be rather limited. However, the impacts of the manufacturing phase can be reduced by improving design (e.g. robustness, design for disassembly) or indirectly by extending a products lifetime or by reusing parts. The following table provides an overview how the key environmental issues identified in relation to desktop and notebook computers will be addressed by the proposed areas for improvement and the ecolabel criteria proposals which will be further elaborated in the following sections of this report.

Table 1.3: Key environmental issues of desktop and notebook PCs and corresponding areas of improvement / ecolabel criteria

<table>
<tr><th>Hot spots</th><th colspan="2">Areas of improvement / ecolabel criteria</th></tr>
<tr><td colspan="3">Production phase / End-of-life phase</td></tr>
<tr><td>Motherboard</td><td>• Upgradeability of components;
• Hazardous substances
• Design for disassembly.</td><td rowspan="7">Lifetime extension
• Durability and reliability
• Expansion capability;
• User repairability;
• Service (availability of spare parts);
• Second-hand usage;
• User instructions.</td></tr>
<tr><td>Power supply</td><td>• Design for disassembly</td></tr>
<tr><td>CD ROM</td><td>• Design for durability
• Design for disassembly</td></tr>
<tr><td>Display</td><td>• Design for disassembly;
• Hazardous substances</td></tr>
<tr><td>Chassis</td><td>• Recycled content;
• Hazardous substances;
• Design for disassembly;
• Material recovery.</td></tr>
<tr><td>Battery</td><td>• Prolongation of batteries’ lifetime;
• Removeability of batteries;
• User instructions.</td></tr>
<tr><td>HDD</td><td>• Design for durability
• Design for resilience</td></tr>
<tr><td colspan="3">Use-phase</td></tr>
<tr><td></td><td>Energy requirements
• Energy efficiency;
• Power management;
• Power supplies;
• User instructions.</td><td></td></tr>
</table>

A number of issues are currently not addressed by the EU Ecolabel criteria although evidence exists for the potential environmental and / or social impacts (e.g.

fluorinated greenhouse gases, conflict-metals). Proposals to include them in the revised criteria are provided in this technical report.

1.4 The proposed framework for the revision

Table 1.4 provides a proposal for a new schematic to cluster and allocate the existing as well as possible new criteria to certain thematic fields which reflect the identified hotspots for computers:

Table 1.4: New proposed criteria cluster and allocation of sub-criteria for the revision of the Ecolabel criteria for personal and notebook computers (as of February 2015)

New proposed criteria cluster	Proposed allocation of sub-criteria
1. Energy consumption	Criterion 1a – Total energy consumption of the computer
	Criterion 1b – Power management
	Criterion 1c – Graphics capabilities
	Criterion 1d – Internal power supplies
	Criterion 1e – Enhanced performance displays
2. Hazardous substances	Criterion 2a – Restrictions on Substances of Very High Concern
	Criterion 2b - Restrictions on specific hazardous substances
	Criterion 2c - Restrictions based on CLP hazard classifications
3. Life time extension	Criterion 3a – Durability testing for portable computers
	Criterion 3b – Rechargeable battery quality and lifetime
	Criterion 3c – Data storage drive reliability and protection
	Criterion 3d – Upgradeability and repairability
4. Design, material selection and end-of-life management	Criterion 4a – Material selection and recyclability
	Criterion 4b – Design for dismantling and recycling
5. Corporate production	Criterion 5a – Sourcing of 'conflict-free' minerals
	Criterion 5b – Labour conditions during manufacturing
6. Information	Criterion 6a – User instructions
	Criterion 6b – Information appearing on the Ecolabel

The following sections and criteria proposals follow the revised schema and criteria clusters in Table 1.4. Note: The final numeration of the single criteria could change in the course of discussions with stakeholders and the final decisions on the criteria.

2. PRODUCT GROUP DEFINITION

2.1 Present scope definition

Present scope, Decisions 2011/337 and 2011/330
The product group 'personal computers' shall comprise: desktop computers, integrated desktop computers, thin clients, displays and keyboards (as a stand-alone item) as defined in Article 2. Notebook computers, small-scale servers, workstations, gaming consoles and digital picture frames shall not be considered personal computers for the purpose of this Decision.
1. The product group 'notebook computers' shall comprise devices which have the following characteristics: (a) They perform logical operations and process data and are designed specifically for portability and to be operated for extended periods of time either with or without a direct connection to an AC power source; (b) They utilise an integrated computer display and are capable of operation off an integrated battery or other portable power source. If a notebook computer is delivered with an external power supply this power supply is considered part of the notebook computer. 2. For the purpose of this Decision, tablet personal computers, which may use touch-sensitive screens along with or instead of other input devices shall be considered notebook computers. 3. Digital picture frames shall not be considered notebook computers for the purpose of this Decision.

2.2 Summary rationale for the final proposal

Summary rationale for the final proposal *(with reference to the draft Act)*
The revised criteria set streamlines the product group by bringing together the formerly separate product groups of personal computers and notebook computers. This combination also reflects the approach taken in Regulation (EU) No 617/2013 on ecodesign requirements for computers and computer servers and in the eligiibility criteria for Energy Star v.6.0/6.1. Moreover, it is proposed to reflect the rapid market growth and visibility to consumers of tablet computers. The new title for the product group is therefore proposed to be expanded to 'Personal, notebook and tablet' computers. Computer displays have been brought together with Televisions in order to create the Display product group, reflecting the increasing commonalities between the two products and the approach taken in the proposed new Ecodesign Regulation for Displays. The scope has been expanded to reflect the full range of computer products covered

by the Ecodesign Regulation and Energy Star 6.0/6.1, with the addition of associated definitions from Energy Star v.6.0/6.1for tablets, portable all-in-one computers, two-in-one computers, portable thin clients, small scale servers and workstations. This will expand the potential number of products that could achieve the ecolabel whilst maintaining allowing for ease of alignment with Energy Star performance.

'Subnotebooks' (also known as Ultrabooks ™) have additionally been defined based mainly on the Intel Corporation's Ultrabook™ definition. This definition complements a new sub-criterion addressing the design for repair and dismantling issues that this relatively new computer form factor raises.

3. PROPOSED CRITERIA REVISIONS

3.1 Cluster 1 – Energy Consumption

3.1.1 Criterion 1(a) and (d) – Total energy consumption of the computer

Present criteria, Decisions 2011/337 and 2011/330
(a) Energy savings for desktop computers, integrated desktop computers and thin clients The energy efficiency performance of desktop and integrated desktop computers shall exceed the appropriate category energy efficiency requirements set out in the Agreement as amended by Energy Star v5.0 by at least the following: - category A: 40 %, - category B: 25 %, - category C: 25 %, - category D: 30 %. The energy efficiency performance of thin clients shall meet at least the energy efficiency requirements for thin clients set out by Energy Star v5.0. Capability adjustments allowed under the Agreement as amended by Energy Star v5.0 may be applied at the same level, except in the case of discrete graphics processing units (GPUs) where no additional allowance shall be given. *(b) Energy savings for computer displays* The computer display's energy efficiency performance in active mode shall exceed the energy efficiency requirements set out in Energy Star v5.0 by at least 30%; computer display sleep mode power must not exceed 1 W; computer displays shall have an energy consumption in on-mode of ≤ 100 W measured when set to maximum brightness; computer monitor off mode power shall not exceed 0.5 W. *Assessment and verification*: The applicant shall declare compliance of the product with these requirements to the competent body.
Energy savings for notebook computers The energy efficiency performance of notebook computers shall exceed the appropriate category energy efficiency requirements set out in the Agreement as amended by Energy Star v5.0 by at least: category A: 25%; category B: 25%; category C: 15%. Capability adjustments allowed under the Agreement as amended by Energy Star v5.0 may be applied at the same level, except in the case of discrete graphics processing units (GPUs) where no additional allowance shall be given. *Assessment and verification*: The applicant shall declare compliance of the product with these requirements to the competent body.

3.1.1.1 Summary of the environmental significance of energy consumption

Desktop PCs

- Within the entire life cycle phases, manufacturing and use phase have a larger impact on the environment. The share of these two phases can vary due to

product lifespan, electricity grid mixes and power consumption, which determine the environmental impacts in the use phase.

- Further studies based only on the investigation of Global Warming Potential (GWP) gave the result that the use phase dominates the GWP.

Notebook PCs

- The detailed LCA studies as well as most of the further analysed studies show that the production of a notebook PC clearly dominates the environmental impacts in comparison to the use phase.

Tablet PCs

- For tablet PCs the greatest proportion of GWP emissions arises in the production phase with 67%, followed by the use phase with 25%. Compared to notebooks, the manufacturing phase may be more relevant due to the short lifetime and the lower power consumption of tablets.

Workstations, servers and thin clients

- To date, there are few robust science-based LCA studies due to the recent emergence of some of these products. Some further, less comprehensive and non LCA studies revealed, however, the following:
- For servers and workstations, the use phase dominates the total results with regard to Greenhouse Gas (GHG) emissions.
- For thin clients, the differentiation of the life cycle phases regarding their environmental impacts are similar to that of a desktop PC with the use phase dominating the GWP of the entire life cycle, but being more than two times lower than the GWP of a desktop PC.

3.1.1.2 Technical background to the proposal

Alignment of the main requirement with Energy Star v6.1

Energy Star requirements are intended to reflect the most efficient 20-25% of computer models on the market. The v6.0 revision of Energy Star came into effect in the USA from the 2nd June 2014. This revision was to have been adopted in the EU but it was decided instead to adopt v6.1, which includes some updates to the scope which are of significance to the ecolabel.

Following approval by the EU Energy Star Board v6.1 was finally adopted on the 15th July 2015, with publication as a Decision of the European Commission [4]. Moving to v6.1 is of benefit to the ecolabel because its scope includes tablets, hybrid notebooks and, a new product form factor to have emerged, portable all-in-one computers.

Comparing the Base Allowances for the Typical Energy Consumption (TEC_{BASE}) of Desktop and Notebook computers within the current and upcoming Energy Star and Ecodesign versions (cf. Figure 3.1.1 and Figure 3.1.2), it can be seen that Energy Star version 6.0 currently has the lowest base allowances in all product sub-categories[5]. So from today's point of view, basing the energy criteria for the EU Ecolabel on Energy Star version 6.0 seems appropriate and goes beyond legally binding Ecodesign requirements starting from 2016.

[4] Commission Decision (EU) 2015/1402 of 15 July 2015 determining the European Union position with regard to a decision of the management entities under the Agreement between the Government of the United States of America and the European Union on the coordination of energy-efficiency labelling programmes for office equipment on the revision of specifications for computers included in Annex C to the Agreement (OJ L 214, 18.8.2015, p.9)

[5] Please note that Energy Star Versions 6.0/6.1 introduces new definitions of sub-categories, thus the products subsumed are not directly comparable. Nevertheless, the maximum TEC allowances provide an indicative comparison.

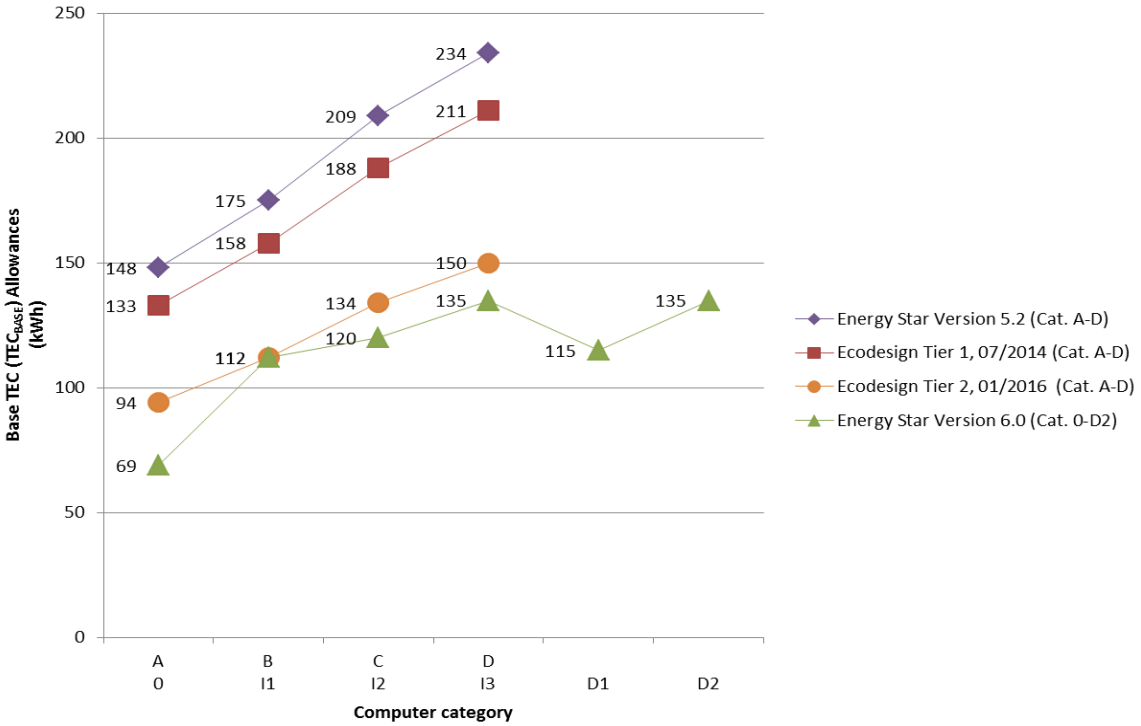

Figure 3.1.1:

Comparison of TEC_{BASE} Allowances of Energy Star versions 5.2 and 6.0 with Ecodesign Tier 1 and Tier 2 for Desktop and Integrated Desktop Computers

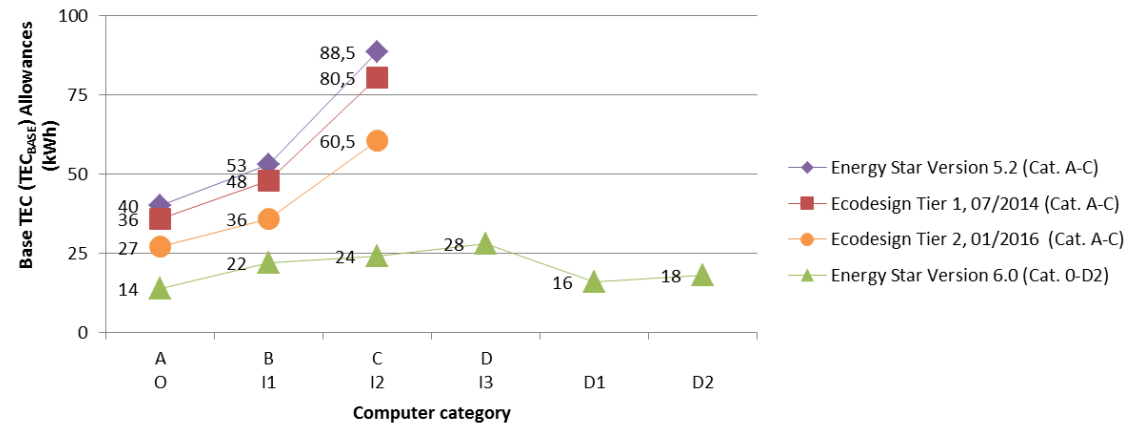

Figure 3.1.2: Comparison of TEC_{BASE} Allowances of Energy Star versions 5.2 and 6.0 with Ecodesign Tier 1 and Tier 2 for Notebook Computers

Future proofing the Ecolabel criterion

The Energy Star v6.0 criteria were devised based on a database of models compiled in 2011/12 so it is inevitable that there may have been changes in performance in the market since the final version of the v6.0 proposals was published in September 2013.

In order to future proof the ecolabel criteria it is possible to address significant or growing proportions of a computers' energy demand in the $E_{TEC\text{-}MAX}$ calculations for which there exists analysis or market evidence for the improvement potential. Reviewing the formulae and allowances, as well as the example calculations provided by the US EPA in the Energy Star documentation [6], it can be seen that the most significant influences on the $E_{TEC\text{-}MAX}$ threshold are:

- Graphics capability, with discrete graphics units being able to qualify for a $TEC_{GRAPHICS}$ allowance that may be greater than the TEC_{BASE} allowance;
- Enhanced Performance Displays, which qualify for the $TEC_{INT\_DISPLAY}$ allowance which, depending on screen size and resolution, can be at least 30-75% greater.

Moreover, a US market survey for Energy Star v5.0 showed that the manufacturers quickly respond to new Energy Star revisions [7]. This suggests that, following the precedent set by the EU Ecolabel criteria for Imaging equipment, and recognising that the criteria must refer to an Energy Star version, a review of market penetration should be proposed after a minimum of two years.

Restricting the energy use associated with graphics capabilities

Graphics capabilities are the most significant influence within the overall E_{TEC_MAX} calculation that sets the qualifying energy benchmark for each computer. The TEC_{BASE} allowance may be between 57% and 96% higher for desktops and integrated desktops and between 14% and 100% higher for notebooks. A further

[6] US Energy Star, *Energy Star programme requirements for computers – partner commitments*, Eligibility Criteria – Version 6.1, 12th August 2014.
[7] US Energy Star, *Energy Star Unit Shipment and Market Penetration Report Calendar Year 2011 Summary*

$TEC_{GRAPHICS}$ allowance for *discrete graphics processing units* (categories D1 and D2) may then provide a further uplift of between 52% and 188% for desktops and integrated desktop and between 100% and 429% for notebooks.

Discrete graphics are used for high performance professional and consumer applications (HD video, video gaming, 3D etc.) providing better picture quality and speed compared to integrated graphics, where the GPU is attached to or integrated into the computer's motherboard sharing resources with the central processing unit and system memory. Those are typically less powerful and slower, being sufficient for basic office applications, web browsing etc.

Analysis of the US Energy Star database (January 2015) indicates that 261 notebook models currently qualify in the discrete graphics D1 and D2 category, equating to 19% of models. In contrast only 10 notebook models currently qualify in the D1 and D2 category, equating to 0.4% of models.

A study carried out in 2012 by CLASP and NRDC in the USA looked at the impact of discrete graphics cards on desktop energy consumption [8]. Tests were carried out in order to compare the additional energy consumption of graphics cards, although there is not understood to be a standard methodology for testing and disaggregating this consumption. The study suggested that for high end (G6 and G7 capabilities) energy consumption related to the unit can vary considerably and does not always increase in function of the capability. An indicative level of performance improvement is reflected in NRDC/CLASP's recommendations for the 10^{th} and 20^{th} percentile of the market in Table 3.1, which are notable for the lower G6 and G7 allowances.

Moreover, mainstream manufacturers such as AMD and NVIDIA are bringing forward units that demonstrate a significant improvement in performance over the Energy Star v6.1 allowances. This is supported by manufacturer claims, which focus on reducing idle power consumption, for example by powering down the GPU in long idle mode [9]. Feedback from computer manufacturers has, however, highlighted that it is not possible or desirable to accurately verify the performance of an individual

[8] CLASP and NRDC, *The impact of graphics cards on desktop computer energy consumption*, September 2012.
[9] AMD, *ZeroCore Power technology*, http://www.amd.com/en-us/innovations/software-technologies/enduro

graphics card. This is because additional energy use is not just associated with the card but at an overall computer system level e.g. CPU, motherboard, memory.

Table 3.1. CLASP/NRDC recommended Energy Star v6.0 target adder levels for desktops

dGfx category (Gigabytes/second) [1]	TEC Allowance (kWh/year)	
	20th percentile	10th percentile
G1 (≤16)	32	30
G2 (16<FB_BW≤32)	40	37
G3 (32<FB_BW≤64)	51	47
G4 (64<FB_BW≤96)	67	62
G5 (96<FB_BW≤128)	82	76
G6 (FB_BW>128) with data width <192 bit)	82	76
G7 (FB_BW>128) with data width ≥192 bit)	97	90
Notes: 1. Categories are defined according to the frame buffer bandwidth in gigabytes per second (GB/s)		

An analysis of the improvement potential from applying the 10th percentile dGfx allowances recommended by CLASP/NRDC is presented in Table 3.2. The improvement potential has been calculated and compared for Energy Star v6.1 category D1 and D2 computers and Ecodesign category C and D on the basis of comparative TEC specifications.

Table 3.2 Indicative TEC improvement potential of the proposed EU Ecolabel dGfx graphics allowances over Energy Star v6.1 and Ecodesign Tier 2

Category D1 Desktop TEC_{MAX} improvement [1]					
Graphics category	**Energy Star 6.1 TEC_{MAX} (kWh)**	**EU Ecolabel TEC_{MAX} (kWh)**	**% improvement**	**Ecodesign category C E_{TEC} (kWh)**	**% improvement**
G1	179.5	173.5	***3.3%***	179	*3.1%*
G2	194.5	180.5	***7.2%***	191	*5.5%*

G3	207.5	190.5	***8.2%***	199	*4.3%*
G4	226.5	205.5	***9.3%***	215	*4.4%*
G5	248.5	219.5	***11.7%***	233	*5.8%*
G6	258.5	219.5	***15.1%***	251	*12.6%*
G7	273.5	233.5	***14.6%***	283	*17.5%*
Notes: *1. Base case used: 2 GB memory, 1 ethernet port, 1 HDD, no EPS allowance*					
Category D2 Desktop TEC_{MAX} improvement [1]					
Graphics category	**Energy Star 6.1 TEC_{MAX} (kWh)**	**EU Ecolabel TEC_{MAX} (kWh)**	**% improvement**	**Ecodesign category C E_{TEC} (kWh)**	**% improvement**
G1	201	195	***3.0%***	197	*1.0%*
G2	216	202	***6.5%***	209	*3.3%*
G3	229	212	***7.4%***	217	*2.3%*
G4	248	227	***8.5%***	233	*2.5%*
G5	270	241	***10.7%***	251	*4.0%*
G6	280	241	***13.9%***	269	*10.4%*
G7	295	255	***13.6%***	301	*15.3%*
Notes: *1. Base case used: 4 GB memory, 1 ethernet port, 1 HDD, no EPS allowance*					

Although of overall less significance in the market, reference dGfx values for the potential improvement for notebook computers can be found in the revisions of the Energy Star v6.0 proposals. The US EPA's Draft 2 proposals from November 2012 [10] contained stricter dGfx proposals which, following adjustment of the base allowances in Draft 3 to be stricter, were then adjusted upwards to ensure enough models with high end graphics capabilities still complied.

[10] US Energy Star, *Energy Star Computers Draft 2 Version 6.0 - May 15, 2012* http://www.energystar.gov/products/spec/computer_specification_version_6_0_pd

3.1.1.3 Final proposal for energy consumption criteria 1(a) and 1(c)

Proposed revised criteria (final proposal)

1(a) Total energy consumption of the computer

The total energy consumption of the computer shall meet the appropriate energy-efficiency requirements set out in Regulation (EC) No 106/2008 and the EU as amended by Energy Star v6.1.

Capability adjustments specified under the Agreement as amended by Energy Star v6.1 may be applied at the same level, with the exception of:

- Discrete Graphics Processing Units (GPUs): See sub-criterion 1(c);
- Internal power supplies: See sub-criterion 1(d)

A specific additional requirement shall apply to enhanced-performance integrated displays, which can be found in sub-criterion 1(e).

Assessment and verification: The applicant shall submit a test report for the computer model carried out according to the Energy Star v6.1 test methods for computers. Energy Star v6.1 registrations in the USA shall be accepted provided that testing according to European input power requirements has been carried out.

1(c) Graphics capabilities

The Functional Adder $TEC_{graphics}$ allowances for discrete graphics cards (dGfx) in desktop, integrated desktop and notebook computers in Table 1 shall apply in place of those in the Energy Star v6.1 eligibility criteria. dGfx shall have power management that shuts down the Graphics Processor (GPU) in the long idle state.

Table 3.3. Functional Adder allowances for discrete graphics cards (dGfx) in desktop, and integrated desktop and notebook computers

dGfx category (Gigabytes/second) [1]	**TEC Allowance (kWh/year)**	
	Desktop and integrated desktops	**Notebooks**
G1 (FB_BW ≤16)	30	9
G2 (16<FB_BW ≤ 32)	37	12
G3 (32<FB_BW ≤ 64)	47	20
G4 (64<FB_BW ≤ 96)	62	25
G5 (96<FB_BW ≤ 128)	76	38
G6 (FB_BW >128 with data width < 192 bits)	76	38
G7 (FB_BW >128 with data width ≥ 192 bits)	90	48
*Notes:*1. Categories are defined according to the frame buffer bandwidth in gigabytes per second (GB/s).		

Assessment and verification: The applicant shall declare Energy Star v6.1 compliance based on the stricter allowances and provide the supporting E_{TEC_MAX} calculation and performance data from the model's test report.

3.1.1.4 Summary rationale for criteria proposals 1(a) and (c)

Summary rationale for the final proposal
The revised criterion establishes a dynamic link with the energy efficiency criteria of Energy Star v6.1 for Computers. The proposal is, however, stricter than v6.1 as it sets specific performance requirements for the most significant energy using components of a desktop computers, which are the most energy intensive form factor. Broad alignment with Energy Star has the benefit of reflecting the best 20-25% products on the market and aligning with an EU labelling scheme with a high level of take-up by the industry. Moreover, the assessment and verification is carried out by Energy Star, reducing the burden for Competent Bodies. Energy Star v6.1 has now been adopted in the EU. It also has the benefit of introducing definitions and criteria for tablet, two-in-one and portable all-in-one computer form factors. Evidence does however suggest that the market penetration of Energy Star products can increase rapidly following adoption of new criteria. The Ecodesign Regulation for Computers is also stricter in some areas than Energy Star v6.1. Recognising that market and technology can adapt quickly stricter sub-criteria have therefore been set for the components that make the most significant contribution to computer energy use – namely graphics cards, power supply units and enhanced displays. Graphics card allowances have been established for desktops and notebook computers that are stricter than Energy Star v6.1. The allowances require greater proportional improvement potential the greater the GPU graphics capability installed. At the high end the improvement potential is estimated to be up to 15% An additional requirement for GPUs to power down in the long idle state has the potential to increase this further up to, indicatively, 20%. As verification is not possible at a component level, applicants must instead be requested to demonstrate use of the stricter allowances in the E_{TEC_MAX} calculation.

3.1.2 Criterion 1(b) – Power management

Present criteria, Decisions 2011/337 and 2011/330
The computer shall comply with the following power management requirements ([1]): (a) Power management requirements Personal computers shall be shipped with the power management system enabled at the time of delivery to the customers. Power management settings shall be: (i) 10 minutes to screen off (display sleep); (ii) 30 minutes to computer sleep (system level S3, suspended to RAM) ([2]). (b) Network requirements for power management (i) Personal computers with Ethernet capability shall have the ability to enable and disable wake on LAN (WOL) for sleep mode. (c) Network requirements for power management (applies to personal computers shipped through enterprise channels only) (i) Personal computers with Ethernet capability must meet one of the following requirements ([3]): — be shipped with WOL enabled from the sleep mode when operating on AC power, or — provide control to enable WOL that is sufficiently accessible from both the client operating system user interface and over the network if computer is shipped to enterprise without WOL enabled. (ii) Personal computers with Ethernet capability shall be capable of both remote (via network) and scheduled wake events from sleep mode (e.g. real time clock). Manufacturers shall ensure, where the manufacturer has control (i.e. configured through hardware settings rather than software settings), that these settings can be managed centrally, as the client wishes, with tools provided by the manufacturer. *Assessment and verification*: The applicant shall provide the competent body with a declaration to certify that the computer has been shipped in the power management settings stated above or better. ([1]) As defined in Energy Star v5.0 except for display sleep requirement. ([2]) Not applicable to Thin Clients. ([3]) Thin clients — only applies if software updates from the centrally managed network are conducted while the unit is in sleep or off mode. Thin clients whose standard framework for upgrading client software does not require off-hours scheduling are exempt from the requirement.
Notebook computers shall comply with power management requirements ([1]) as follows: (a) Power management requirements Notebook computers shall be shipped with the power management system enabled at the time of delivery to the customers. Power management settings shall be: (i) 10 minutes to screen off (display sleep); (ii) 30 minutes to computer sleep (system level S3, suspended to RAM). (b) Network requirements for power management (i) Notebook computers with Ethernet capability shall have the ability to enable and disable Wake on LAN (WOL) for sleep mode. (c) Network requirements for power management (applies to notebook computers shipped through enterprise channels only) (i) Notebook computers with Ethernet capability shall meet one of the following requirements: — be shipped with Wake On LAN enabled from the sleep mode when operating on AC power, or — provide control to enable WOL that is sufficiently-accessible from both the client operating system user interface and over the network if notebook computer is shipped to enterprise without WOL enabled.

Present criteria, Decisions 2011/337 and 2011/330
(ii) Notebook computers with Ethernet capability shall be capable of both remote (via network) and scheduled wake events from Sleep mode (e.g. Real Time Clock). Manufacturers shall ensure, where the manufacturer has control (i.e. configured through hardware settings rather than software settings), that these settings can be managed centrally, as the client wishes, with tools provided by the manufacturer. *Assessment and verification*: the applicant shall provide the competent body with a declaration to certify that the computer has been shipped in the power management settings stated above or better. ([1]) As defined in Energy Star v5.0 except for display sleep requirement.

3.1.2.1 Technical background to the proposal

The criteria for power management were proposed to be aligned to the forthcoming new Energy Star program requirements for computers, version 6.1, which incorporate the previous EU Ecolabel requirements. The initial proposal was for a stricter time to display sleep mode but stakeholders questioned what the benefit would be of moving from shipping a product with 10 minutes instead of 15 minutes to sleep mode.

However, it was highlighted that the Ecodesign Regulation 617/2013 for computers and computer servers legally requires from 1 July 2014 that "*the computer shall be placed on the market with the display sleep mode set to activate within 10 minutes of user inactivity"*.

To supplement the strict combination of Energy Star v6.1 and the legal requirements of Ecodesign it was proposed instead to include a criterion requiring that the user is informed if they attempt to disable a power management function. This would reflect the pre-installed power management software currently provided by OEMs such as Toshiba.

3.1.2.2 Final proposal for 1(b) power management criteria

Proposed revised criteria (final proposal)
1(b) Power management Whenever the user or a software attempts to deactivate the default power management settings, a warning message shall be displayed communicating to the user that an energy saving setting will be disabled and giving the option to retain the setting. ***Assessment and verification:*** The applicant shall provide the description of the power management settings that appears in the model's user manual, accompanied by screen shots of examples when

warning messages are displayed.

3.1.2.3 Summary rational for the final proposal

Summary rationale for the final proposal
With the incorporation of strict power management criteria into Energy Star v6.1 and the Ecodesign Regulation for Computers diminishing returns can be obtained from further measures. A proposal to address the user interaction with power management software has instead been accepted. This will ensure that users of ecolabel products are prompted to maintain default power management settings.

3.1.3 Criterion 1(c) – Internal power supplies

Present criteria, Decisions 2011/337 and 2011/330
Internal power supplies shall meet at least the energy efficiency requirements for internal power supplies set out by Energy Star v5.0. *Assessment and verification*: The applicant shall declare the compliance of the product with these requirements to the competent body.

3.1.3.1 Technical background to the proposal

Energy Star generally follows the TEC approach, calculating the maximum total energy consumption (TEC) including all specific allowances for different components, inter alia internal power supply units. This means that when requiring stricter energy efficiency for the internal PSU, on the other hand higher specific allowances for PSU apply (see Table 3.4).

Table 3.4: Power supply efficiency allowances (Source: Energy Star v6.1)

Computer type	**Minimum efficiency at specified proportion of rated output current**				**Allowance$_{PSU}$**
	10%	**20%**	**50%**	**100%**	
Desktop	0.81	0.85	0.88	0.85	0.015
	0.84	0.87	0.90	0.87	0.03
Integrated Desktop	0.81	0.85	0.88	0.85	0.015
	0.84	0.87	0.90	0.87	0.04

Cross-check of Energy Star, Ecodesign and 80Plus requirements

In discussions with stakeholders the importance of Ecodesign minimum requirements and the independent labelling scheme for power supplies, 80Plus, were highlighted and a comparison of the performance requirements requested. In terms of selectivity, analysis in the Task 4 background report highlighted that 80Plus certified internal power supply units are readily available at bronze, silver and gold levels.

A comparison of these requirements with the independent labelling scheme 80Plus is provided, as requested by stakeholders, in Table 3.5. Ecodesign provides a 1% improvement on 80Plus Bronze at 20% and 100%. The lower requirement in Energy Star v6.1 is comparable with Silver and the higher requirement is intermediate to Silver and Gold. However, when the overall benefit of the Energy Star requirement is adjusted to reflect the TEC_{PSU} allowance received it can be seen that the improvement potential when compared with Ecodesign is reduced.

Table 3.5: Comparison of desktop internal power supply efficiency requirements for 80Plus, Energy Star v6.1 and the Ecodesign Regulation

Minimum efficiency at:	230 V Input power			
	Power factor (100% rated output)	**20 % of rated output**	**50 % of rated output**	**100 % of rated output**
80plus bronze	-	81 %	85 %	81 %
80plus silver	-	85 %	89 %	85 %
80plus gold	-	88 %	92 %	88 %
80plus platinum	-	90 %	94 %	91 %
80plus titanium	90 %	94 %	96 %	91 %
Energy Star v6.1	-			
(i) Minimum efficiency		85-87 %	88-90%	85-87%
(ii) Adjusted for allowance		83.5-85.5%	86.5-88.5%	83.5%-85.5%
Ecodesign computers	90 %	82 %	85 %	82 %

Early discussions with stakeholders highlighted some concerns about consumer's willingness to pay for a more efficient power supply. Information on the cost difference between an 80+ bronze PSU compared to PSU with silver and gold standard was provided. For example, for a 300W power supply unit, changing from 80+ bronze to the 80+ silver standard would double the cost for consumers from around 5 to around 10 US Dollars. This data is summarised in Table 3.6.

Table 3.6 : Approximate pricing of Power Supply Units with different 80+ standards as of July 2013 (Source: Stakeholder input)

Efficiency Baseline APFC 68% Efficient	300 Watts Cost OEM/Consumer	460 Watts Cost OEM/Consumer	270 Watts Cost OEM/Consumer
80+ Bronze	$3.45/$5.18	$2.65/$3.98	$3.25/$4.88
80+ Silver	$6.90/$10.35	$8.22/$12.33	$6.00/$9.00
80+ Gold	$8.10/$12.15	$10.95/$16.43	$7.95/$11.93
80+ Platinum	$11.25/$16.88	$14.35/$21.53	$11.45/$17.18

It is important to note, however, that neither Energy Star nor Ecodesign account fully for energy in a desktop computers active (working) mode, as illustrated in Figure 3.1.3, because this cannot be predicted. A more efficient power supply would therefore also ensure that energy and cost savings are made in the active mode.

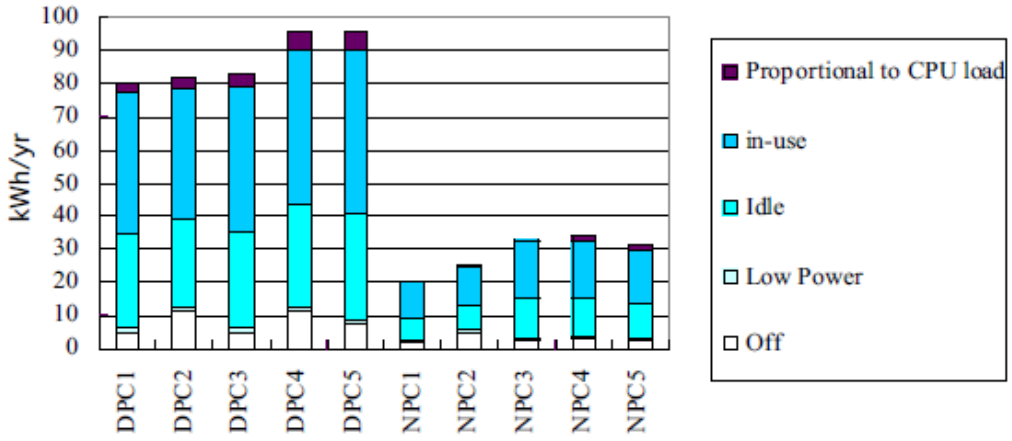

Figure 3.1.3

. Illustrative annual energy use for desktop computers in an office

Source: Kawamoto,K et al (2005)

3.1.3.2 Final proposal for 1(d) internal power supplies

Proposed revised criteria (final proposal)
1(d) Internal Power Supplies Internal power supplies in desktop and integrated desktop computers shall meet the requirements for the TEC_{PSU} allowances of Energy Star v6.1 and shall achieve minimum efficiencies as a proportion of the rated output current of 0.84 at 10%, 0.87 at 20%, 0.90 at 50% and 0.87 at 100%. ***Assessment and verification:*** The applicant shall declare compliance of the model's internal power supply supported by the products Energy Star v6.1 E_{TEC_MAX} calculation and either performance data from the model's test report or independent power supply performance certifications.

3.1.3.3 Summary rationale for the final proposal

Summary rationale for the final proposal
The efficiency of a power supply influences energy use in all modes of computer operation, including the active (working) mode which is not addressed by Ecodesign or Energy Star. The minimum requirement within Energy Star v6.1 reflects the legal minimum performance in the Ecodesign Regulation for Computers. The optional power supply allowance within Energy Star v6.1 reflects the Silver performance of the 80Plus labelling scheme, but the performance improvement is offset to some extent by the gain from the TEC_{PSU} energy allowance. The sub-criterion therefore requires take-up of the power supply allowance at the highest level of efficiency in the eligibility criteria, for which there is evidence of the market availability of PSU to meet the specification. Verification is, at a basic level, based on demonstration of the use of the stricter allowances in the E_{TEC_MAX} calculation, supported by the option to provide certification of the performance of the power supply from a scheme such as 80Plus.

3.1.4 Criterion 1(e) – (New proposal) Enhanced performance displays

3.1.4.1 Technical background to the proposal

Closer analysis of the E_{TEC_MAX} allowances reveals that an additional allowance can be obtained for 'enhanced performance' integrated displays. Enhanced performance displays are defined by Energy Star v6.1 as follows:

Enhanced-performance Integrated Display: An integrated Computer Display that has all of the following features and functionalities:

(1) A contrast ratio of at least 60:1 at a horizontal viewing angle of at least 85°, with or without a screen cover glass;

(2) A native resolution greater than or equal to 2.3 megapixels (MP); and

(3) A color gamut of at least sRGB as defined by IEC 61966-2-1. Shifts in color space are allowable as long as 99% or more of defined sRGB colors are supported.

With the trend towards higher resolution screens such as Apple's Mac Book Pro models which incorporate 'Retina' displays and Samsung's Galaxy tablet models incorporating AMOLED screen technology there could be an implication for the number of computer models receiving an additional allowance for display energy use.

Taking the Retina technology as an example the potential increase in the $TEC_{INT\_DISPLAY}$ allowance can be illustrated. The technology integrates more pixels in a 15 inch screen than in a 60 inch diameter High Definition television screen [11]. The resulting specification is 2880 by 1800 megapixels. Using a Toshiba Satelite C series (15.6 screen, 1920 by 768 pixels) and an Asus N Series (15.6 screen, 1920 by 1080 pixels) as benchmarks for comparison the increase in the (estimated) energy consumption within the E_{TEC_MAX} equation would be 60-70%.

Automatic Brightness Control as an improvement measure

Automatic Brightness Control (ABC) is a feature installed in televisions and which is now becoming more common as an energy saving measure in notebooks. An Ambient Light Sensor (ALS) is installed which dims the screen backlight in function of the ambient light. If calibrated correctly this could have the potential for up to 30% savings in energy use for an LED display [12]. A paper by manufacturer AMS highlights the importance of ensuring that the ALS is sensitive enough to distinguish

[11] Apple, *MacBook Pro*, https://www.apple.com/macbook-pro/features-retina/

[12] Enenkel,J, *Automatic mobile display backlight control: techniques to improve user experience*, AMS technical article.

between, for example, office working conditions and dimly lit conditions in a home, but not so much that the transitions are noticeable or cause irritation to the user [13].

Validation of ABC according to the routine in the Energy Star v6.0 requirements for televisions is cited by AMS as being sufficient to ensure a minimum practical improvement. This is because the validation routine tests power useage at 50 lux ambient light in addition to 10, 100 and 300 lux [14]. The addition of 50 lux reflects user surveys which suggested that 50 lux was a common background light level. It cannot, however, at this stage be inferred whether this assumption can also be applied to computers or, in fact, whether the ratio between 100 lux and the higher lux level of >300-500 for office lighting is of greater importance.

Expert commentary also suggests that the best solution would be to allow users to set the brightness levels according to their own judgement and preference [15]. The facility for users to adjust the brightness gradient of an ABC system is not currently provided in products by leading manufacturers.

3.1.4.2 Final proposal for 1(e) enhanced performance display criteria

Proposed revised criteria (final proposal)
1(e) Enhanced-performance displays Integrated desktop and notebook computers that incorporate Enhanced Performance Displays shall automatically adjusts the picture brightness to the ambient light conditions. This Automatic Brightness Control (ABC) function shall be installed as the default setting. The ABC shall be validated according to the following test procedure: Test (i) $(\frac{P_{50}-P_{10}}{P_{10}}) \geq 5$ Test (ii) $(\frac{P_{100}-P_{50}}{P_{50}}) \geq 5$ Test (iii) $P_{300} \geq P_{100}$ Where P_n is the Power consumed for On Mode with ABC enabled at *n* lux with a direct light source. ***Assessment and verification:*** The applicant shall submit a test report for the computer model showing compliance with the specified validation procedure.

[13] Luidolt,M and D,Gamperl, *How to comply with the Energy Star v6.0 standard for LED TVs*, AMS Technical article.

[14] See the Eligibility Criteria for Energy Star v6.0 Televisions

[15] Soneria, R.M. (2011) *BrightnessGate for the iPhone & Android Smartphones and HDTVs: Why Existing Brightness Controls and Light Sensors are Effectively Useless*, http://www.displaymate.com/AutoBrightness_Controls_2.htm

3.1.4.3 Summary rationale for the criterion proposal

Summary rationale for the final proposal
Enhanced performance integrated displays such as Apple Retina or Samsung AMOLED technology require additional energy to power the greater number of pixels and the associated graphics processing. These displays are also awarded significant additional allowances in the Energy Star E_{TEC_MAX} equation. Data is not currently available to set a performance benchmark for such displays. Instead a requirement is proposed that Automatic Brightness Control (ABC) is installed. This feature enables savings to be achieved by adjusting screen brightness to ambient conditions. ABC must, however, be correctly calibrated in order to ensure user satisfaction and energy savings.

3.2 Cluster 2 – Hazardous substances

Articles 6(6) and 6(7) of the Ecolabel Regulation (EC) 66/2010 place restrictions on the presence of hazardous substances in ecolabelled products, using REACH and CLP as their main reference points. The research results from the background paper on hazardous substances in computers, displays and televisions highlighted the need for an interpretation of these two articles that is workable for complex electronic products.

The requirements of the Ecolabel Regulation have up until now been interpreted by a standard legal text addressing 'hazardous substances and mixtures' which has, since 2010, been added as a criteria for each product group. This can be seen in Criteria 5 of Decision 2011/337/EU for personal computers and Criteria 4 of Decision 2011/330/EU for portable computers (see below).

Present criteria, Decisions 2011/337 and 2011/330
"Hazardous substances and mixtures" In accordance with Article 6(6) of Regulation (EC) No 66/2010 the product or any part of it shall not contain substances referred to in Article 57 of Regulation (EC) No 1907/2006 nor substances or mixtures meeting the criteria for classification in the following hazard classes or categories in accordance with Regulation (EC) No 1272/2008 of the European Parliament and of the Council. List of hazard statements and risk phrases: *see equivalent listing above*

The use of substances or mixtures which change their properties upon processing (e.g. become no longer bioavailable, undergo chemical modification) so that the identified hazard no longer applies is exempted from the above requirement. Concentration limits for substances or mixtures meeting the criteria for classification in the hazard classes or categories listed in the table above, and for substances meeting the criteria of Article 57(a), (b) or (c) of Regulation (EC) No 1907/2006, shall not exceed the generic or specific concentration limits determined in accordance with Article 10 of Regulation (EC) No 1272/2008. Where specific concentration limits are determined, they should prevail over the generic ones. Concentration limits for substances meeting criteria of Article 57(d), (e) or (f) of Regulation (EC) No 1907/2006 shall not exceed 0,1 % weight by weight. The following substances/uses of substances are specifically derogated from this requirement: Homogenous parts with weight below 10 g: Nickel in stainless steel *Assessment and verification:* for each part above 10 g the applicant shall provide a declaration of compliance with this criterion, together with related documentation, such as declarations of compliance signed by the suppliers of substances and copies of relevant Safety Data Sheets in accordance with Annex II to Regulation (EC) No 1907/2006 for substances or mixtures. Concentration limits shall be specified in the Safety Data Sheets in accordance with Article 31 of Regulation (EC) No 1907/2006 for substances and mixtures.
"Substances listed in accordance with Article 59(1) of Regulation (EC) No 1907/2006" No derogation from the exclusion in Article 6(6) may be given concerning substances identified as substances of very high concern and included in the list foreseen in Article 59 of Regulation (EC) No 1907/2006, present in mixtures, in an article or in any homogenous part of a complex article in concentrations higher than 0,1 %. Specific concentration limits determined in accordance with Article 10 of Regulation (EC) No 1272/2008 shall apply in case it is lower than 0,1 %. *Assessment and verification:* the list of substances identified as substances of very high concern and included in the candidate list in accordance with Article 59 of Regulation (EC) No 1907/2006 can be found here: *http://echa.europa.eu/chem_data/authorisation_process/candidate_list_table_en.asp* Reference to the list shall be made on the date of application. The applicant shall provide a declaration of compliance with this criterion, together with related documentation, such as declarations of compliance signed by the suppliers of substances and copies of relevant Safety Data Sheets in accordance with Annex II to Regulation (EC) No 1907/2006 for substances or mixtures. Concentration limits shall be specified in the Safety Data Sheets in accordance with Article 31 of Regulation (EC) No 1907/2006 for substances and mixtures.

3.2.1 Summary of the environmental significance of hazardous substances

The Task 3 LCA review identified that with regard to freshwater aquatic ecotoxicity, marine aquatic ecotoxicity and terrestrial ecotoxicity, the manufacturing phase is more significant than the use phase. These impacts are mainly associated with environmental pollution related to the extraction of raw materials and to the processing of sub-assemblies such as motherboards.

The above listed impact categories are significant also for the more energy intensive products in their use phase, such as desktops, being associated with electricity generation. Emissions during the end of life phase can also be significant if computers are disposed of improperly – for example, by burning cables and printed wiring boards to recover metals.

In general LCA studies are not able to identify and characterise the hazard inventory of substances that may be present in a final product sold to a consumer. A specific background report was prepared to scope and identify hazards that may be present [16]. This scoping identified the following broad forms that hazardous substances may be present in the final product:

- Metals and alloys that are used in solders, connectors, switches and relays *e.g. lead solder, cadmium in metal contacts, nickel scratch proof coatings*;
- Plastic additives that impart a function that may be physical/mechanical, safety or design related e*.g. colourants, fillers, plasticisers, stabilisers, flame retardants*;
- Materials, solvent and salts that together serve a function as part of the design and chemistry of sub-assemblies *e.g. lithium ion batteries, liquid crystals in display units;*
- Contaminants and process residues in plastic and glass e*.g. Polyaromatic Hydrocarbons in plastic and man-made rubber, arsenic in screen glass;*
- Intentionally added biocides that address consumer hygiene issues associated with day to day use of a computer *e.g. biocide added to keyboard plastic;*

3.2.2 Approach taken to hazardous substance criteria development for Computers

Following extensive discussions with stakeholders a new approach was applied to the computer product group. The methodology was based on the findings of the EU Ecolabel's Horizontal Task Force on Chemicals [16]:

[16] JRC-IPTS, *Findings of the EU Ecolabel Chemicals Horizontal Task Force – Proposed approach to hazardous substance criteria development*, 24th February 2014

- An initial screening was carried out of the bill of components/materials (see section 2.4 of the Hazardous Substances paper) followed by an initial identification of substance groups by their function. This reflects the broad approach outlined in the box below.
- Case studies and OEM restricted substance listings were collated that enabled the state-of-the-art in hazard substitution to be identifed.
- Additional input was requested from stakeholders in order to identify substitutions that have been made and also, if required, to identify derogations that may be required.
- A sub group consisting of a representative cross section of the stakeholders was formed in order to obtain further information, discuss technical issues in detail and to develop and test a workable criterion proposal.

In order to screen and evaluate the existing evidence compiled in the September 2013 background document on hazardous substances [17] and new evidence submitted by stakeholders subsequent to this two matrices were setup:

1. *Candidate List and RoHS screening matrix:* The IEC 62474 Declarable substance list for electrotechnical products [18] was used as the starting point for identifying substances from the most current ECHA Candidate List that may be relevant to computers and displays. The IEC list is frequently updated by a dedicated team and is therefore understood to be accurate as well as assisting in screening the list.
2. *Hazardous substance screening matrix:* The evidence gathered to date was structured, firstly, according to substance groups, which can generally be seen to related to functions associated with components of the product, and secondly according to the components/sub-components where hazardous substances are/may be found. A summary of the evidence used to compile

[17] JRC-IPTS, *Hazardous substances criteria development (draft v1),* September 2013, http://susproc.jrc.ec.europa.eu/computers/stakeholders.html
[18] International Electrotechnical Commission, *IEC 62474 - Material Declaration for Products of and for the Electrotechnical Industry,* http://std.iec.ch/iec62474

the matrix can be found in Table 3.7. This evidence is supplemented by feedback from product group stakeholders and sub-group members, including OEM's.

Table 3.7: Main evidence base used to compile the screening matrix

Screening	Evidence base
RoHS (recast) Directive	• Relevance of exemptions identified from OEM restriction lists
RoHS ATP	• Oeko-Institut and Austrian EPA reports with recommendations on extended RoHS scope
ECHA Candidate List	• Substances of relevance to the product group using IEC 62474 Declaration List (see colour coded version appended) • ECHA and Member State risk assessments and dossiers (e.g. German BFR - PAHs)
Substitution analysis	• EU ENFIRO study of environment-compatible flame retardants • US EPA Printed Circuit Board and decaBDE evaluations • Green Screen assessments for TV enclosures and plasticisers • COWI and the Danish Technological Institute compilation for plastics
Industry substitutions and restrictions	• OEM chemical restriction lists (with a focus on SG members HP, Samsung, Dell, LG) • International Electronics Manufacturing Initiative (iNEMI) • EFRA and PINFA guides to flame retardant applications in electronic equipment • SubSport Case Story substitution database • OEM product and component specifications

The analysis carried out using the matrix was used to derive the following outputs which form the basis for the scope and ambition level of the criteria proposal:

- Current hazard benchmarks: *Substances that are currently used or were used until recently in mainstream products*. For each substance the CAS number and, as far as possible, their hazard profile have been identified for comparative purposes.
- Proposed substitution benchmarks: *Substitutes for hazardous substances currently used in mainstream products that have been implemented, or are proposed for implementation, by leading manufacturers*. For each substance the CAS number and, as far as possible, hazard profile have been identified for comparative purposes.

- Proposed restrictions: *Substance or substance group restrictions that have been identified from OEM restriction lists or from risk assessment exercises by the European Commission, Member State or Intergovernmental bodies*. Where a restriction is proposed:
  - The specific substances, how they relate to the product and, where appropriate, a concentration limit are identified.
  - The potential to specify analytical testing of component parts to strengthen verification is flagged for follow-up and, if agreed to be appropriate in terms of the available test methods and burden for applicants, specification.
  - For some special cases possible derogation conditions are briefly flagged.

The complete matrix can be found in Annex 1 of the Task 5 technical background report.

3.2.3 Development of the sub-criteria

3.2.3.1 Criterion 2(a) - Substances of Very High Concern

In discussions within the SG there was a general agreement on setting a threshold of 0.10% for the non-presence of Candidate List substances. This is the threshold for notification under the REACH Regulation and, moreover, manufacturers and their suppliers are familiar with having to provide declarations at or above this threshold. Manufacturer's experience was also that there are very limited substances on the Candidate List that may be present above 0.1% at the article level (usually only plasticisers).

A more significant issue raised by manufacturers was whether the threshold should be applied at 'complex article' (the whole product), sub-assembly, component or material level. This would be stricter than current practice because many products are imported as a finished article. Some manufacturers do not assemble their final products, having decided to outsource their design and assembly.

However, agreed to introduce further selectivity into the criterion because *some manufacturers request declarations of compliance at what is termed 'sub-assembly'*

level e.g. populated motherboard or HDD unit as supplied for final assembly. A stakeholder highlighted that a sub-assembly such as a HDD may be sold in the EU as an article itself, so it seems reasonable to ask for verification at a level equivalent to a sub-assembly that a consumer might be able to obtain themselves as a spare/replacement part.

In order to arrive at a sub-assembly listing a comparison was made between the SVHC sub-assembly declarations of the two major manufacturers participating in the SG. The results are presented in Table 3.8.

Table 3.8. Comparison of the sub-assembly lists of two major computer manufacturers

Dell [1]	**Hewlett Packard** [2]
- Populated motherboard (includes RAM, graphics, CPU etc.) - Data storage device (HDD, SSD) - Optical Drive (if installed) - Internal *or* external Power Supply Unit - Chassis and bezel - Mechanical assemblies (fans, heatsinks) - Internal cables/cords/connectors - Power cord *Desktop-specific* - Wired or wireless keyboard - Wired or wireless mouse *Notebook-specific* - LCD display - Battery - Fingerprint reader	- Printed Circuit-board Assembly - Graphics card - Memory module(s) - Hard Disk Drive - Solid State Drive - Optical Disk Drive - Internal or external Power Supply Unit - Fan assembly and heat sink - Power cord - Keyboard Desktop-specific - Front bezel - Wired or wireless keyboard - Wired or wireless mouse Notebook-specific - Display panel - Port replicator/docking station - Power adapter - Battery - Touchpad
Notes: 1. Dell (2010) *EU REACH SVHC disclosure on the Candidate List*. Sample disclosure listing 2. HP, *EU Regulation 1907/2006 (REACH) Compliance*, HP Substance report.	

It was also noted in SG discussions that there not all Candidate List substances are for electronics. The IEC 62474 substance declaration list [19] is used as a tool to pre-screen the Candidate List for relevance. This list includes notes on what functions substances serve and in which products and/or components they may be present. This is then provided to suppliers who must then provide declarations down to concentration limit of 0.1%. In general it was felt by SG members to be relevant and reasonable to carry out such a pre-screen.

3.2.3.2 Criterion 2(b) – Restriction of specific hazardous substances

In the April 2014 (v1) an initial criteria proposal was put forward based on the restriction lists of leading manufacturers. These lists are used to communicate to suppliers substances that shall not be present in their products. The different types of restrictions broadly fell into the following categories:

- Plastic additives that impart a function that may be physical/mechanical, safety or design related e*.g. colourants, stabilisers*;
- Restriction of *RoHS exemptions that may sunset or are not deemed to necessary in leading products* e.g. lead solder in servers, cadmium in metal switches and relays, mercury in screen backlighting units;
- Biocides use for consumer hygiene purposes *e.g. biocide added to keyboard plastic;*
- Contaminants and process residues in plastic and glass e*.g. Polyaromatic Hydrocarbons in plastic and man-made rubber, arsenic in screen glass;*

Based on further analysis and stakeholder feedback the final criterion 2(b) was streamlined and the following restrictions removed that were deemed unnecessary:

- Phthalates that are already restricted under 2(a) because they are SVHCs;
- Cadmium and lead restrictions that are already subject to legal requirements under RoHS;

[19] International Electrotechnical Commission (IEC), *IEC 62474: Material declaration for products of and for the electrotechnical industry, http://std.iec.ch/iec62474*

- PFOA residue in PTFE non-dripping agents which may be present at less than 0.1% in plastic sub-assemblies;
- Controls on cleaning and degreasing agents such as benzene as there is no evidence that they carry over to the final product at concentrations >0.1%

Where possible test methods for assessment and verification were cross checked based on methods used by manufacturers and/or which are linked to RoHS.

3.2.3.3 Criterion 2(c) – Restriction of CLP hazards

The initial background research highlighted that a complete picture of hazards that may be present in a computer product is not available [20]. Moreover, whilst the CAS numbers of colourants that may be used in different types of plastic can be identified from the catalogues of, for example, Clariant [21] and BASF [22] an overview of the hazard profile of additives such as colourants and their comparative improvement potential is not currently available. Suppliers are also often given flexibility as to how they meet certain specifications e.g. plastic colour.

It was agreed early on in the AHWG and SG to focus attention on the hazard profile and substitution of flame retardants and plasticisers. Flame retardants and plasticisers have been the main focus for planned substitutions of hazardous substances by leading manufacturers. These substance groups are also notable for being the first examples of substitutions by computer manufacturers where hazard classifications have formed the basis for decision making. This process has been supported by research programmes of the US EPA and assessments using tools such as Green Screen.

Having identified the main substitute flame retardants and plasticisers used by leading manufacturers, their hazard classifications were used to develop derogations reflecting the specific range of substances used in different computer components.

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[20] JRC-IPTS, *Hazardous substances criteria development (draft v1),* September 2013, http://susproc.jrc.ec.europa.eu/computers/stakeholders.html

[21] Clariant (2007) *The coloration of plastics and rubber*, Pigments & Additives Division.

[22] BASF, *Housing applications*, Accessed 2014, http://www.plasticadditives.basf.com/ev/internet/plastic-additives/en_GB/content/plastic-additives/Industries/Electrical_Electronics/electrical_electronics_applications

Member States and manufacturers requested a summary of the flame retardants and plasticisers that, indicatively, based on use of the JRC-IPTS decision tree in Figure 3.7 of the Task 5 technical background report, would meet the derogation conditions in proposed criterion 2(c). These are summarised in Table 3.9 and Table 3.10.

Decisions on derrogations submitted by stakeholders are summarised in the Task 5 Technical Background report. These derogations address antimony trioxide, beryllium (in ceramic form and copper alloys), nickel in stainless steel and scratch proof coating, lithium ion battery cathodes and electrolytes.

Table 3.9. Flame retardants determined as meeting the derogation conditions

Flame retardant	**CAS No**	**Hazard group**
Derogated for use in main printed circuit board, CPU assembly, Data storage drives, Internal connectors and sockets, power supply units.		
Dihydrooxaphosphaphenanthrene (DOPO) CAS No	35948-25-5	Group 3: H411, H412
Fyrol PMP (Aryl Alkylphosphinate)	63747-58-0	Group 3: H413
Magnesium hydroxide (MDH) *with zinc synergist*	1309-42-8	Group 3: H413
Ammonium polyphosphate	68333-79-9	Group 3: H413
Aluminium hydroxide (ATH) *with zinc synergist*	21645-51-2	Group 3: H413
Bisphenol A Bis (diphenyl Phosphate)	5945-33-5	Not classified
Derogated for use in external power cables and power packs		
Magnesium hydroxide (MDH) *with zinc synergist*	1309-42-8	Group 3: H413
Ammonium polyphosphate	68333-79-9	Group 3: H413
Aluminium hydroxide (ATH) *with zinc synergist*	21645-51-2	Group 3: H413
Bisphenol A Bis (diphenyl Phosphate)	5945-33-5	Not classified

Derogated for use in plastic casings and bezels		
Triphenyl phosphate	115-86-6	Group 2: H400, H411
Resorcinol Bis (Diphenyl Phosphate)	125997-21-9	Group 2: B, H400, H410
Phosphoric acid, mixed esters with [1,1‟-bisphenol-4,4‟-diol] and phenol	1003300-73-9	Group 2: H351, H400. H410
Polyphosphonate	68664-06-2	Group 2: H351, H410
Ethane bis (pentabromophenyl) (EBP)	84852-53-9	Group 2: H351
Antimony Trioxide synergist (with EBP)	1309-64-4	Group 2: H351
Poly[phosphonate-co-carbonate]	77226-90-5	Group 3: H413
Bisphenol A Bis (diphenyl Phosphate)	5945-33-5	Not classified

Table 3.10. Plasticisers determined to meet the derogation conditions

Plasticiser	**CAS No**	**Hazard group**
Derogated for use in external power cords and power packs, external casings and internal cables		
Trioctyl trimetallate (TOM/TOTM)	3319-31-1	Not classified
Dioctyl terephthalate (DOTP)	6422-86-2	Not classified
Hexamoll DINCH	166412-78-8	Not classified
DIDP	68515-49-1	Not classified
DINP	28553-12-0	Not classified.

Reflecting the issues raised in relation to the end of life management of computer motherboards and cables (see Section 3.2.5), accompanying derogation conditions are proposed based on fire testing to demonstrate low dibenzo dioxin and furan emissions. This approach is intended to focus on the end of life emissions rather than the control of specific chemistries. This test is also to be applied to inherently flame retardant cable materials, so as to ensure equal treatment.

3.2.3.4 An updated approach to hazard assessment and verification

Industry stakeholders that have invested heavily in alternative chemistries highlighted early on the need to avoid so-called 'regrettable substitutions' i.e. substitutions made on the basis of limited scientific evidence of their improvement over substances that are to be phased out.

In seeking to determine which substances or hazard classifications shall be derogated for use in the EU Ecolabel it was therefore considered important to consult with ECHA in order to identify key factors to take into account during the evaluation of different sources of hazard classification evidence and to then use this to develop a decision making tool in order support the process.

The resulting decision tree is presented in Figure 3.2.1. This tool was then used to determine hazard classifications for the substitute flame retardants and plasticisers identified and to redraft the assessment and verification text.

A subject of debate with stakeholders was what sources of information could be used from outside of the EU if the REACH and CLP system do not provide a clear decision. Tools have been developed in the USA to address similar challenges when seeking to make decisions on the hazard profile of substances. The US EPA, for example, developed a hazard classification matrix for its design for the environment programme which it has applied to a range of different flame retardants. It was agreed in discussions with ECHA that the findings from exercises carried out by such so-called 'Peer Agencies' [23] could be used as evidence.

Discussions and feedback from the AHWG2 and the SG also supported a recognition and/or alignment with the benchmarking systems of independent schemes such as Green Screen [24]. At least two major computer manufacturers are now using Green Screen assessment tool to make decisions on investment in substitutions.

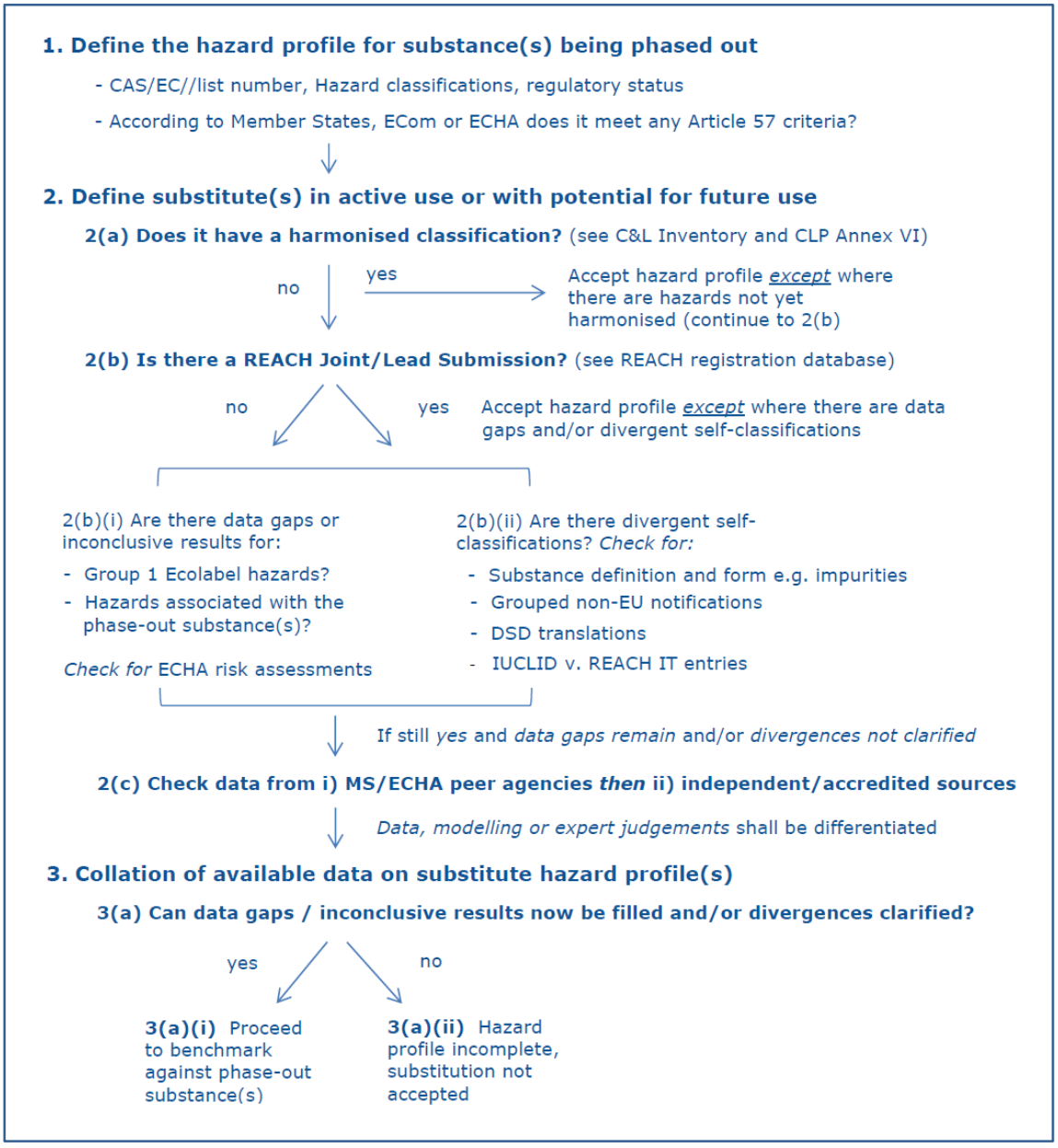
Some concerns were raised that Green Screen as a private system should not be used as the sole verification route for the EU Ecolabel. This concern is reflected in

[23] ECHA, *Co-operation with peer regulatory agencies*, http://echa.europa.eu/en/about-us/partners-and-networks/international-cooperation/cooperation-with-peer-regulatory-agencies

[24] Clean Production Action (2013) *Green Screen chemical hazard assessment procedure v1.2*

the design of the decision tree in Figure 3.2.1 and the revised assessment and verification text, which emphasises the need to check data from ECHA Peer Agencies before resorting to independent hazard assessment schemes operated in line with ISO 17065.

Figure 3.2.1 JRC-IPTS decision tree used to determine hazard classifications



3.2.4 Addressing hazardous emissions from improper WEEE end-of-life management

A number of stakeholders highlighted the need to address the improper disposal of computers in the end of life phase. The environmental impacts associated with the informal recycling and improper treatment of printed circuit boards and cables to recover precious metals and copper [25] are of particular concern. Moreover, concerns relating to the end-of-life phase of electrical products has driven action by computer manufacturers to phase-out those materials and flame retardants for which evidence exists of the potential for toxic emissions [26].

In terms of the scale of the issue the European Environment Agency estimate that 16-38% of the EU's WEEE waste (between 550,000 and 1,300,000 tonnes) was exported in 2008 [27]. Moreover, whilst illegal WEEE shipments are classified as hazardous waste under the Basel Convention and are the subject of controls under the recast WEEE Directive, the EEA highlight that there are no restrictions on the export of goods for re-use, for which the end of life phase may not comply with expected EU norms for WEEE disposal.

Analyses of emissions from fire simulations and samples of environmental pollution from WEEE treatment sites has shown that there is the potential for a range of toxic emissions to arise from unregulated treatment processes, including species of Polychlorinated and Polybrominated dibenzo-p-dioxins and furans (PCDD/DF and PBDD/DF) [28] [29] and carcinogenic Polycyclic Aromatic Hydrocarbons (PAHs) [30].

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[25] Oeko-Institut, *Recycling critical raw materials from waste electronic equipment*, Commissioned by the North Rhine-Westphalia State Agency for Nature, Environment and Consumer Protection, 24th February 2012 *and* Oeko-Institut, *Informal e-waste management in Lagos, Nigeria – socio-economic impacts and feasibility of international recycling operations*, UNEP SBC project, June 2011

[26] Chem Sec, *Leading Electronics companies and Environmental organisations urge EU to restrict more hazardous substances in electronic products in 2015 to avoid more global dioxin formation*, 19th May 2010, http://www.chemsec.org/images/stories/publications/ChemSec_publications/RoHS_restrictions_Company__NGO_alliance.pdf

[27] European Environment Agency, *Movements of waste across the EU's internal and external borders*, Report No 7/2012

[28] Gullett, B.K.; Linak, W.P.; Touati, A.; Wasson, S.J.; Gatica, S.; King, C.J *Characterisation of air emissions and residual ash from open burning of electronic wastes during simulated rudimentary recycling operations*, Journal of Material Cycles & Waste Management 9: 69-79, 2007

These uncontrolled emissions have led to the exposure of communities and the pollution of local environments, as evidenced by studies that have sampled the environment around WEEE treatment sites [31] [32], and by programmes of the UNEP and the World Health Organisation developed under the auspices of the Basel Convention that aim to monitor e-waste movements and to protect the health of workers and communities[33] [34].

LCA modelling carried out for the FP7 ENFIRO project provides for a comparison of the potential for hazardous emissions from improper WEEE disposal scenarios for a notebook computer (see Figure 3.2.2). The aggregated, normalised results illustrate the significance of the contribution of dioxin and furan emissions to the human toxicity midpoint for a notebook incorporating mainly brominated flame retardants within the plastic casing, circuit boards and cable sheaths. The contribution of plastics incorporating non-halogenated flame retardants to the human toxicity midpoint is also evident in the results, reflecting high TEQ emissions from carcinogenic PAHs.

Some stakeholders emphasised the importance of considering PAHs alongside dioxin and furan emissions. PAHs may arise from the combustion or pyrolysis of aromatic substances and polymers such as polyolefins and epoxy resins. Evidence from WEEE sites in China, India and Africa appears to support this assertion and highlight the significance of emissions to air and fly ash. Simulated fire test data arising from studies in the US and Sweden enables a contribution analysis of

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[29] Duan et al, *Characterization and Inventory of PCDD/Fs and PBDD/Fs Emissions from the Incineration of Waste Printed Circuit Board*, Environmental Science & Technology, 2011, 45, 6322–6328

[30] Blomqvist,P et al, *Polycyclic Aromatic Hydrocarbons (PAHs) quantified in large-scale fire experiments*, Fire technology, 48 (2012), p-513-528

[31] Sepúlveda,A et al, *A review of the environmental fate and effects of hazardous substances released from electrical and electronic equipments during recycling: Examples from China and India*, Environmental Impact Assessment Review 30 (2010) 28–41

[32] Wang,Y et al, *Polycyclic aromatic hydrocarbons (PAHs) in soils and vegetation near an e-waste recycling site in South China: Concentration, distribution, source, and risk assessment*, Science of the Total Environment 439 (2012) 187–193

[33] UNEP, *E-waste in Africa*, Accessed October 2015 http://www.basel.int/Implementation/Ewaste/EwasteinAfrica/Overview/tabid/2546/Default.aspx

[34] World Health Organisation, *Childrens environmental health: Electronic waste*, http://www.who.int/ceh/risks/ewaste/en/

PxDD/DF and PAHs emissions to human toxicity under simulated improper conditions to be made.

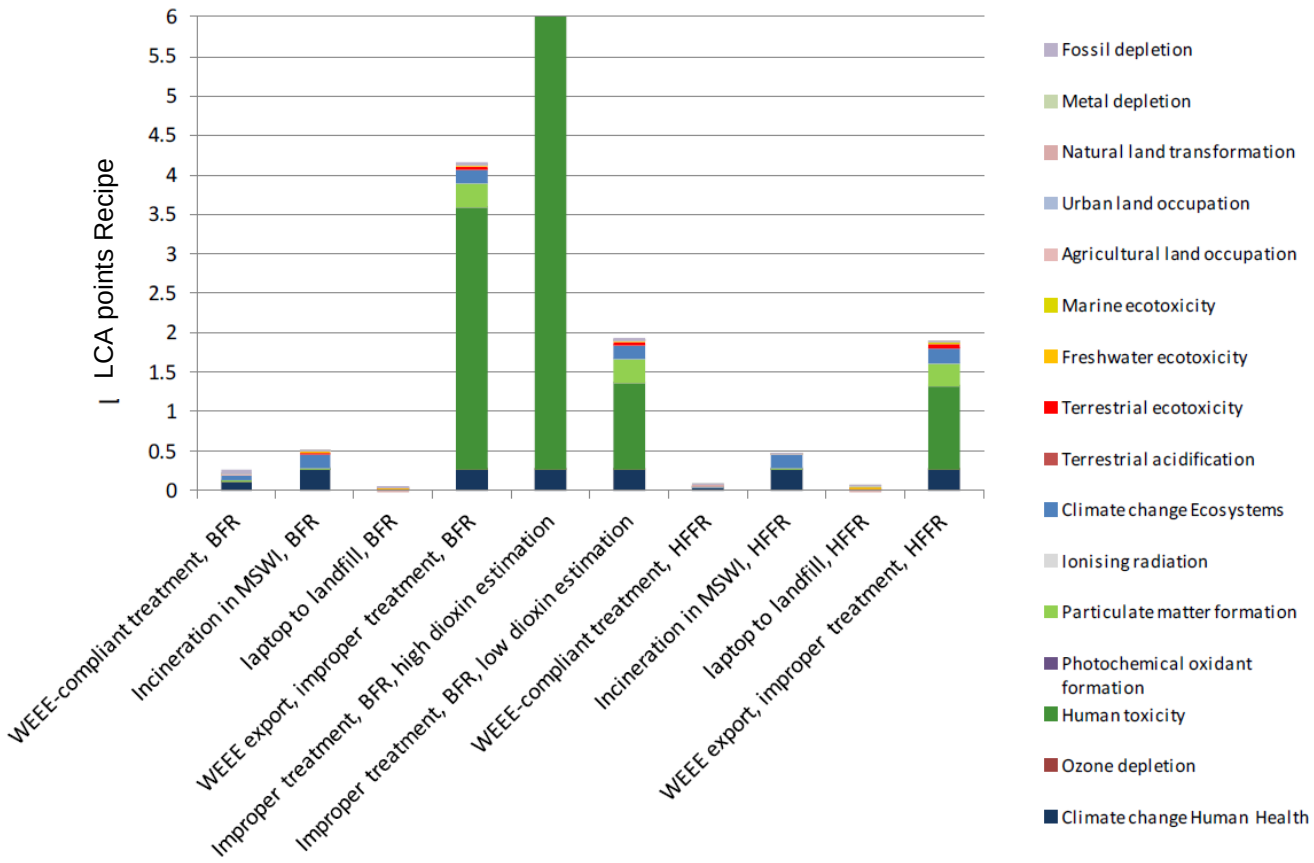

Figure 3.2.2. The influence of dioxin formation during improper WEEE treatment on the total environmental impact of the waste treatment of one laptop.

Source: ENFIRO project (2013)

Emissions data for PCBs and cables was chosen for analysis. A combination of Characterisation Factors from the EU ILCD database and WHO Toxic Equivalence Factors (TEF) for PxDD/DF and PAHs have been used. The findings are presented in Table 3.11. For PCBs they show that PAHs make a significant contribution, in the region of 24%, whilst for cables they show that PCDD/DF are more relevant than PAHs, which in the worst case scenario contribute less than 1%.

Table 3.11 Contribution analysis of PxDD/DF and PAHs emissions in Comparative Toxic Units for Human Health (CTUh) per kg component tested

Hazardous emissions	Printed Circuit Board laminate (brominated FR)	Electrical cable (polymer and conductor)	
		Polyvinyl chloride insulation	Polyethylene insulation
PCDD/DF	-	2.19E-08 (99%)	2.16E-09 (96%)
PBDD/DF	1.79E-08 (76%)	-	-
PAHs	5.75E-09 (24%)	1.71E-10 (1%)	8.80E-11 (4%)

Data sources: US EPA (2013), SP (2001)

Minimising the potential for hazardous emissions from cables and PCBs

One proposed approach to reducing the potential for hazardous end-of-life emissions is to move to halogen free components. For example, computer manufacturers are increasingly making 'halogen free' claims for Printed Circuit Boards according to IEC 61249-2-21. This standard defines a concentration limit of 900ppm for bromine present in the resin of a PCB. This approach may, however, too restrictive if new flame retardant chemistries are developed – for example, EBP (CAS No. 84852-53-9) which has been demonstrated in testing to have lower dioxin emissions.

An alternative, more technology-neutral approach, is to fire-test material and flame retardant combinations for hazardous emissions. This form of testing is already used for cables, with a standardised test for the emissions of halogen acid gases that are precursors for PCDD/DF or PBDD/DF formation (EN 60754-1) used to support product claims made for '*halogen free low smoke'* cables according to IEC 62821.

Laboratory testing of components for toxic emissions of high concern for the environment - notably PCDD/DFs, PBDD/DFs and PAHs – has been carried out on PCBs for the US EPA's Design for the Environment programme [35] and on cables by

[35] Sidhu.S, Morgan.A, Kahandawala.M, Muddasani.K, Gullett.B and D.Tabor, *Use of cone calorimeter to identify selected polyhalogenated dibenzo-p-dioxins/furans and polyaromatic hydrocarbon emissions from the combustion of circuit board laminates*, Final Report prepared for the U.S. Environmental Protection Agency by the University of Dayton Research Institute, October 22, 2013

the Swedish National Research and Testing Institute [36], as well as in studies by, amongst others, Gullett et al (2007), Hull et al (2008) and Li et al (2009).

Using a laboratory fire test to simulate improper WEEE treatment

Simulation of the improper thermal treatment of WEEE waste can be approximated based on reported conditions under which it is carried out in, for example, Africa, India and China. Cables are typically burnt in open fires or drums in oxygen limited conditions in the temperature range 300-600^{o}C and PCBs are typically subject to pyrolysis within the temperature range 200-500^{o}C. Fire performance test methods and scenarios such as those described in laboratory scale fire test methods ISO 19700 or IEC 60695-7-50 can then be used to define standardised test conditions for the burning of component samples.

In terms of the determining and quantifying the emissions from a sample, EN 1948 and ISO 11338 are understood to be suitable for PxDD/DF and PAHs determination, respectively. As already noted, EN 60754-1 can be used to determine halogen acid gas emissions, with the test method combining the fire test and emissions quantification. These tests, which entail a combination of a fire simulation, emissions capture and quantification, are understood to cost upwards of €1,000/sample. Feedback from the University of Dayton in the USA has highlighted the need for guidance on the emissions capture stage when seeking to combine fire simulation and quantification test methods.

Establishing emissions limits for PCBs

As already highlighted, computer manufacturers are now able to make claims for 'low halogen' PCBs according to IEC 61249-2-21. This is likely to reflect cases where the manufacturer has requested the use Group 3 flame retardants in their PCBs. Whilst this move may lead to reduced PBDD/DF emissions, this does not necessarily ensure that emissions of PAHs are minimised. It is therefore proposed to introduce a fire test for PAHs emissions where such a claim is made.

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[36] Simonson et al, *Fire LCA model: Cables case study*, SP Report 2001:22 *and* Simonson et al, *Cable case study II – NHXMH and NHMH cable*, SP Report 2005:45

Given that data is not available for PAHs emissions from PCB resins with the most commonly used Group 3 flame retardant Dihydrooxaphosphaphenanthrene (DOPO), it is proposed to set an initial safety limit of 0.1 mg TEQ/g based on the best performing brominated PCB laminate with low halogen components (e.g. CPU) as tested in the 2013 US EPA study. To support comparability the test method is proposed to reflect that used by University of Dayton for the US EPA study.

For PCBs using Group 3 flame retardants a stricter derogation condition is considered to be required. This is proposed as combining the need for the FR to be reacted into the resin, thereby preventing potential migration from the laminate material in the end of life phase, and for a fire test to determine both PBDD/DF and PAHs emissions.

It is proposed to set an initial PBDD/DF safety limit of 0.4 ng TEQ/g based on the best performing brominated PCB laminate with low halogen components (e.g. CPU) as tested in the 2013 US EPA study. Based on the results of that study this would achieve a reduction in emissions of 50% when compared to a brominated PCB laminate alone.

Establishing emissions limits for cables

As already highlighted, cable manufacturers are able to make claims for 'halogen free low smoke' cables according to IEC 62821. This specifies that emissions resulting from a fire test of the power cord polymer shall show halogen acid gas emissions of less than 5.0 mg/g. It is therefore proposed as the safety limit where Group 3 flame retardants are used and a 'halogen free low smoke' claim is made.

For cables using Group 2 flame retardants, or that are made from inherently flame retardant materials, a stricter derogation condition is considered to be required. The comparative results from the Swedish SP cable fire testing using a large chamber test method (IEC 60332-3-10) have been used to establish a threshold safety limit for cable emissions. These fire tests showed that halogen free products, such as thermoplastic elastomer cables, may still produce dioxin and furan emissions due to low levels of chlorine still being present.

The proposed limit of 0.3 ng TEQ/g cable reflects the highest reported result for low PxDD/DF emission cable typologies, but with a margin applied to take into account higher potential emissions from the smaller scale, but more commonly used and cost effective ISO 19700 tube furnace test method.

3.2.5 Final proposal for 2(a)/(b)/(c) hazardous substances criterion

Final criterion proposal

Criterion 2. Hazardous substances in the product, sub-assemblies and component parts

The presence in the product, or defined sub-assemblies and component parts, of substances that are identified according to Article 59 of Regulation (EC) No 1907/2006 [37] (the 'REACH Regulation') or meet the criteria for classification according to Regulation (EC) No 1272/2008 [38] (the 'CLP Regulation') for the hazards listed in Table 2, shall be restricted in accordance with sub-criterion 2(a), (b) and (c). For the purpose of this criterion Candidate List Substances of Very High Concern (SVHCs) and CLP hazard classifications are grouped in Table 2 according to their hazardous properties.

Table 2. Grouping of Candidate List SVHCs and CLP hazards

Group 1 hazards

Hazards that identify a substance as being within Group 1:

- Substances that appear on the Candidate List for Substances of Very High Concern (SVHC)
- Substances classified as Carcinogenic, Mutagenic and/or Toxic for Reproduction (CMR) Category 1A or 1B: H340, H350, H350i, H360, H360F, H360D, H360FD, H360Fd, H360Df

Group 2 hazards

Hazards that identify a substance as being within Group 2:

- Category 2 CMR: H341, H351, H361f, H361d, H361fd , H362
- Category 1 aquatic toxicity: H400, H410
- Category 1 and 2 acute toxicity: H300, H310, H330, H304
- Category 1 aspiration toxicity: H304
- Category 1 Specific Target Organ Toxicity (STOT): H370, H372

[37] Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals Agency amending Directive 1999/45/EC and repealing Council Regulation (EEC) No 793/93 and Commission Regulation (EC) No 1488/94 as well as Council Directive 76/769/EEC and Commission Directives 91/155/EEC, 93/67/EEC, 93/105/EC and 2000/21/EC (OJ L 396, 30.12.2006, p.1).

[38] Regulation (EC) No 1272/2008 of the European Parliament and of the Council of 16 December 2008 on classification, labelling and packaging of substances and mixtures, amending and repealing Directives 67/548/EEC and 1999/45/EC, and amending Regulation (EC) No 1907/2006 (OJ L 353, 31.12.2008, p. 1).

Group 3 hazards

Hazards that identify a substance as being within Group 3:

- Category 2, 3 and 4 aquatic toxicity: H411, H412, H413
- Category 3 acute toxicity: H301, H311, H331, EUH070
- Category 2 STOT: H371, H373

2(a) Restriction of Substances of Very High Concern (SVHC's)

The product shall not contain substances that have been identified according to the procedure described in Article 59(1) of the 'REACH Regulation' and included in the Candidate List of SVHCs at concentrations of greater than 0.10% (weight by weight). The same restriction shall apply to the sub-assemblies forming part of the product that are listed in Table 3.

No derogation from this requirement shall be given to Candidate List SVHCs present in the product or in its sub-assemblies in concentrations greater than 0,10 % (weight by weight).

Table 3. Sub-assemblies and component parts to which Criterion 2(a) shall apply

- Populated motherboard (including CPU, RAM, graphics units)
- Data storage devices (HDD and SSD)
- Optical Drive (CD and DVD)
- Display unit (including backlighting)
- Chassis and fixings
- Plastic casings and bezels
- External keyboard, mouse and external trackpad
- Internal and external Power Supply Units
- External AC and DC power cords
- Rechargeable batteries packs

In communicating this requirement to suppliers of the listed sub-assemblies applicants may pre-screen the REACH Candidate List using the IEC 62474 declarable substance list [39]. The screening shall be based on identification of the potential for presence of substances in the product.

Assessment and verification: The applicant shall compile declarations of the non-presence of SVHCs substances at or above the specified concentration limit for the product and the sub-assemblies identified in Table 3. Declarations shall be with reference to the latest version of the Candidate List published by ECHA [40]. Where declarations are made based on a pre-screening of the candidate list using IEC 62474 the screened list given to sub-assembly suppliers shall also be provided by the applicant. The version of the IEC 62474 declarable substance list used shall reflect the latest version of the Candidate List.

2(b) Restrictions on the presence of specific hazardous substances

The sub-assemblies and component parts identified in Table 4 shall not contain the specified hazardous substances at or above the stipulated concentration limits.

[39] International Electrotechnical Commission (IEC), *IEC 62474: Material declaration for products of and for the electrotechnical industry, http://std.iec.ch/iec62474*

[40] ECHA, *Candidate List of substances of very high concern for Authorisation*, http://www.echa.europa.eu/candidate-list-table

Table 4. Substance restrictions that shall apply to sub-assemblies and component parts

Substance group	**Scope of restriction**	**Concentration limits (where applicable)**	**Assessment and verification**
i) Metal solder and contacts	Exemption 8b in accordance with Directive 2011/65/EU[41] relating to the use of *cadmium in electrical contacts* shall not be permitted.	0.01% w/w	Declaration to be provided by the manufacturer or final assembler supported by a valid test result. *Test method:* IEC 62321-5
	Exemption 7b in accordance with Directive 2011/65/EU[6] relating to the use of lead solder in *small-scale servers* shall not be permitted.	0.1% w/w	
ii) Polymer stabilisers, colourants and contaminants	The following organotin stabiliser compounds classified with Group 1 and 2 hazards shall not be present in *external AC and DC power cords and power packs*: - Dibutyltin oxide - Dibutyltin diacetate - Dibutyltin dilaurate - Dibutyltin maleate - Dioctyl tin oxide - Dioctyl tin dilaurate	n/a	Declaration to be provided by the sub-assembly supplier.
	Plastic casings and bezels shall not contain the following colourants: - Azo dyes that may cleave to the carcinogenic aryl amines listed in Appendix 8 of the REACH Regulation, and/or - Colourant compounds included in the IEC 62474 declarable substances list.	n/a	Declaration to be provided by the sub-assembly supplier.

[41] Directive 2011/65/EU of the European Parliament and of the Council of 8 June 2011on the restriction of the use of certain hazardous substances in electrical and electronic equipment (recast) (OJ 174, 1.7.2011, p.88)

	Polycyclic Aromatic Hydrocarbons (PAHs) classified with Group 1 and 2 hazards shall not be present at concentrations greater than or equal to individual and sum total concentration limits in any external plastic or man-made rubber surfaces of: - Notebooks and tablets; - Peripheral keyboards, - Mice, - Stylus and trackpads; - External power cables. The presence and concentration of the following PAHs shall be verified: PAH's restricted by the REACH Regulation: - Benzo[a]pyrene, - Benzo[e]pyrene, - Benzo[a]anthracene, - Chrysen, - Benzo[b]fluoranthene, - Benzo[j]fluoranthene, - Benzo[k]fluoranthene - Dibenzo[a,h]anthracene, *Additional PAH's subject to restriction:* - Acenaphthene - Acenaphthylene - Anthracene - Benzo[ghi]perylene - Fluoranthene - Fluorene - Indeno[1,2,3-cd]pyrene - Naphthalene - Phenanthrene - Pyrene	The individual concentration limits for PAHs restricted under REACH shall be 1 mg/kg The sum total concentration limit for the 18 listed PAHs shall not be greater than 10 mg/kg	Test report to be provided by the applicant for relevant parts of the identified parts of the product. *Test method*: AfPS GS 2014:01 PAK.

iii) Biocides	Biocides intended to provide an anti-bacterial function shall not be incorporated into plastic or rubber parts of keyboards and peripherals.	n/a	Declaration to be provided by the sub-assembly supplier.
iv) Mercury in backlights	Exemption 3 in accordance with Directive 2011/65/EU [42] relating to the use of mercury in *cold cathode fluorescent lamps and external electrode fluorescent lamps (CCFL and EEFL)* shall not be permitted.	n/a	Declaration to be provided by the sub-assembly supplier.
v) Glass fining agents	Arsenic and its compounds shall not be used in the manufacturing of LCD display unit glass, screen cover glass and glass used in track pad surfaces.	0.0050% w/w	Declaration to be provided by the glass supplier(s) supported by an analytical testing report.

Assessment and verification: The applicant shall provide declarations of compliance and test reports according to the requirements in Table 4. Test reports, where required, shall be valid at the time of application for the relevant production model and all associated suppliers. Where sub-assemblies or component parts with the same technical specification originate from a number of different suppliers, tests where applicable shall be carried out on parts from each supplier.

2(c) Restrictions based on CLP hazard classifications

Flame retardants, plasticisers, steel additives and coatings, cathode materials, solvents and salts that meet the criteria for classification with the CLP hazards in Table 2 shall not be present in the sub-assemblies and component parts in Table 5 at or above a concentration limit of 0.10% (weight by weight). The most recent classification rules adopted by the European Union as Adaptations to Technical Progress (ATPs) shall take precedence when determining hazard classifications.

Table 5. Sub-assemblies and component parts to which Criterion 2(c) shall apply

Parts containing flame retardants

- Printed Wiring Boards >10 cm^2
- Central Processing Units (CPU's)
- Connectors and sockets
- Data storage devices (HDD and SSD)
- Plastic casings and bezels
- Internal and external Power Supply Units
- External AC and DC power cords

Parts containing plasticisers

- Internal cables and cords
- External AC and DC power cords
- External Power Supply Units
- Plastic casings and bezels

[42] ibid 6

Parts with stainless steel alloys and/or nickel coatings

- Chassis, casings, bolts, nuts, screws and brackets

Rechargeable battery packs

- Rechargeable battery cells

(i) Derogations for the use of hazardous flame retardants and plasticisers

The use of flame retardants and plasticisers meeting the criteria for classification with CLP hazards listed in Table 2 are derogated from the requirements of criterion 2(c) provided that they meet the conditions specified in Table 6. Inherently flame retardant external AC and DC power cord materials shall also meet the conditions in Table 6(ii)(b).

Table 6. Derogations conditions that shall apply to the use of flame retardants and plasticisers

Substances	***Sub-assembly or component part***	***Scope of derogation***	***Assessment and verification***
Flame retardants	i) Main Printed Circuit Board (inclusive of RAM and graphics printed wiring boards).	The use of flame retardants in motherboard laminates is derogated under either of the following conditions: (a) The flame retardant is classified with a Group 3 hazard. Where a claim is made in conformance with IEC 61249-2-21 [43] a fire test of the PCB simulating improper WEEE disposal shall show PAHs emissions to be ≤ 0.1 mg TEQ /g. (b) The flame retardant is reacted into the polymer resin and a fire test of the PCB simulating improper WEEE disposal shall show Poly Brominated dibenzo dioxin and furan (PBDD/DF) emissions to be ≤ 0.4 ng TEQ/g and PAHs emissions to be ≤ 0.1 mg TEQ/g.	Declaration to be provided by the sub-assembly supplier supported by documentation to verify hazard classifications. *or* A third party test report for the combination of base board material and flame retardant. *Test method:* ISO 5660 in oxidative pyrolysis conditions (IEC 60695-7-50 fire type 1b with a heat flux of 50 kW/m^2). Quantification shall be made according to EN 1948 (PBDD/DF) and/or ISO 11338 (PAHs).
	ii) External AC and DC power cords.	The use of flame retardants and their synergists is derogated under either of the following conditions: (a) The flame retardant and its synergist are classified with a Group 3 hazard. Where a claim is	Declaration to be provided by the sub-assembly supplier supported by documentation to verify hazard classifications.

[43] According to IEC 61249-2-21 claims can be made for the 'halogen free' composition of a printed circuit board material

		made in conformance with IEC 62821 [44] a fire test of the power cord polymer shall show halogen acid gas emissions of less than 0.5 mg/g. (b) Fire test results for the power cord simulating improper WEEE disposal shall show polychlorinated dibenzo dioxin and furan emissions of ≤ 0.3 ng TEQ/g Power cords insulated with inherently flame retardant materials shall be subject to the part (b) fire testing requirement.	*and where required:* A third party test report for the power cord. *Test method:* IEC 60754-1 or ISO 19700 in under-ventilated conditions (IEC 60695-7-50 fire type 3a with a heat flux of 50 kW/m^2) PCDD/DF quantification shall be made according to EN 1948.
	iii) External plastic casings and bezels.	Flame retardants and their synergists classified with Group 2 and 3 hazards are derogated for use.	Declaration to be provided by the sub-assembly supplier supported by documentation to verify hazard classifications.
	iv) Miscellaneous subassemblies and parts: - CPU assembly - Data storage drives - Internal connectors and sockets - Power supply units.	Flame retardants classified with Group 3 hazards are derogated for use.	Declaration to be provided by the sub-assembly supplier supported by documentation to verify hazard classifications.
Plasticisers	i) External power cords and power packs, external casings and internal cable	Plasticisers classified with Group 3 hazards are derogated for use.	Declaration to be provided by the sub-assembly supplier supported by documentation to verify hazard classifications.

(ii) Derogations for the use of additives, coatings, cathode materials, solvents and salts

[44] According to IEC 62821 claims can be made for the 'halogen free low smoke' cables

The use of stainless steel additives and coatings, cathode materials, solvents and salts meeting the criteria for classification with CLP hazards listed in Table 2 are derogated from the requirements of criterion 2(c) provided that they meet the conditions specified in Table 7.

Table 7. Components and subassemblies that are specifically derogated

Substances	***Sub-assembly or component part***	***Scope of the derogation***	**Assessment an verification**
Metal additives and coatings	i) Metal components	Stainless steel alloys and scratch resistant coatings containing nickel metal classified with H351, H373 and H412. *Derogation condition:* The migration of metallic nickel from scratch resistance coatings on parts of a casing where they may in direct and prolonged contact with skin shall not exceed >0.5 μg /cm^2/week.	Identification of steel parts by weight and location in the product Where external casing parts come into direct and prolonged skin contact a a test report shall be provided. *Test method:* EN 1811
Cathode materials	ii) Lithium ion and polymer batteries	Battery cell cathode materials classified with group 2 and 3 hazards. These shall include: - Lithium cobalt oxide - Lithium manganese dioxide - Lithium iron phosphate - Lithium cobalt nickel manganese oxide	Declaration to b provided by the batter or cell supplier supporte by documentation t verify hazar classifications.
Solvents and salts		Electrolyte solvents and salts classified with group 2 and 3 hazards. These shall include: - Propylene carbonate - Ethylene carbonate - Diethyl carbonate - Di-Methyl Carbonate - Ethyl methyl carbonate - Lithium Hexafluorophosphate	

Assessment and verification: The applicant shall provide a declaration of compliance with criterion 2 c. The declaration shall be supported by the list of flame retardants, plasticisers, steel additives and coatings, cathode materials, solvents and salts used in the sub-assemblies and component parts listed in Table 5.together with declarations about their hazard classification or non-classification.

The following information shall be provided to support declarations of the hazard classification or non-classification for each substance and material:

- The substance's CAS, EC or list number;
- The physical form and state in which the substance is used;

- Harmonised CLP hazard classifications;
- Self-classification entries in ECHA's REACH registered substance database [45].

Self-classification entries from joint submissions shall be given priority when comparing entries in the REACH registered substance database.

Where a classification is recorded as 'data lacking' or 'inconclusive' according to the REACH registered substance database, or where the substance has not yet been registered under the REACH system, toxicological data meeting the requirements in Annex VII to the REACH Regulation shall be provided that is sufficient to support conclusive self-classifications in accordance with Annex I of the CLP Regulation and ECHA's supporting guidance. In the case of 'data lacking' or 'inconclusive' database entries, self-classifications shall be verified, with the following information sources being accepted:

- Toxicological studies and hazard assessments by ECHA peer regulatory agencies [46], Member State regulatory bodies or Intergovernmental bodies;
- A Safety Data Sheet fully completed in accordance with Sections 2,3,9,10, 11 and 12 of Annex II to the REACH Regulation;
- A documented expert judgement provided by a professional toxicologist. This shall be based on a review of scientific literature and existing testing data, where necessary supported by results from new testing carried out by independent laboratories using methods recognised by ECHA;
- An attestation, where appropriate based on expert judgement, issued by an accredited conformity assessment body that carries out hazard assessments according to the GHS or CLP hazard classification systems.

Information on the hazardous properties of substances may, in accordance with Annex XI to the REACH Regulation, be generated by means other than tests, for instance through the use of alternative methods such as in vitro methods, by quantitative structure activity models or by the use of grouping or read-across.

For the derogated substances and materials listed in Tables 6 and 7, the applicant shall provide proof that all the derogation conditions are met. Where test reports are required, they shall be valid at the time of application for a production model.

3.2.6 Summary rationale for the final criterion proposal

Summary rationale for the final criterion proposal
The criterion seeks to find a workable interpretation of Articles 6(6) and 6(7) of the Ecolabel Regulation. The starting point for the proposal has been a technical assessment of the best practice of leading manufacturers, together with an in-depth understanding of how they verify hazardous substance restrictions along their supply chains. This has resulted in a proposal consisting of three main elements: *2(a) Restriction of Candidate List SVHCs:* It was determined that front runner

[45] ECHA, *REACH registered substances database*, http://www.echa.europa.eu/information-on-chemicals/registered-substances

[46] ECHA, *Co-operation with peer regulatory agencies*, http://echa.europa.eu/en/about-us/partners-and-networks/international-cooperation/cooperation-with-peer-regulatory-agencies

OEMs can verify the non-presence of SVHCs at product level and, marking a higher ambition level, for defined ‘subassemblies’. Moreover, market leaders use the IEC 62474 restricted substance list to screen for the relevance of Candidate List substances in electronic products. IEC 62474 has therefore been proposed as a means to aid pre-screening and communication with suppliers.

2(b) *Substance-specific hazard restrictions:* The industry is more accustomed to communicating requirements for the non-presence of specific substances to suppliers than hazard restrictions. A sample of manufacturer's substance restriction lists were therefore analysed and a listing compiled for the Ecolabel criterion, with a focus on restrictions that restrict Group 1 and 2 hazards.

For each restriction specific substances have been identified, together with their hazard classification and a specification for how they shall be restricted. Combinations of laboratory tests and declarations are requested for verification. Reflecting current best practice, testing is proposed as being required for each supplier of identical components or sub-assemblies.

2(c)(i) Flame retardants and plasticiser hazard derogations: It was identified early in the process that front runner OEMs can only currently verify hazard classifications, and demonstrate progress on substitution.

An analysis of technical progress made by manufacturers in substituting hazardous flame retardants and plasticisers was carried out. This was used to identify which hazards may still require derogation jn order to permit the use of these alternatives.

Recognising the potential for *toxic emissions from the improper disposal of circuit boards and cables outside of the EU*, where they may be burnt or pyrolysed to recover metals and critical raw materials, applicants may comply with the derogation by passing a fire emissions test for poly brominated and polychlorinated dibenzo dioxins and furans and PAHS. This approach has the advantage of providing a technology-neutral means of encouraging safer

chemistry.

For flame retardants classified with Group 3 hazards, PAHs or halogen gas emissions testing is required to support voluntary claims for '*low halogen'* or '*halogen free low smoke*' components. For flame retardants classified with Group 2 hazards stricter conditions apply, with testing for dioxins, furans and PAHs required. The proposed emissions limits encourage improved performance compared to mainstream cable and PCB components.

2(c)(ii) Functional materials and subassembly hazard derogations: In addition to flame retardants and plasticisers, derogations have been granted for nickel in steel, battery cathodes and battery electrolytes. The latter are components of the high performance batteries required in criterion 3(b).

The approach taken to the assessment and verification of hazard classifications has been updated for this product group. A set of rules were agreed in discussion with ECHA to verify hazard classification based on the best available information in the REACH registered substance database. Only after this should non-EU sources be checked, with hazard assessments by ECHA peer agencies such as the US EPA, given priority ahead of SDS third party hazard verification systems and expert judgements.

A trend was identified for computer manufacturers investing in hazard substitution to use the US third party hazard verification tool Green Screen. This tool provides a sophisticated method for evaluating and benchmarking a substances hazard profile. Reflecting the use of such tools, and their anticipated wider adoption by OEMs and other ecolabels such as TCO, the EU Ecolabel hazard list has been aligned with Green Screen benchmark levels. The use of third party verified hazard assessment tools has also been permitted as a form of verification.

3.3 Cluster 3 – Lifetime extension

The LCA review and Technical Analysis revealed that attention should be paid to the extension of the lifetime of computers in order to reduce the overall environmental impacts caused by ever shorter lifecycles, primary extraction and manufacturing processes. This is particularly important for notebooks and tablets, where lower energy consumption in the use phase means that the production phase is proportionally more important. Product lifespans also tend to be shorter.

In the current criteria Decisions, requirements that influence the lifetime of computers are spread across different discontinuous criteria ("lifetime extension", "repairability"). To emphasise the importance of lifetime extension for computers, for the revision it is proposed to cluster the associated criteria, rearrange some of the sub-criteria and to complement them with new proposals.

3.3.1 Criterion 3(a) – Durability testing for portable computers

3.3.1.1 Technical background to the proposal

Failure and repairs required as a result of common accidents and stresses

With notebooks computers set to shortly become the most common form factor for computers in the market the conditions to which computers are exposed to have changed significantly. Notebooks may be exposed to a range of stresses and environmental conditions depending on whether they are used by students, business travellers or out in the field on, for example, industrial sites.

A study by warranty providers Squaretrade of 30,000 new laptops over their first three years of ownership highlighted a hardware failure rate of 20.4% and accidental damage level of 10.6% It was also highlighted a significant variation in reliability between leading brands, ranging from 15.6% to 25.6% [47].

[47] Squaretrade Inc, *1 in 3 laptops fail over 3 years*, USA, November 16th 2009 http://www.squaretrade.com/htm/pdf/SquareTrade_laptop_reliability_1109.pdf

A major survey of 300 businesses in the USA by market analysts IDC[48] looked at the improvement potential of 'Rugged' and 'semi-rugged' notebooks. They found that on average each year:

- 14.2% of notebooks required repair or replacement due to physical failure,
- 9.5% of notebooks required repair or replacement due to an accident.

The most common component failures and accidents that may occurred are illustrated in Figure 3.3.1 and Figure 3.3.2.

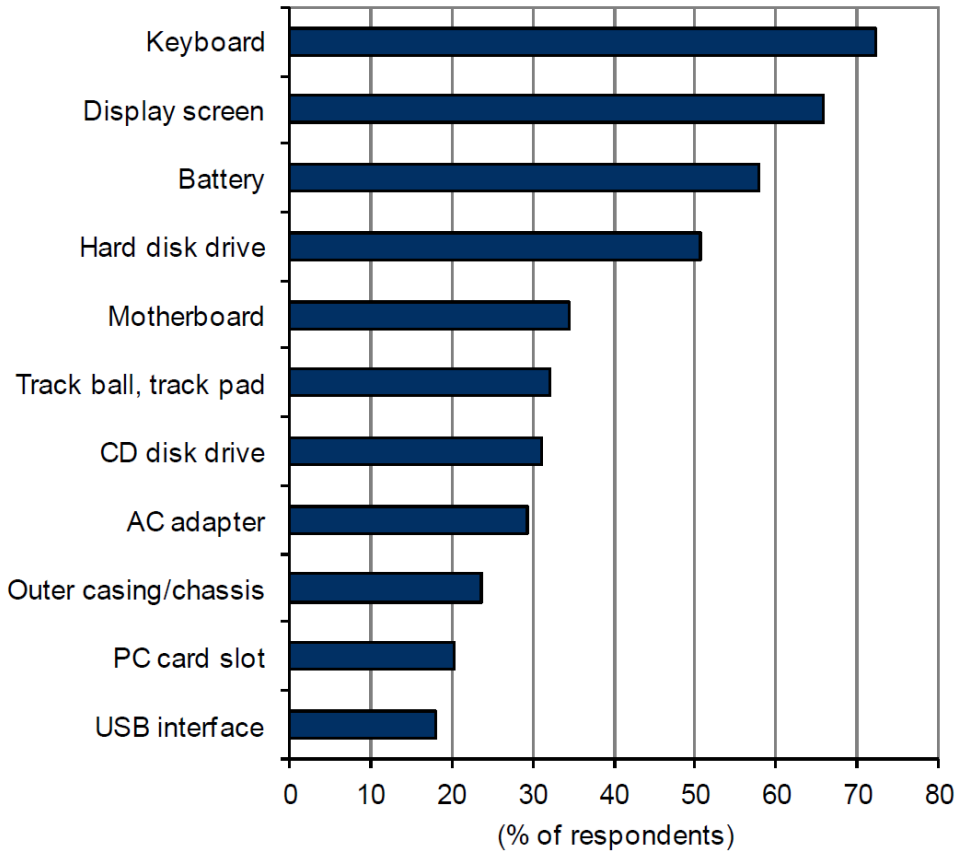

Figure 3.3.1 Survey results for the most common notebook components that suffered damage

Source: IDC (2011)

[48] IDC, *The Business case for ruggedized PC's*, USA, June 2012

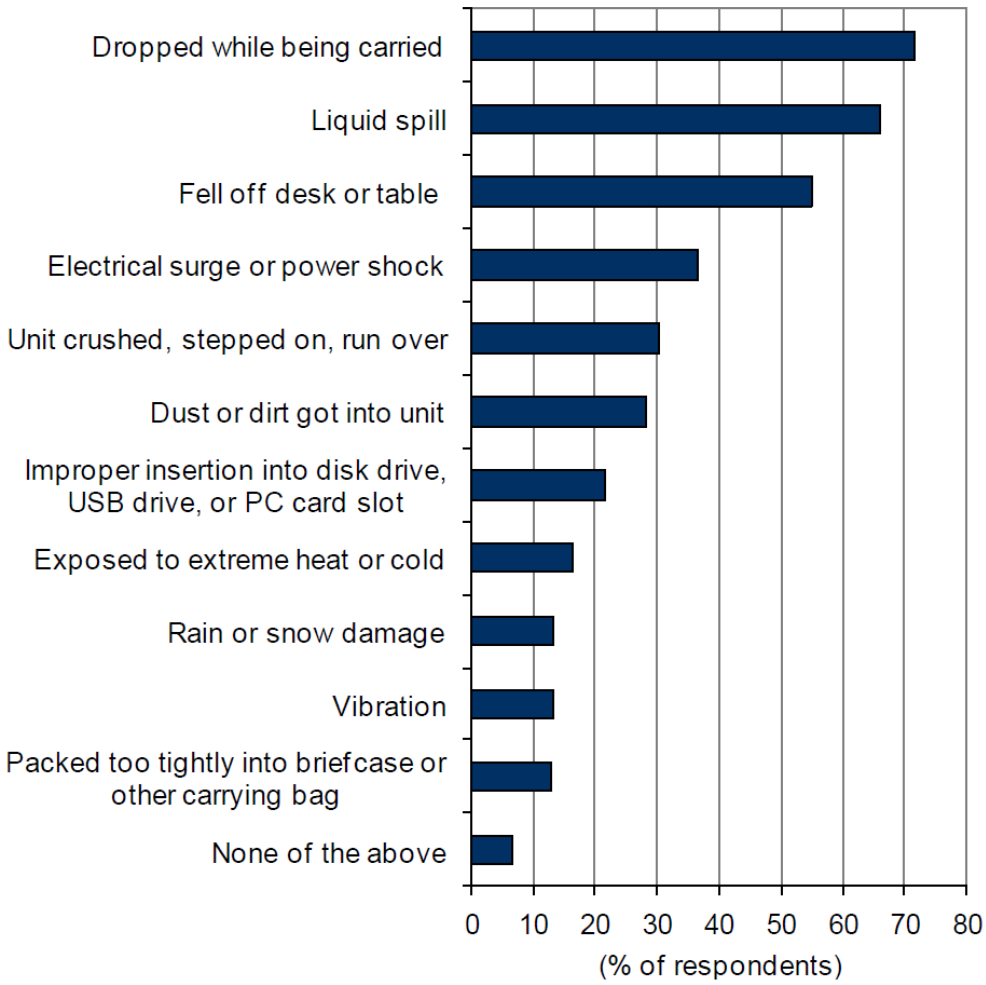

Figure 3.3.2 Survey results for the most common accidents that notebooks suffer

Source: IDC (2011)

Of most significance from the IDC study is the claimed extension of lifespan for a 'semi-rugged' notebook, on average from 2 years 5 months to 3 years 6 months. However, a direct correlation between this lifespan extension and the relative importance of specific design features is not possible to identify.

Scope and market selectivity of durability tests

At the AHWG2 stakeholders expressed concern about the extent of the testing and the implications for cost and selectivity of the EU Ecolabel. Further discussions with a leading notebook manufacturer experienced with this form of testing highlighted the

importance of a focus on vibration, shock and temperature to ensure in day to day use that a product is more durable.

Drop testing is different in that reflects an accident. The original drop test proposal of 122 cm was considered too strict and could be reduced to 70-80 cm in order to reflect an accidental fall from a desk or whilst carrying a notebook. The application of such a test to all models of Taiwanese manufacturer Asus suggests that a robust chassis and shell can be achieved without an unacceptable price premium. Moreover, this form of drop testing is now applied to well-known tablet brands such as Microsoft's Surface series [49].

The benefits of such as tests are reflected in the findings of Squaretrade (2009) which highlighted the reliability of Asus and Toshiba models. Sample failure rates for Toshiba are illustrated in Figure 3.3.3. The market availability of durability tested models, the tests applied and their pricing was indicatively reviewed. The results are summarised in Table 3.12.

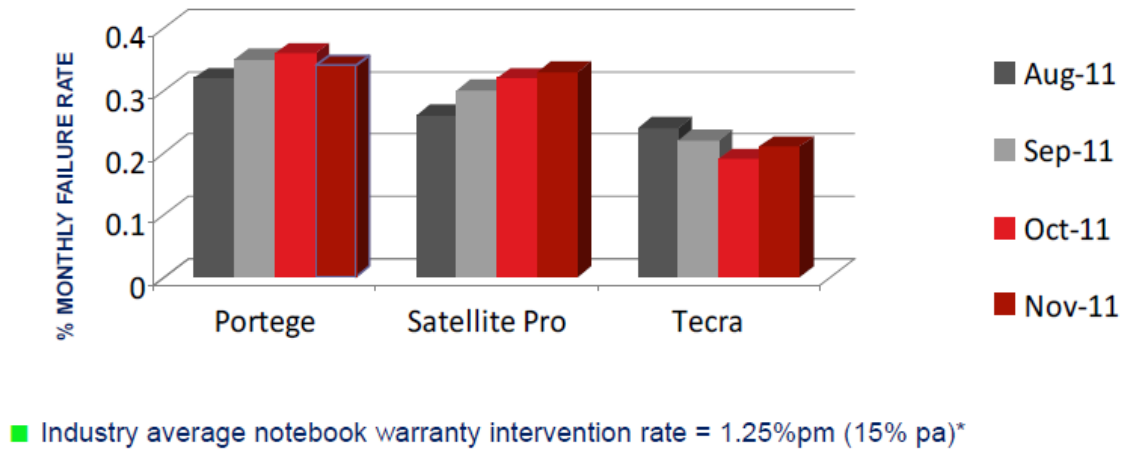

Figure 3.3.3 Sample monthly failure rates for durability tested notebook models

Source: Toshiba (2012)

[49] Information Week, *Microsoft surface drop tests*, Accessed 2012, http://www.informationweek.com/mobile/mobile-devices/video-microsoft-surface-drop-tests/d/d-id/1106957?

Table 3.12.Updated review of notebook durability testing applied by leading manufacturers

Manufacturer	Market segment (% with testing applied)	Models to which testing is applied	Scope of testing
HP	Consumer range (no models)	*No testing claims made for consumer models.*	n/a
	Business range (88% models)	250-i2/3/5, 350-i2/3/5, 350-G1,355-G2 series	Internal test specifications: • Water spill resistant keyboard
		Probook series 455-G1, 640-G1, 645-G1, 840-G1, 430-G2, 450-G2, 455-G2, 470-G2 Elitebook series 820-G1, 840-G1, 1040-G1, 725-G2, 745-G2, Folio 4010-G1, 8470p	Ínternal 'total test process' based on MIL-STD-810G standards: • Drop, shock, vibration, dust, humidity, altitude, temperature range, temperature shock Additional test specifications: • Keyboard strokes (7 year simulation) • Screen/lid open-close (6 year simulation)
Acer	Consumer range (no models)	*No testing claims made for consumer models.*	n/a
	Business range (14% models)	Travelmate P2, P4, B, Aspire S7	Internal test specifications: • Water spill resistant keyboard
		Travelmate P6	Internal test specifications: • Drop, shock, vibration, dust, temperature range • Screen/lid open-close • Dust ingress
Lenovo	Lenovo range (no models)	*No testing claims made for consumer models.*	n/a
	Thinkpad range (56% of models)	11E/T/X/L/W/G series	MIL-STD-810G standards: • Drop, shock, vibration, dust, humidity, altitude, temperature range, temperature shock Additional internal test specifications: • Screen pressure test • Water spill resistant keyboard • Hinge durability

Manufacturer	Market segment (% with testing applied)	Models to which testing is applied	Scope of testing
Dell	Consumer range (32% of models)	XPS	n/a
		Inspiron 3000,5000,7000 models	Internal test specification: • Temperature range • Screen lid open/close (25,000 times) • Keyboard (10 million key strokes) • Trackpad (1 million presses)
	Business range (46% of models)	Latitude series 3000, 5000 models,	MIL-STD-810G standards: • Shock, vibration, temperature range, temperature shock
		Inspiron series 3000,7000 models	Internal test specification: • Temperature range • Screen lid open/close (25,000 times) • Screen lid torsion (25,000 times) • Keyboard (10 million key strokes) • Trackpad (1 million presses)
Asus	All notebooks (100% of models)	All notebook series	Internal test specifications: • Drop, shock and vibration tests • Temperature range • Keyboard strokes simulation • Screen pressure test • Screen lid open/close (20,000 times)
	Business range (100% of models)	ProB and ProP series	Internal test specification with higher performance for: • Drop test (+100% increase in drop height) • Screen pressure test (+20%) • keyboard strokes (+100%)
Toshiba	Consumer range (no models)	*No testing claims made for consumer models.*	n/a
	Business range (58% models)	Tecra series Portege series	Highly Accelerated Lifetime Test simulating 3 years of use: • Drop, shock and vibration tests • Temperature range

Manufacturer	Market segment (% with testing applied)	Models to which testing is applied	Scope of testing
			• Screen pressure test • Water spill resistant keyboard

The findings indicate that comprehensive durability testing, including drop, shock and vibration tests, tend to be carried out for business models. Asus is, however, notable for applying more rigorous tests to its consumer and business models.

Moreover, whilst manufacturers' websites make a clear distinction between home and business models this is not always reflected in how models are sold to consumers by retailers. A mix of home and business models can be found on sale by high street and internet retailers. The consumer may therefore not know they are buying a 'business' model.

Test methods and benchmarks of durability

The terms ‘rugged’ and ‘semi rugged’ used by analysts and manufacturers are mainly defined with reference to the US Department of Defence’s MIL-STD-810G test standards[50] and the IP65 (Ingress Protection) standards[51]. The tests and their associated performance benchmarks for ‘semi-rugged’ relate to:

- Drop
- Vibration
- Shock
- Pressure at varying altitudes
- Temperature over a range between –29^{o}C to +60^{o}C
- Temperature shock
- Humidity

[50] US Department of Defence, *Test method standard MIL-STD 810G*, 31st October 2008
[51] UL, *Environmental ratings for enclosures based on Ingress Protection (IP) Code designations*, http://www.ul.com/global/eng/pages/offerings/services/hazardouslocations/ref/ingress/

Stakeholders expressed concern that reference should, however, be made to more familiar EN or IEC standards. The tests described by MIL 810-G and IP are for the most part reflected by similar test procedures in the IEC 60068 'environmental testing' series and the IEC 60529 'Degrees of protection provided by enclosures' standard. Where possible the proposed test methods have therefore been updated based on an approximation to the equivalent IEC standard. An exact equivalence could not be identified for the water spillage test, so instead reference has been made to the IEC definition of 'acceptable conditions for water ingress'.

The detailed test specifications were determined by cross referencing test definitions proposed by US market intelligence company Endpoint [52] with test specifications provided in-confidence by Toshiba and Asus, and the published test procedures of HP and Dell. For a number of tests – namely screen resilience, keyboard lifespan and hinge resilience - standardised methods could not be identified:

- Screen resilience, which has been updated to with reference to LCD quality tests for Asus, Toshiba, Apple and LG [53]. The inspection requirements could be further elaborated on in the User Manual based on manufacturer guidelines for LCD units.
- Keyboard lifespan is further specified to ensure that testing is weighted to reflect the most commonly used keys.
- Hinge failure was highlighted by a manufacturer as being a breakage that is particularly costly to repair. A test based on a set number of openings and closures of the screen is therefore proposed, allowing a minimum lifespan for the product to be defined.
- Liquid spillage is generally carried out for hot and cold drinks and either based on an even spillage or a spillage concentrated in specific locations.

[52] Endpoint Technologies Associated, *Redefining rugged: Assessing the spectrum of durability in the notebook market*, USA, 2008 and 2011

[53] AUO B133EW07 V0 *display specification for LED backlight with high color gamut* (Apple specification) *and* LG Display, *HD TFT specification for approval*, September 2012

The lack of standardisation has therefore required some flexibility in how the testing is specified.

Equipment suppliers for such tests can be identified [54], so the verification has been updated to require that the equipment and setup used for the test is reported. In all cases tests must be carried out by a third party.

For tablets a combination of the proposed screen resilience tests with a drop test is, based on the practices of leading manufacturers such as Microsoft and Fujitsu, as well as warranty providers such as Square Trade [55], considered to be essential to ensure a durable tablet product. The majority of manufacturers are already understood to use toughened glass such as Corning's Gorilla glass and Schott's Xensation glass, so there would be limited scope for market differentiation by having a specific performance requirement for the screen glass.

3.3.1.2 Final proposal for notebook durability criteria

Final criteria proposal

3(a) Durability testing of portable computers

(i) Tests that shall apply to notebook computers

The notebook computer model shall pass durability tests. Each model shall be verified to function as specified and meet the stipulated performance requirements after performing the mandatory tests in Table 8 and a minimum of one additional test selected from Table 9.

Table 8. Mandatory durability test specification for notebook computers

Test	Test conditions and performance benchmarks	Test method
Resistance to shock	*Specification:* A minimum of a 40G peak half-sine wave pulse shall be applied three times for a duration of a minimum of 6 ms to the top, bottom, right, left, front and rear side. *Functional requirement:* The notebook shall be switched on and running a software application during the test. It shall continue to function following the test.	IEC 60068 Part 2-27: Ea Part 2-47

[54] *See for example* Design & Assembly Concepts, http://www.dac-us.com/testandreliability.html

[55] Squaretrade, *New Research Rates Google's New Nexus 7 Tablet a "Medium Risk" 5 Breakability Score, Outscoring the iPad Mini*, August 2013 http://www.squaretrade.com/press/new-research-rates-googles-new-nexus-7-tablet-a-medium%20risk-5-breakability-score-outscoring-the-ipad-mini

Resistance to vibration	*Specification:* Randomised sinusoidal vibrations in the frequency 5Hz up to a maximum of 250Hz shall be applied for a minimum of 1 sweep cycle to the end of each axis to the top, bottom, right, left, front and back side. *Functional requirement:* The notebook shall be switched on and running a software application during the test. It shall continue to function following the test.	IEC 60068 Part 2-6: Fc Part 2-47
Accidential drop	*Specification:* The notebook shall be dropped from a height of 76 cm onto a non-yielding surface covered with a minimum of 30mm of wood. One drop shall be made on the top, bottom, right, left, front and rear side, as well as each bottom corner. *Functional requirement:* The notebook shall be switched off during the test but shall successfully boot up following each test. The casing shall remain integral and the screen undamaged following each test.	IEC 60068 Part 2-31: Ec (Freefall, procedure 1)

Table 9. Additional durability test specifications for notebook computers

Test	**Test conditions and performance benchmarks**	**Test method**
Temperature stress	*Specification:* The notebook shall be subjected to a minimum of four 24 hour exposure cycles in a test chamber. The notebook shall be switched on during a cold cycle at -25^{o}C and a dry heat cycle at +40^{o}C. The notebook shall be switched off during a cold cycle at -50^{o}C and dry heat cycling between +35 and +60^{o}C. *Functional requirement:* The notebook shall be checked that it functions following each of the four exposure cycles.	IEC 60068 Part 2-1: Ab/e Part 2-2: B
Screen resilience	*Specification:* Two loading tests shall be carried out. A load of 50kg shall be evenly applied to the screen lid. A minimum load of 25kg shall be applied to the centre of the screen to an area with a diameter of approximately 3cm. The notebook shall be placed on a flat surface during each test. *Functional requirement:* The screen surface and pixels shall be inspected for the absence of lines, spots and cracks after application of each loading.	The test equipment and setup used shall be confirmed by the applicant.
Water spill ingress	*Specification:* Two tests shall be carried out. A minimum of 30 ml of liquid shall be poured evenly over the keyboard of the notebook *or* onto three specific, separated locations, actively drained away	Acceptance conditions: IEC 60529 (water ingress)

	after a maximum of 5 seconds and the computer then tested for functionality after 3 minutes. The test shall be carried for a hot and a cold liquid. *Functional requirement:* The notebook shall remain switched on during and after the test. The notebook shall then be dismantled and visually inspected so as to pass the IEC 60529 acceptance conditions for water ingress.	
Keyboard lifespan	*Specification:* 10 million random keystrokes shall be applied to the keyboard. The number of keystrokes per key shall be weighted to reflect the most commonly used keys. *Functional requirement:* The keys shall then be inspected for their integrity and functionality.	The test equipment and setup used shall be confirmed by the applicant.
Screen hinge lifespan	*Specification:* The screen shall be fully opened and then closed 20,000 times. *Functional requirement:* The screen shall then be inspected for any loss of stability and hinge integrity.	The test equipment and setup used shall be confirmed by the applicant.

(ii) Tests that shall apply to tablet and two-in-one computers

The tablet computer model or the tablet component of a two-in-one computer model shall pass durability tests. Each model shall be verified to function as specified and meet the stipulated performance requirements for each test as specified in Table 10.

Table 10. Mandatory durability test specification for tablet and two-in-one notebook computers

Test	**Test conditions and performance benchmarks**	**Test method**
Accidential drop	*Specification:* The tablet shall be dropped from a height of 76 cm onto non-yielding surface covered with a minimum of 30mm of wood. One drop shall be made on the top, bottom, right, left, front and rear side, as well as each corner. *Functional requirement:* The tablet shall be switched off during the test but shall successfully boot up following each test. The casing shall remain integral and the screen undamaged following each test.	IEC 60068 Part 2-31: Ec (Freefall, procedure 1)
Screen resilience	*Specification:* Two loading tests shall be carried out. A load of 50kg shall be evenly applied to the screen lid. A minimum load of 25kg shall be applied to the centre of the screen to an area with a diameter of approximately 3cm. The notebook shall be placed on a flat surface during each test.	The test equipment and setup used shall be confirmed by the applicant.

	Functional requirement: The screen surface and pixels shall be inspected for the absence of lines, spots and cracks after application of each loading.	

Assessment and verification*:* The applicant shall provide test reports showing that the model has been tested and has met the functional performance requirements for durability. Testing and verification shall be carried out by a third party laboratory. Existing tests for the same model, carried out to the same or a stricter specification, shall be accepted without the need to retest.

3.3.1.3 Summary rationale for the final proposal

Summary rationale for the criterion proposal
Notebook and tablet computers are exposed to a wide range of environmental stresses during use. US market research has shown that this can result in a number of common accidents and, if the product is not designed to be durable, common component failures. Data from warranty returns suggest a 30% overall failure rate for notebooks in the first three years of ownership, with hardware accounting for two thirds and accidents one third. There may also be significant variation in hardware reliability between leading brands, with a failure range over three years of between 15.6% to 25.6% reported. Feedback from the warranty returns of manufacturers implementing durability tests for portable computers demonstrates that warranty claims and failure rates are reduced. Whilst stakeholders initially expressed concern that such tests were only applied to high end business notebooks, follow-up market research has showed that at least two major manufacturers apply such tests to all consumer models and that consumers purchase notebooks that are marketed as business notebooks. A basic set of durability tests have therefore been specified with reference to those tests commonly applied by the leading OEM's to models in the EU market and using (where possible) IEC environmental testing standards. Tests and benchmarks defined by Endpoint Technologies were cross referenced with the test specifications

of Toshiba, Asus, HP and Dell.

Three mandatory notebook tests have been defined – shock, vibration and accidental drop. Shock and vibration tests are understood from discussions with leading manufacturers to be fundamental in ensuring that a notebook is robust in day to day usage. Moreover, the most common accident identified by surveys is an accidential drop.

In addition, it is proposed that applicants choose at least one supplementary test from a list of the most commonly applied tests, so as to reflect potential accidents or environmental conditions. These comprise temperature stress, screen resilience, water ingress, keyboard lifespan and screen hinge resilience. This approach would give manufacturers flexibility to choose the test(s) based on priorities for the model and its target market, as well findings from their own warranty returns,

3.3.2 Criterion 3(b) – Rechargeable battery quality and lifetime

For notebook computers and tablet computers, the lifetime of the rechargeable batteries is a limiting factor to the overall lifetime of the whole product. Their production has also been identified as an environmental hot spot and is associated with the use of Critical Raw Materials such as cobalt.

Thus, a new criteria is proposed for inclusion in the revised criteria documents for computers addressing the lifetime of batteries. A linked requirement for the ease of extracting batteries from products is also proposed under Criteria cluster 4.

3.3.2.1 Technical background to the proposal

Stakeholder feedback highlighted that the durability of the batteries is one of the most important quality aspects for notebooks and other portable devices. Therefore, the inclusion of meaningful criteria regarding the “long-life” battery quality was considered a key issue and a robust and, at least, indicative testing method for battery lifetime should be identified.

Battery life and cycle length within today's market

Battery lifetime declarations are now required to be made for notebooks under the non-energy related requirements of the Ecodesign Implementing Measure Regulation (EU) 207/2013 Annex II Part 7.1 'Information to be provided by manufacturers' (from 1st July 2014):

> *(o) the minimum number of loading cycles that the batteries can withstand (applies only to notebook computers);*

Technical commentators suggest that 300-500 cycles is the de facto standard for lithium ion batteries[56]. The ITU (International Telecommunication Union) recently published Recommendation L.1010 on Green Batteries which proposes retention of 80% of capacity after 500 cycles as a benchmark for a long lasting battery[57].

Of the notebook manufacturers that dominate the EU market share Acer, Dell, Asus, HP and Toshiba all offer high end consumer or business models with over 7-8 hour battery life and 800 or 1000 cycle batteries. It was highlighted in discussions with a leading lithium ion battery manufacturer that it is more important to specify longer cycle endurance for notebooks where the battery cannot be readily changed by the consumer.

Notable amongst the leading OEM's is Apple who offers 80% retention of charge after 1,000 cycles as standard on new MacBook Pro and Air models[58]. The cost of these batteries is higher, with the costs for design/development/testing passed onto the OEM in the price of the battery, which may be up to 80% more expensive than 300-500 cycle performance.

Feedback from some OEM's also highlighted that consumers are, in practice, generally more interested in the number of hours that a battery will give them 'off grid'. For 15 inch+ screen desktop replacements battery life can now extend to an

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[56] Battery University, *How to prolong lithium based batteries*, http://batteryuniversity.com/learn/article/how_to_prolong_lithium_based_batteries

[57] ITU, *Green batteries solution for mobile phones and other hand-held information and communication technology devices*, Recommendation ITU-T L.1010, February 2014, http://www.itu.int/rec/T-REC-L.1010-201402-P

[58] Apple, *Determining battery cycle count*, Accessed March 2014, http://support.apple.com/kb/ht1519

estimated 7-8 hours+ (dependant on hardware combinations). For Ultrabooks it can extend from estimated 8-9 hours to up to 16 hours in one example. This performance is based on battery packs formed from cylindrical or, more usually because of the form factor, prismatic or lithium polymer cells[59]. Prismatic lithium ion cells are more durable because they swell less upon charging, resulting in reduced degradation and a longer life span.

Manufacturers of cylindrical and prismatic batteries with greater capacity and longer cycles include Samsung[60], Boston Power (supplying Asus)[61] and Amperex (supplying Apple)[62]. Boston Power carries the Nordic Swan Ecolabel for batteries, which requires 80% charge retention after 800 cycles[63].

Extending battery life using intelligent charging

The battery life cycle can be extended through the use of intelligent charging systems. Battery life span degrades more rapidly if there is a deep charge and discharge i.e. if a battery is charged to near 100% capacity and is then subjected to near full discharge. Minimising the 'depth of discharge' will therefore extend the lifespan of the battery, as illustrated in Table 3.13.

Table 3.13: Relationship between depth of discharge and number of cycles

Depth of discharge	Discharge cycles
100% DoD	300 – 500
50% DoD	1,200 – 1,500
25% DoD	2,000 – 2,500
10% DoD	3,750 – 4,700

Source: Battery University (2014)

Pre-installed software is now provided with some notebooks, for example with Apple, Asus and Toshiba products, which rewrites the firmware of the battery and limits

[59] Hewlett Packard, *Understanding lithium ion and smart battery technology*, www.hp.com
[60] Samsung SDI, *Cells, packs and prismatic battery products*, http://www.samsunglib.com/en/app/laptop.jsp
[61] Boston Power, *Sonata cell*, http://www.boston-power.com/resources/download/sonata-5300-data-sheet
[62] Amperex Technology, http://www.atlbattery.com/technology/en/technology-4.htm
[63] Nordic Ecolabelling of Rechargeable Batteries, Version 4.2, December 2010 – 31 December 2015

charging to approximately 80% of battery capacity. This has the potential to extend the battery life cycle by >50%.

Benchmarking and verifying performance

For the measurement of battery cycle endurance the industry standard is IEC EN 61960. IEC 61960 specifies both a standard endurance in cycles test at 0.2 I_t A and an accelerated endurance in cycles test routine based on increased charge of 0.5 I_t A within the tolerance of the battery. The latter was introduced into the last revision by CENELEC technical body CLC/TX 21X in 2011. An accelerated test based on EN 62660-1 is also understood to have potential for adaption to notebook and tablet batteries and is briefly discussed below.

Battery life can be verified using a range of different software packages and test routines. The most commonly used benchmarking softwares are Powermark by Futuremark [64] and Mobilemark by BAPCo [65]. Powermark and Mobilemark are professional benchmarking programmes which can be used to simulate combinations of different tasks using typical combinations of mainstream software on a portable computer until the battery power is run down.

For Powermark, Mobilemark and PCMark the scenarios and rules underlying each tool appear too complex to describe the underlying criterion. Reference is therefore proposed to be made in the criterion to a specific software packages and associated scenarios.

Legal and commercial battery guarantees

Stakeholders commented that, in contrast to the one year battery guarantee communicated by manufacturers, the guarantee must not be shorter than the legal guarantee period for the whole product, which is a minimum of 2 years. In practice manufacturers distinguish between physical defects that may occur – for example if the battery does not accept charge or prevents the computer switching on [66] - and a

[64] Futuremark, *Powermark*, Accessed 2014, http://www.futuremark.com/benchmarks/powermark
[65] BAPCo, *Mobilemark 2012*, Accessed 2014, http://bapco.com/products/mobilemark-2012
[66] Asus, *Battery information centre*, http://www.asus.com/us/support/Article/604/

gradual reduction in the charge capacity of the battery, which is an inevitable function of the chemical nature of batteries. For a typical lithium ion battery with a capacity of 300-500 cycles the decline will, in the majority of cases, occur within the first two years of ownership.

Some manufacturers offer a three or four year commercial guarantee with the option for battery replacement in the event of a defect occurring and, where longer cycle prismatic batteries are provided, there is a reduction in charging capacity below a stated threshold [67]. It should be noted, however, that the consumer must pay for this replacement service because it extends the legal guarantee coverage beyond what could be defined as a defect.

3.3.2.2 Final proposal for battery quality and lifetime

Final criterion proposal
3(b) Battery quality and lifetime (i) Minimum battery life: Notebooks, tablets and two-in-one computers shall provide the user with a minimum of 7 hours of rechargeable battery life after the first full charge. For notebooks this shall be benchmarked using either: - For home and consumer products the Futuremark PCMark 'Home' scenario. - For business or enterprise products the BAPCo Mobilemark 'Office productivity' scenario. For models which qualify for Energy Star $TEC_{graphics}$ allowances, the 'Media creation & consumption' scenario shall be used instead. (ii) Charging cycle performance: Notebook, tablet and two-in-one computer rechargeable batteries shall meet the following performance requirements, dependant on whether the rechargeable battery can be changed without tools (as specified in sub-criterion 3(d)): - Models in which rechargeable batteries can be changed without tools shall maintain 80% of their declared minimum initial capacity after 750 charging cycles; - Models in which rechargeable batteries cannot be changed without tools shall maintain 80% of their declared minimum initial capacity after 1000 charging cycles. This performance shall be verified for rechargeable battery packs or their individual cells according to the IEC EN 61960 'endurance in cycles' test, to be carried out at 25°C and at a rate of either 0.2 I_t A or 0.5 I_t A (accelerated test procedure). Partial charging may be used to comply with this requirement (as specified in sub-criterion 3(c)(iii)). (iii) Partial charging option for achieving cycle performance: The performance requirements described in 3(b)(ii) may be achieved using factory installed software and firmware which partially charges the battery up to 80% of its capacity. In this case partial charging shall be set as the default charging routine and the battery performance shall then be verified at up to 80% charging according to the requirements in sub-criterion 3(b)(ii). The maximum partial charge shall provide a battery life that complies with sub-criterion 3(b)(i).

[67] Toshiba, *Toshiba EU warranty extensión*, http://www.toshiba.eu/services/warranty-extension/laptops-tablets/ext103eu-vba/tab/terms-and-conditions/

(iv) Minimum guarantee: The applicant shall provide a minimum two year commercial guarantee for defective batteries.

(v) User information: Information about known factors influencing the lifetime of rechargeable batteries, as well as instructions on how the user can prolong battery life, shall be included in factory installed energy management software, written user instructions and posted on the manufacturer's website.

***Assessment and verification**:* The applicant shall provide a third party test report showing that the rechargeable battery pack or cell types making up the pack used in the product meet the specified rechargeable battery life and charging cycle capacity. Partial charging and the accelerated test method specified by IEC EN 61960 may be used to demonstrate compliance.. The applicant shall also provide a demonstration version of the energy management software and the text content of user instructions and website postings shall additionally be provided.

3.3.2.3 Summary rationale for the final criterion proposal

Summary rationale for the final criterion proposal

The proposed new criterion would introduce minimum requirements for the performance of rechargeable batteries in notebooks and tablets. Rechargeable Battery performance is an important factor influencing the perceived quality and lifespan of a portable computer, particularly when it is more difficult for the consumer to change the battery. The proposal addresses both the number of hours of usage the battery provides and the number of charging and discharging cycles that the battery will endure.

The battery time in hours is an important measure of quality for consumers, with a conservative minimum of 7 hours proposed. This will ensure a good minimum performance for desktop replacement notebooks. Commercial benchmarking software shall be used to measure this performance, with the software specified selected because it simulates demanding real life use patterns.

The number of charging cycles before the battery capacity declines by a fixed percentage is an important measurement of how long the battery will maintain the performance in hours communicated to the consumer. The charge cycle proposal establishes 80% retention after 750 and 1000 cycles as performance benchmarks. This performance reflects the best performing batteries on the market with brands such as Apple, for example, providing this specification on all notebook models.

Moreover, the proposal distinguishes between products based on how easy it is to change the battery (*see criterion 3(e) where this is defined further*). A longer cycle performance is proposed to be required for subnotebooks where the consumer cannot change the battery without invalidating the product's warranty.

Recognising that higher performance batteries can be up to 80% more expensive than 300-500 cycle batteries, and that longer battery life can also be achieved by reducing the depth of charge, some flexibility has been introduced into the proposal so as to allow for the benchmarks to be met by partial charging. This would allow a cheaper battery with a 500 cycle life to have an extended cycle life of approximately 750 cycles.

3.3.3 Criterion 3(c) – Data storage drive reliability and protection

3.3.3.1 Technical background to the proposal

Hard disk drives (HDD) are one of the computer components where according to WRAP (2011) [68] the most common faults are reported by several studies and product surveys. It is also understood that there can be significant variations in the reliability of HDD products. Durability/reliability is very important from an environmental perspective (certainly as well as from a user perspective). In this respect, the attempt to include meaningful quality criteria for HDDs was strongly supported.

It was commented early on that the same drives were used by small and large manufacturers. The main challenge raised by stakeholders was therefore ease of verification and the identification of a metric or system that will suit all manufacturers and components.

Follow-up OEM enquiry and review of expert literature

Feedback from four major OEMs suggested that similar quality parameters are applied across all HDD purchases for specific form factors, suggesting that comparisons would instead need to be made between HDD models or OEM requirements. The main points from the survey are summarised in Table 3.14..

[68] See http://www.wrap.org.uk/sites/files/wrap/Laptop%20case%20study%20AG.pdf

For notebooks, two physical design features were highlighted – free-fall sensors and shock absorption – which can be related based on field data to common stresses on a drive. SSD is an alternative solution because it has no moving parts.

Table 3.14: Summary of OEM feedback on HDD and SSD specifications

Hard Disc Drives (HDD)	
Reliability and durability specifications	Responses confirmed a set of standard OEM requirements for quality control including: • Error rate • Mean Time Between Failure • Annual Failure Rate • Load/unload endurance Operating shock, vibration and temperature range were particularly highlighted for mobile applications. Most defects are related to shock and vibration.
Physical design features	For notebooks free-fall sensors (accelerometers) are used in some drives for business models. Shock absorption is also specified, in some cases instead of free-fall sensors.
Improvement potential of features	No information was provided to verify the improvement potential of the quality control parameters.
Verification	Standard quality control and supplier qualifications processes are used, with all HDD required meeting the same requirements for each OEM. In the case of portable HDD protection by shock absorption this is verified by notebook drop and vibration tests.
Solid State Drives (SSD)	
Exemption from the criterion?	In general SSD should be exempted from general quality requirements. Most HDD failures are related to moving parts, which SSD do not have.
Reliability and durability specifications	General reliability and durability parameters are still required as part of quality control for SSD e.g. error rate, MTBF, AFR.

Technical research by drive manufacturer Western Digital and research by Strom et al (2007) for Samsung and Seagate suggested that physical protection of the HDD from external shocks that could damage the disk surface should be a priority for the EU Ecolabel. This is because head clearance – the air gap (or 'headspace') between the magnetic read/write head and the surface of the rotating disk – are now the most significant physical reliability issue for HDD, as highlighted in Table 3.15.

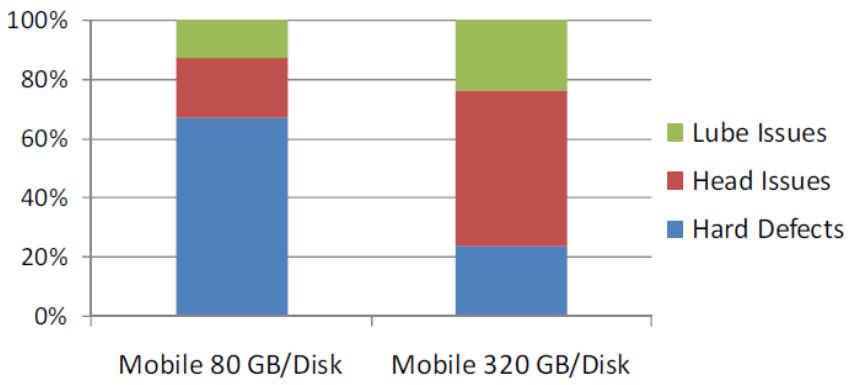

Figure 3.3.4. Reasons for field failures in notebook HDD

Source: Western Digital (2013)

Desktop and server drive reliability

The potential to use the metric 'Mean Time Between Failure' (MTBF) was discussed and was highlighted as being based on a statistical calculation across thousands of drives. Manufacturer Seagate instead recommend the use of Annual Failure Rate as a clearer indication of the probability of a HDD failing during its lifespan[69]. The AFR is calculated as follows:

AFR = 1 – exp(– Annual Operating Hours / MTBF)

So a MTBF of 1,600,000 hours represents an AFR of 0.55% for a server HDD running 24/7.

A Mean Time Between Failure (MTBF) for enterprise (server) drives of between 1,600,000 and 2,000,000 would represent a good performing drive which, based on a duty cycle of 168 hours per week, would translate into Annualised Failure Rates (AFR) of between 0.44% and 0.55%. For business or consumer desktops it is more difficult to determine a good performance based on available information, primarily because manufacturers do not tend to report MTBF for consumer or business drives. Intel suggest a MTBF of 700,000 which, assuming a duty cycle of 20% (1,752 hours) would equate to an AFR of 0.25%.

[69] Seagate, *Diving into MTBF and AFR: Storage reliability specs explained*, 26th April 2010, http://enterprise.media.seagate.com/2010/04/inside-it-storage/diving-into-mtbf-and-afr-storage-reliability-specs-explained/

Another metric relevant to enterprise (server) drives is 'bit error rate'. It is understood that bit errors (unrecoverable data) are symptomatic of head and writing problems. Expert commentary [70] suggests that a bit error rate of 1 in 10^{14} bits would not impact on a consumer or business desktop user but would not be suitable for enterprise (server) use. Instead bit error rates in the range of 1 in 10^{15} to 1 in 10^{16} bits are highlighted for enterprise grade drives.

Notebook drive protection features

Portable drives should be protected from shock, vibration and sudden drops during use. Common features identified included shock protection. free-fall sensors and solid state drives:

- The use of *physical damping to protect against vibration and shock* was identified as a design feature of 'rugged' and 'semi-rugged' notebooks (see section 3.3.4). Specifications for operational and non-operational shock tolerance of notebook HDD of four major manufacturers – Seagate, Western Digital, HGST and Toshiba – suggests a performance range of 300-400 (operational) to 900-1,000 (non-operational) G force.
- *Free-fall sensors* are either fitted externally or internally to a HDD and detect a sudden motion associated with a fall. The free-fall sensor specifications of four major manufacturers – Seagate, Western Digital, HGST and Toshiba – suggest a performance range of 150 – 300 milliseconds. In the worst case this would still protect against a drop whilst being carried by hand.

The increasing trend towards specification of solid state drives was also identified as a means of improving data protection because this type of drive has now moving parts.

[70] Newman, H, *How to choose a hard drive*, Enterprise Storage Forum, 27th February 2014, http://www.enterprisestorageforum.com/storage-management/how-to-choose-a-hard-drive-1.html

3.3.3.2 Final proposal for HDD durability and reliability criteria

Final criteria proposal

3(c) Data storage drive reliability and protection

i. Desktop computers, workstations, thin clients and small-scale servers

The data storage drive or drives used in desktops, workstations and thin clients marketed for business use shall have a projected Annualised Failure Rate (AFR) of less than 0.25%.

Small-scale servers shall have a projected AFR of less than 0.44% and a Bit Error Rate for non-recoverable data of >1 in 10^{16} bits.

The AFR shall be calculated based on the Mean Time Between Failure (MTBF). The MTBF shall be determined based on Bellcore TR-NWT-000332, issue 6, 12/97 or field collected data.

i. Notebook computers

The primary data storage drive used in notebooks shall be specified to protect the drive and data from shock and vibration. The drive shall comply with one of the following:

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

(ii) The HDD drive head should retract from the disc surface in less than or equal to 300 milliseconds upon detection of the notebook having been dropped.

(iii) A solid state storage drive technology such as Solid State Drive (SSD) or embedded Multi Media Card (eMMC) is used.

Assessment and verification: The applicant shall provide a specification for the drive or drives integrated into the product. This shall be obtained from the drive manufacturer and shall be supported by an independently certified technical report verifying that the drive complies with the specified performance requirements.

3.3.3.3 Summary rationale for the final criterion proposal

Summary rationale for the final criterion proposal

The protection of data and minimisation of downtime for repairs and/or data recovery is a priority for consumers. A criterion is therefore be proposed that addresses data storage drive durability and reliability.

Reliability is considered to the be main issue for stationary drives, with the commonly used industry metrics of Mean Time Between Failure – a statistical estimate for the reliability of a model of drive – and Annual Failure Rate – an annualised prediction weighted to reflect the estimated number of hours the computer will run for – used as the basis for the criterion.

A benchmark is only set for business desktop computers and enterprise (server)

drives because apart from defects that appear within the first few months, the majority of failures are only likely to manifest themselves in drives that run for significantly longer hours than consumer drives.

Protection is a more significant issue for portable computers. This is because conventional rotating drives can be easily damaged by shock or vibration. The most common damage is caused by abrupt contact between the magnetic head and the disk surface. Two options are therefore given for applicants to provide a more durable rotating drive. Shock and vibration testing, together with physical damping, can make a drive more resilient. The drive head can also be designed to retract from the disk if the computer is dropped or receives a shock.

An alternative and increasingly common approach used in subnotebooks is to specify a Solid State Drive. Although more expensive they have no moving parts and are therefore more durable. Costs are falling rapidly and so SSD and eMMC, which is used in tablets, are given as a further option for compliance with the criterion for portable computers.

3.3.4 Criterion 3(d) – Upgradeability and Repairability

To avoid an early replacement of the whole computer in the case of worn out or defective single components, the upgradeability and repairability of products are major factors that can facilitate a lifetime extension. Thus it is proposed to place a focus on the revision of these criteria. In addition, the ease of changing notebook and tablet batteries was also highlighted as a priority by stakeholders, complementing criteria proposal 3(b).

Present criteria, Decisions 2011/337 and 2011/330
"User repairability": The applicant shall provide clear instructions to the end-user in the form of a manual (in hard or soft copy) to enable basic repairs to be undertaken. The applicant shall also ensure that spare parts are available for at least five years from the end of production of the personal computer and/or computer monitor / notebook computer. *Assessment and verification*: The applicant shall declare the product's compliance with these requirements to the competent body together with a copy of the repair manual.

3.3.4.1 Technical background to the proposal

Target components for upgrades and repairs

The upgradeability of computer products was identified as differing significantly;

- Desktop computers, desktop workstations and small scale server: still certain components can be more or less be easily upgraded (HDD, SSD, memory) or expanded by additional slots (graphics),
- Notebooks:
  - HDD/SSD, memory, CD/DVD/Blu-ray drive, rechargeable battery: some are easily be upgradeable, some are already glued in
  - Videocards for notebooks are not exchangeable separately, as mainly on-board graphic processing unit (GPU), i.e. integrated on motherboard
- Ultrabooks as sub-category of notebooks: The thinner and smaller the form factor, the more complicated is an exchange and upgradability of components; for the reason of saving space, most components are fixed by being glued in.
  - Mostly, neither HDD/SSD nor RAM is exchangeable against new components; either ultrabooks are secured with special screws or the RAM is soldered up with the motherboard[71]. Example for good upgradeability of HDD and RAM: ASUS Zenbook UX32DV[72] (onboard *plus* removable RAM).
  - Rechargeable batteries are mostly fixed and only replaceable by manufacturers. Examples for best practice: ASUS Zenbook UX32DV, Dell Latitude 6430u and Sony Vaio T13[73]
- In general: Motherboard and CPU are rather more difficult to exchange for upgrades; the exchange of the CPU is theoretically possible, however,

[71] Sources: www.com-magazin.de/praxis/hardware/20-fakten-zu-ultrabooks-7388.html; www.heise.de/newsticker/meldung/Oeko-Logo-EPEAT-winkt-Ultrabooks-durch-1729666.html 15.10.2012

[72] Source: www.ifixit.com/Teardown/Asus+Zenbook+UX32VD+Teardown/10120

[73] Source: www.onlinekosten.de/news/artikel/50054/2/Ultrabook-Beratung-Vor-und-Nachteile-der-duennen-Dauerlaeufer

meanwhile it is often soldered up with the motherboard for the reason of better heat dissipation.[74]

The components that have to be exchangeable have been further detailed based on further research and evidence; for repairs, keyboards, screen, battery and HDD are of relevance, for upgrades HDD/SSD, memory and battery.

An explicit distinction between repairs that might be undertaken by end-users and others only by professional repair services has not been made. Clarification is often provided in the product manual which repairs might be done by the consumer without affecting the manufacturers' guarantee/warranty. The criterion on repair service includes a requirement that it must not be limited exclusively to applicant's Authorised Service Providers.

The criteria on availability of spare parts have been further detailed regarding the possibility of being "original or backwardly compatible". The number of five years, however, has not been shortened as partly being required. For computer products, it seems that the type of models changes every year; in order to facilitate a real lifetime *prolongation*, the availability of spare parts for 3 years would only address the average lifetime of computers.

Provision of commercial guarantees

Regarding longer product guarantees, research by WRAP [75] concluded that longer standard guarantees or warranties maximise consumer pull for longer lifetimes. They are seen by consumers as a show of faith by the manufacturer in the lifetime of their product. An overview of the standard warranties provided by different manufacturers, is presented in Table 3.15.

[74] www.gamestar.de/hardware/praxis/notebooks/2323984/notebook_tuning_teil_1.html
[75] WRAP, *Electrical and electronic product design: product lifetime*, UK, January 2013; http://www.wrap.org.uk/sites/files/wrap/WRAP%20longer%20product%20lifetimes.pdf

Table 3.15: Overview of standard warranties provided by different manufacturers

Manu-facturer	Standard warranty				Opening of hardware allowed?
	PCs	Notebooks/ Netbooks	Notebook battery	Monitors	
Acer	• Consumer PCs: 1-2 years • Business PCs: 1-3 years	• Notebooks: 1-2 years • Netbooks: 1 year	6 months	• Consumer LCDs: 2 years • Professio-nal LCDs: 3 years	Upgrade of hardware not generally forbidden, but defects caused by improper repairs or incorrect components not covered by warranty
Apple	Generally 1 year				Allowed, when in handbook the exchange of components like RAM or HDD are described explicitly; if not in the manual, hardware may only be opened by Authorized Apple Service Provider (AASP)
Asus	2 years	2 years	1 year	3 years	Exchange of RAM and HDD allowed
Dell	Service against payment of a fee: 1 year				Components like RAM, HDD or cards are allowed to exchange
Fujitsu	2 years	2 years	1 year	3 years	Yes, e.g. RAM; generally warranty covers only original configurations
HP	2 years for certain product series	2 years for certain product series	Excluded from standard warranty	n.a.	Upgrade of hardware not generally forbidden, e.g. RAM, but defects caused by improper repairs or incorrect components not covered by warranty
Lenovo	1-3 years depen-ding on model	1-3 years depending on model	1 year	n.a.	Yes, e.g. RAM
LG	2 years	2 years	6 months	3 years	No, only by authorized / specialized dealers
Toshiba	n.a.	1-3 years depending on model	1 year	n.a.	Upgrade of hardware not generally forbidden, e.g. RAM, but defects caused by improper repairs or incorrect components are not covered by warranty

The reference to an extended warranty has been updated to reflect the language used in Directive 99/44/EC on the sale of consumer goods which refers to guarantees. A clause has been added to clarify how this relates to the legal obligation of the manufacturer (or seller).

Moreover, it has also been clarified that the three year commercial guarantee period referred to is inclusive of the minimum two year period of conformity, and that the same service shall be provided as a commercial guarantee, including pick-up and return, at no cost to the consumer.

Ensuring that batteries can be easily changed

Consideration of how easy it is for a notebook or tablet battery to be changed was raised by a number of stakeholders and is now considered by the Ecodesign Regulation for computers which imposes a requirement that from July 2014:

> *'If a notebook computer is operated by battery/ies that cannot be accessed and replaced by a non-professional user….manufacturers shall provide in the technical documentation, and make available on free-access websites and on the external packaging of the notebook computer, the following information 'The battery[ies] in this product cannot be easily replaced by users themselves'.'*

Moreover, Annex VII of the WEEE Directive and The Battery Directive 2013/56/EC require Member States to ensure that manufacturers design appliances to allow the readily removal of waste batteries by end-user or by qualified professionals that are independent of the manufacturer.

In order to define 'ease of extraction' benchmarks for the EU Ecolabel a sample of sub-notebook and tablet computers were analysed by the JRC [76]. The analysis of sub-notebooks took as its starting point the 28 models addressed by the Electronics

[76] Laura Talens Peiró, Fulvio Ardente, Fabrice Mathieux (2016) *Analysis of material efficiency of Energy related Product for the development of EU Ecolabel criteria, Analysis of product groups: personal computers and electronic displays*, Joint Research Centre

Takeback Coalition in their 2012 briefing [77]. The analysis of tablets took as its basis a study published by Fraunhofer IZM which disassembled and analysed 21 models [78]. In both cases JRC-IES analysed in further detail audio-visual material, available over the internet, in order to estimate the steps required to access and extract the battery packs. The steps required were codified and the number of models falling under each code determined.

Table 3.16 presents the results of the analysis carried out for the 28 subnotebook models. In addition to the number of steps, the tools required to extract the battery and the number of units from the sample found with such features are also included. The last column refers to the units (in percentage) that meet each of the dismantling codes defined.

The JRC's findings were that whilst there are a small number of subnotebook and tablet units on the market with battery packs easily removed by spring load release, most require the use of universal tools and/or the removal of glued or soldered-in contacts and fixings. The most common number of steps needed to extract battery packs *using only universal tools* are three for subnotebooks, and four for tablets.

For 46% of the subnotebook models studied the battery can be extracted by removing the base cover, unplugging the battery from the main printed circuit board (PCB) and then unscrewing it from the laptop chassis. Among the tablet models studied, 20% could be opened by using a spudger and screwdriver to open the casing, followed by unscrewing up to three connectors.

A further related issue identified by the Fraunhofer IZM study was the potential for metal (copper) tapes, adhesive strips and/or cables to prevent access to battery packs. It is therefore proposed that this issue is considered alongside soldering and gluing as a basic requirement for facilitating ease of access.

[77] Electronics Takeback Coalition, *Ultra-inconvenient*, 15th August 2012

[78] Fraunhofer IZM, *Disassembly analysis of slates: Design for repair and recycling evaluation*, Final report, August 2013.

Table 3.16. Steps required to extract batteries in selected sub-notebook models

Code	Embedded battery?	Steps	Number of steps	Tools	Number of units	% units
A	No	Spring-loaded release	1	none	1	4
B	No	Unscrew battery pack	1	Screwdriver	1	4
C	Yes	Remove base cover, unscrew and unplug battery pack	3	Screwdriver	13	46
1+C	Yes	Steps described in C plus one pre-step. For example, remove rubber feet and connector cover on the side	4	Screwdriver	2	7
2+C	Yes	Steps described in C plus two pre-step. For example, remove rubber feet, connector shell on the side and remove additional screws	5	Screwdriver	2	7
1+C+1	Yes	Steps described in C plus one pre-step and one post-step. For example, remove rubber feet, connector shell on the side, remove adhesives and unplug additional cables	5	Screwdriver	2	7
D	Yes	Remove base cover, remove adhesive, unscrew and unplug battery pack	4	Screwdriver	2	7
2+D	Yes	Steps described in D plus two pre-steps. For example, remove rear panel and HDD unit	6	Screwdriver	1	4
E	Yes	Remove base cover, connectors, lift tape, unscrew and unplug battery pack, and pull without disconnecting speakers cables	6	Screwdriver	2	7
F	Yes	Unscrew base cover, turn the computer and press the tab in to loosen the keyboard, unplug the keyboard cable, unplug and remove the palm rest, unscrew battery and lift it out of the laptop	6	Screwdriver	1	4
5+F	Yes	Steps described in E plus 5 pre-steps. For example, remove SD blank, unscrew and remove access door, remove the memory and remove screws	11	Screwdriver	1	4

Source: Peiró.L.T, Ardente.F and Mathieux.F (2016)

Final proposal for upgradeability and repairability criteria

Final criteria proposal

3(d) Upgradeability and Repairability

For the purpose of upgrading older components or undertaking repairs and replacements of worn out components or parts, the following criteria shall be fulfilled:

(i) Design for upgrades and repair: The following components of computers shall be easily accessible and exchangeable by the use of universal tools (i.e. widely used commercially available tools such as a screwdriver, spatula, plier, or tweezers):

- Data storage (HDD, SSD or eMMC),
- Memory (RAM),
- Screen assembly and LCD backlight units (where integrated),
- Keyboard and track pad (where used)

- Cooling fan assemblies (in desktops, workstations and small-scale servers)

(ii) Rechargeable battery replacement: The rechargeable battery pack shall be easy to extract by one person (either a professional user or a professional repair service provider) according to the steps defined below [79]. Rechargeable batteries shall not be glued or soldered into a product and there shall be no metal tapes, adhesive strips or cables that prevent access in order to extract the battery. In addition, the following requirements and definitions of the ease of extraction shall apply:

- For notebooks and portable all-in-one computers it shall be possible to extract the rechargeable battery manually without tools;
- For sub-notebooks it shall be possible to extract the rechargeable battery in a maximum of three steps using a screwdriver;
- For tablets and two-in-one notebooks it shall be possible to extract the rechargeable battery in a maximum of four steps using a screwdriver and spudger;

For sub-notebooks, ultrabooks, tablets and two-in-one computers simple instructions on how the rechargeable battery packs are to be removed shall be marked on the base cover of the product or provided in the user instructions.

(iii) Repair manual: The applicant shall provide clear disassembly and repair instructions (e.g. hard or electronic copy, video) to enable a non-destructive disassembly of products for the purpose of replacing key components or parts for upgrades or repairs. This shall be made publicly available or by entering the products unique serial number on a webpage. Additionally, a diagram shall be provided on the inside of the casing of stationary computers showing the location of the components listed in (i) can be accessed and exchanged. For portable computers a diagram showing the location of the battery, data storage drives and memory shall be made available in pre-installed user instructions and via the manufacturers website for a period of at least five years.

(iv) Repair Service / Information: Information should be included in the user instructions or on the manufacturer's website to let the user know where to go to obtain professional repairs and servicing of the computer, including contact details. During the guarantee period referred to in (vi) this may be limited to the applicant's Authorised Service Providers.

(v) Availability of spare parts: The applicant shall ensure that original or backwardly compatible spare parts, including rechargeable batteries (*if applicable*), are publicly available for at least five years following the end of production for the model.

(vi) Commercial Guarantee: The applicant shall provide at no additional cost a minimum of a three year guarantee effective from purchase of the product. This guarantee shall include a service agreement with a pick-up and return or on-site return option for the consumer. This guarantee shall be provided without prejudice to the legal obligations of the manufacturer and seller under national law.

Assessment and verification: The applicant shall declare the compliance of the product with these requirements to the competent body. Additionally, the applicant shall provide:

- A copy of the user instructions
- A copy of the repair manual and supporting diagrams
- A description supported by photographs showing compliance for battery extraction
- A copy of the guarantee and service agreement
- Pictures of any diagrams, markings and instructions on the computer casing

[79] A step consists of an operation that finishes with the removal of a component or part, and/or with a change of tool.

3.3.4.2 Summary rationale for the final proposal

Summary rationale for the criterion proposal
The criterion aims to ensure that the consumer is able to easily upgrade and/or repair an Ecolabel computer product. The list of key components has been checked and revised to focus on those with the most significant potential for failure or likely need for upgrade. Reflecting common practice the proposal allows for repairs under warranty to be carried out by a repair service provider. The continued availability of parts for a 5 year period has been updated with reference to backward compatibility. Responding to concerns relating to the trend for batteries to be embedded within products, research was carried out by JRC-IES in order to study more exhaustively the steps and tools needed to extract battery packs from sub-notebooks and tablet computers. With the trend towards batteries that are embedded in products battery removal has become a concern for both consumers and recyclers, who under the WEEE and Battery Directives must extract batteries safely in order to detoxify the product and ensure efficient recycling at the end of the product's life. The sub-criterion requires larger notebook batteries to be extracted without tools. However, recognising that subnotebooks and tablet batteries are more embedded in the majority of models on the market, the requirement for these form factors defines the smallest number of steps using a screwdriver. A basic requirement is set for all models to ensure that batteries are not soldered or glued into the product, and that tapes, cables and adhesive strips do not prevent access. A requirement to provide a commercial warranty of three years has been retained, being a demonstration to the consumer of a manufacturers confidence in the product. Moreover, the relationship between the manufacturers and sellers legal obligations under guarantee is clarified.

3.4 Cluster 4 – Design, material selection and end-of-life management

Similar to the cluster lifetime extension, the research results of Task 3 and Task 4 highlighted the need to focus attention on end-of-life (EoL) management of computers to reduce the overall environmental impacts since secondary resources from recycling can substitute primary production.

In the current criteria documents, requirements affecting the EoL-management of computers are distributed across several criteria ("Recycled content", "Design for disassembly"). To assign greater importance to the EoL of computers, it is proposed to cluster and rearrange the criteria so they focus on recycling and dismantling.

Present criteria, Decisions 2011/337 and 2011/330
"Recycled content": The external plastic case of the system unit, monitor and keyboard shall have a post-consumer recycled content of not less than 10% by mass. *Assessment and verification*: The applicant shall provide the competent body with a declaration stating the percentage post-consumer recycled content.

Present criteria, Decisions 2011/337 and 2011/330
"Design for disassembly": The manufacturer shall demonstrate that the personal computer/monitor can be easily dismantled by professionally trained personnel using the tools usually available to them, for the purpose of undertaking repairs and replacements of worn out parts, upgrading older or obsolete parts, and separating parts and materials, ultimately for recycling or reuse. To facilitate dismantling: (a) Fixtures within the personal computer shall allow for its disassembly, e.g. screws, snap-fixes, especially for parts containing hazardous substances; (b) Circuit boards, and/or other precious metal-containing components, shall be easily removable using manual separation methods both from the product as a whole and from specific components (such as drives) that contain such boards to enhance recovery of high value material; (c) All plastic materials in covers/housing shall have no surface coatings incompatible with recycling or reuse; (d) Plastic parts shall be of one polymer or be of compatible polymers for recycling and have the relevant ISO 11469 marking if greater than 25 g in mass; (e) Metal inlays that cannot be separated shall not be used; (f) Data on the nature and amount of hazardous substances in the personal computer shall be gathered in accordance with Council Directive 2006/121/EC and the Globally Harmonised System of Classification and Labelling of Chemicals (GHS). *Assessment and verification*: A test report shall be submitted with the application detailing the dismantling of the personal computer. It shall include an exploded diagram of the personal computer labelling the main components as well as identifying any hazardous substances in components. It can be in written or audio-visual format. Information regarding hazardous substances shall be provided to the competent body in the form of a list of materials identifying material type, quantity used and location.

3.4.1 Criterion 4(a) – Material selection and information

3.4.1.1 Technical background to the proposal

Sub-criterion 4(a)(i): Adopting a practical approach to plastics marking

Although some stakeholder comments claimed that plastic marking has little influence on recycling practices, other stakeholders reported that recyclers do use this information for their sorting activities. As the marking is widely established in practice, it is suggested to retain this requirement. The codes in ISO 1043-4 identifying flame retardants was identified as being particularly important.

In the new proposal, exemptions are made for cases where technical limitations or restrictions result in marking not being feasible. For example, transparent plastic parts of display units such as PMMA light guides, which are understood to be easy to identify, and printed circuit boards are exempted from this requirement. A technical justification shall be provided where an exemption applies.

Sub-criterion 4(a)(ii): addressing the 'recyclability' of plastics

Evidence from pilot studies on recyclability[80], dismantling studies such those carried out by JRC-IES [81] and Fraunhofer IZM (2013) [82], as well as feedback from recyclers, confirmed the importance of considering the recyclability of plastic components.

Two potential approaches were considered. The first based on a 'recyclability rate' calculation as specified in IEC 62635, reflecting a hypothetical scenario for EU end-of-life WEEE treatment. The second based on consideration of specific technical issues relating to combinations of plastics, metals and additives. Given that the former may change over time and is not comprehensive enough to address specific technical challenges associated with plastic components, it was decided to adopt the second approach.

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[80] Peeters.J.R, Vanegas.P, Tange.L, Van Houwelingen.J and J.R.Duflou, *Closed loop recycling of plastics containing Flame Retardants*, Journal of Resources, Conservation and Recycling, 84 (2014) p-35-43

[81] Ardente, F.; Mathieux, F.: *Integration of resource efficiency and waste management criteria in European product policies – Second phase. Report no 2, Application of the project's method to three product groups*. Joint Research Centre – Institute for Environment and Sustainability, Ispra, 2012

[82] Fraunhofer IZM, *Disassembly analysis of slates: Design for repair and recycling evaluation*, Final report, August 2013.

The potential for sub-criterion in 4(a) to verify the recyclability of plastic enclosures were mainly reviewed against the underlying criterion of successful US ecolabel EPEAT - the IEEE 1680.1 standard for the environmental assessment of computer products [83]. The IEEE 1680.1 criteria of relevance include:

- A requirement relating to the avoidance of paints of coatings that are incompatible with recycling;
- An option criterion that plastic enclosures shall not contain molded-in or glue-on metal unless the metal inserts can be easily removed;

The importance of addressing these points was highlighted by research and feedback on design for recycling. Concern was, however, raised by stakeholders about what constitutes compatibility with recycling. 'Compatible' is defined in EPEAT as being when:

> *'Paints and coatings on plastic parts are proven to be compatible with recycling processes if they do not significantly impact the physical/mechanical properties of the recycled resin. Significant impact is defined as >25g reduction in notched Izod impact at room temperature as measured using ASTM D256-05 [ISO 180].'*

Notable in this definition is the reference to a specific testing method for the physical/mechanical properties of recycled resin. For metal inserts the verification options include a listing of commonly available tools that can be used to remove a metal insert and a statement from a recycling company with electronics recycling expertise confirming that the product design meets the requirements.

Whilst the miscibility of plastic following the recovery and separation of dismantled products is a problem, the plastic/additive combinations used are, as a factor affecting recyclability, more directly controllable at the design stage. As has been previously highlighted, plastic combinations with additives such as flame retardants are a concern.

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[83] IEEE Computer Society, *Standard for Environmental Assessment of personal computer products*, IEEE Std 1680.1-2009, 5th March 2010.

Feedback from a major computer OEM confirmed that FRs are incorporated into plastic computer casings, even though this is not a regulatory requirement. Moreover, the ENFIRO WP8 LCA findings recommended expanding the recycling of plastics in such a way as to retain the functional value of FR's.

The requirements relating to the addition of flame retardants has been aligned with the same physical/mechanical test according to ISO 180 that is proposed for paints and coatings. The proposal is based on a mandatory criterion in IEEE 1680.1 (EPEAT) and reflects the tests used by Peeters et al (2014).

Sub-criterion 4(a)(iii):Feasibility and verification of recyclate content

This proposal is supported by evidence from leading manufacturers such as Dell [84], Lenovo [85] and Asus [86] of high levels of recycled content being achieved in notebooks casings, but recognises that there are still practical problems faced by even front runner manufacturers in consistently meeting a higher requirement, the threshold of 10% has been retained as a minimum requirement. However, in order to incentivise manufacturers wishing to work towards a high recycled content it is proposed that – following the example of cotton content – higher content claims may be displayed in Box 2 next to the Ecolabel.

The requirement is not limited to external plastics any more but shall now apply to the total plastic (by weight) in the product, excluding Printed Circuit Boards and display optical plastics. Additionally exemptions have been made for tablets, subnotebooks, two-in-one notebooks, and for products with metal casings where the remaining proportion of plastic would be much smaller. This reflects limited evidence for the use of recycled plastic in smaller form factor computers and the smaller proportional weight of recyclate this would suppose (e.g. indicatively <10g in a tablet with a plastic casing).

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[84] Dell, *Closed loop recycled content*, http://www.dell.com/learn/us/en/uscorp1/corp-comm/closed-loop-recycled-content

[85] Lenovo, *Post consumer and post industrial recycled content*, http://www.lenovo.com/social_responsibility/us/en/materials.html

[86] Green Electronics Council, *ASUS: Taiwan's Environmental Pioneer in EPEAT* http://greenelectronicscouncil.org/asus-taiwans-environmental-pioneer-epeat/

Concerns were raised at the first AHWG about the verification of recycled content. Given the existence of traceability standards such as EN 15343, and related national standards such as QA-CER (Belgium), which provide systems for tracing the original and flows of waste polymers, it is therefore proposed that a third party verification required is introduced.

3.4.1.2 Final criterion proposal for 4(a) Material selection and recyclability

Final criteria proposal

4(a) Material selection and recyclability

Applicants shall comply with, as minimum, criterion part (i) together with either part (ii) or part (iii).

(i) Material information to facilitate recycling:

Plastic parts with a mass greater than 25 grams for tablet computers and 100 grams for all other computers shall be marked in accordance with ISO 11469 and ISO 1043, sections 1-4. The markings shall be large enough and located in a visible position in order to be easily identified. Exemptions are made in the following cases:

- *Printed circuit boards, Polymethyl Methacrylate Board (PMMA) and display optical plastics forming part of display units;*
- *Where the marking would impact on the performance or functionality of the plastic part;*
- *Where the marking is technically not possible due to the production method;*
- *Where the marking causes defect rates under quality inspection, leading to an avoidable wastage of materials.*
- *Where parts cannot be marked because there is not enough appropriate surface area available for the marking to be of a legible size to be identified by a recycling operator;*

(ii) Improving the recyclability of plastic casings, enclosures and bezels:

Parts shall not contain molded-in or glued-on metal inserts unless they can be removed with commonly available tools. Disassembly instructions shall show how to remove them (see sub-criterion 3(d));

For parts with a weight greater than 25 grams for tablet computers and 100 grams for all other computers, the following treatments and additives shall not result in recycled resin with a >25% reduction in the notched izod impact when tested according to ISO 180:

- Paints and coatings
- Flame retardants and synergists

Existing test results for recycled resin shall be accepted provided that the recycled resin is derived from the same input material that the plastic parts of the product are composed of.

(iii) Minimum recycled plastic content:

The product shall contain on average a minimum 10% content post-consumer recycled plastic measured as a percentage of the total plastic (by weight) in the product excluding Printed Circuit Boards and display optical plastics. Where the recycled content is greater than 25% a declaration may be made in the text box accompanying the Ecolabel (see Criterion 6(b)). *Tablets, subnotebooks, two-in-one notebooks and products with a metal casing are exempt from this sub-criterion.*

***Assessment and verification**:*

The applicant shall verify recyclability by providing valid mechanical/physical test reports according to

ISO 180 and disassembly instructions. Valid test reports obtained from plastics recyclers, resin manufacturers or independent pilot tests shall be accepted.

The applicant shall provide the Competent Body with an exploded diagram of the computer or a parts listing in written or audio-visual format. This shall identify the plastic parts by their weight, their polymer composition, and their ISO 11469 and ISO 1043 markings. The dimension and position of the marking shall be visually illustrated and, where exemptions apply, technical justifications shall be provided.

The applicant shall provide third party verification and traceability back to plastic component suppliers for post-consumer recycled content claims. Average content claims may be calculated on a periodic or annual basis for the model.

3.4.1.3 Summary rationale for the final proposal

Summary rationale for the final criterion proposal

The revised criterion focussed on three important elements of materials selection and recyclability: i) plastics marking, ii) recyclability and iii) recycled content. Plastics marking is proposed as a mandatory requirement, recognising at the most basic level the importance of information about the polymers and additives used. Recognising that ii) or iii) are more challenging for applicants because they suppose specific design specifications, resin testing and/or supply chain management, applicants may choose which sub-criterion they comply with.

The requirements on *plastics marking* are applied based on 100g and 25g weight thresholds, reflecting the size and weight of the most significant plastic parts that may be present in different sized computer products. Exemptions have been introduced for certain components, such as display light guides, in order to ensure the criterion does not inhibit technical functions.

The proposal updates the requirements from the previous criterion in order align them with criteria supporting *recyclability* (as defined by IEC 62635) and *compatibility with recycling* in the electronic ecolabel IEEE 1680.1 (EPEAT), as well as reflecting feedback from technical literature, JRC-IES and the recycling industry on how plastics segregation and recycling can be facilitated.

The approach to verification of 'recyclability' has been strengthened with reference to specific dismantling requirements and mechanical/physical testing. The proposals

include a new focus on the recyclability and marking of plastics containing flame retardants. This is because plastics containing these substances are now entering the waste stream and pose specific challenges for recycling.

The minimum requirement for the *recycled content* of plastics has been retained at 10% but recognising that some manufacturers have achieved much higher recycled contents in casings, the potential to declare a higher content has been introduced, which would reward front runners. Smaller computer products are, however, exempted because there is limited evidence of progress for these products and the required recyclate content would be very small.

3.4.2 Criterion 4(b) – Design for disassembly and recycling

As was set out in the Task 3 and 4 reports, material recovery from computers is important because of the environmental impacts associated with resource extraction. This can be facilitated by appropriate design to allow for ease of disassembly and dismantling. Nevertheless, the current criteria requirements are not very specific regarding the dismantling process and the key components affected.

Of direct relevance to this EU Ecolabel criterion is the recommendation of the EU Raw Materials Initiative in 2010 that policy actions are undertaken to *'make recycling of raw materials-containing products more efficient'* including *'mobilising end of life products with critical raw materials for proper collection*'.

Proposals have therefore been developed that are focussed 'hot spot' components for environmental impacts during the production phase. The verification required reflects the state-of-the-art for disassembly tests and as proposed to facilitate manual (or automatic) dismantling under the Ecodesign Directive for displays.

3.4.2.1 Technical background to the criteria proposal

Design for repair v. design for disassembly

The criterion ‘design for disassembly’ has been renamed ‘design for disassembly and recycling’; the focus of this criterion is now clearly set on recycling by removing the

introduction "…*for the purpose of undertaking repairs and replacements of worn out parts, upgrading older or obsolete parts*…". Typically disassembly for repair or upgrade purposes is carried out significantly differently from disassembly for recycling: While the first one requires caution to avoid any damage, the latter can (at present) accept damage to parts as it solely aims at recycling.

The proposed new criterion is considered an improvement on the previous criterion because although a product may be easy disassembled for repair it may not be suitable for easy disassembly. It is economically viable to spend tens of minutes to repair a computer, but not more than few minutes for dismantling.

The time and complexity of disassembly are a proxy for the cost effectiveness of dismantling to extract components that are valuable from both a life cycle and resource efficiency perspective. Research suggests that this will remain the case even if dismantling is, in the future, carried out robotically [87].

Moreover, strategic concerns about Critical Raw Materials are also becoming more significant in policy making. As was highlighted in Section 3.4.2.2 in general CRMs can only be efficiently recovered by early stage manual dismantling and separation of components e.g. PWBs, capacitors, HDDs.

A further issue to highlight is battery removal. This is a legal requirement for detoxification before shredding under the WEEE Directive. This may have implications for some designs and models, as was analysed in Section 3.4.2.2.

Identifying metal, CRM and plastic components of life cycle significance

LCA (Life Cycle Assessment) studies for desktop, notebook and tablet computers[88] were screened further in order to identify hot spots relating to specific metals, CRM's or plastics. In addition, bills of materials (BOM) for a notebook computer and a

[87] R. Knoth, M. Hoffmann, B. Kopacek, P. Kopacek, and C. Lembacher, *Intelligent disassembly of electronic equipment with a flexible semi-automatic disassembly cell*, Austrian Society for Systems Engineering and Automation.

[88] Cf. http://susproc.jrc.ec.europa.eu/computers/stakeholders.html, Task 3 report

desktop computer were used as a further reference for components that should be addressed by the criterion – see Table 3.17 and Table 3.18 [89].

It can be seen that CRM's are concentrated in a small number of main components, primarily the motherboard, batteries, HDD, optical drives and LED backlights. Sub-components can then be identified that would then require extraction in order to recover the CRM's – for example, capacitors containing tantalum, magnets containing neodymium, LED cells containing gallium.

Table 3.17: Indicative occurrence of high value metals and CRM's in an indicative notebook computer

Metal	Content per notebook (mg)	LCA hot spot	EU CRM	Occurrence in the notebook
Cobalt	65,000		✓	Lithium ion batteries
Neodymium	2,100		✓	HDD motors and accelerators (70%) Loudspeakers (30%)
Tantalum	1,700		✓	Motherboards capacitors (90%) Other PCB capacitors (10%)
Silver	440	✓		Motherboard (57%) Other PCB's (43%)
Praseodymium	270		✓	HDD accelerators (53%) Loudspeakers (47%)
Gold	100	✓		Motherboard (54%) Other PCB's (46%)
Dysprosium	60		✓	HDD accelerators
Indium	40		✓	Display and LED Backlights
Palladium	40		✓	Motherboard (64%) Other PCB's (36%)
Platinum	4		✓	HDD platters
Rare Earths [a]	2.48		✓	LED backlights
Gallium	1.6		✓	LED backlights

Notes:

a) Yttrium, gadolinium, cerium, europium

[89] Oeko-Institut, *Recycling critical raw materials from waste electronic equipment*, Commissioned by the North Rhine-Westphalia State Agency for Nature, Environment and Consumer Protection, 24th February 2012 *and* Oeko-Institut, *Informal e-waste management in Lagos, Nigeria – socio-economic impacts and feasibility of international recycling operations*, UNEP SBC project, June 2011

Table 3.18: Indicative occurrence of high value metals and CRM's in an indicative desktop computer (without display)

Metal	Content per desktop (mg)	LCA hot spot	EU CRM	Occurrence in the notebook
Steel	6,737.50	✓		Chassis and enclosure
Plastics	1,579.55			Enclosure, cables, peripherals
Aluminium	550.21	✓		Chassis, capacitors, HDD platters
Copper	413.225	✓		Circuitry, cables,capacitors
Zinc	25.94			-
Tin	19.57	✓		Solder
Antimony	18.58		✓	Solder, flame retardants
Nickel	12.70	✓		Metal plating
Neodymium	5.87		✓	HDD motors and accelerators Loudspeakers
Silver	1.70			Motherboard and other PCB's
Gold	0.26	✓		Motherboard and other PCB's
Palladium	0.12		✓	Motherboard and other PCB's
Chromium	0.02			Coatings
Ceramics & others	366.04			Heat sinks, power supply units and capacitors

The market potential and need for dismantling and CRM recovery

The collection of WEEE in Europe has grown rapidly since the introduction of the WEEE Directive in 2003 and this is set to increase further as the recast WEEE Directive is transposed at a European level. Whilst it is possible to identify components and sub-components for selective extraction it does not, however, follow that their extraction is currently economically or technically feasible.

The main plastics fraction (e.g. PC/ABS casing), steel and aluminium chassis, alloy casings (painted or unpainted), rechargeable lithium ion batteries, capacitors with a diameter larger than 2.5 cm, external power cables and Printed Circuit Board's larger than 10 cm^2 are generally extracted and passed on to the relevant markets for materials recycling.

From a resource point of view, leading actors in the specialist metals and CRM market claim that some manual pre-treatment, including complete removal of PCBs and other components such as HDD's, followed by subsequent recovery of the precious metals would enable a significantly more efficient recovery of various metals, CRM's and REE's[90]. Taking silver, gold and palladium as examples the recovery rate could be increased in selected scenarios from 12-26% to 90%.

The market position with regards to specific component parts of computers and displays is briefly summarised below:

- Plastic casings: Despite the prevalence of shredding the recent REWARD/EFRA pilot study highlights the importance of plastics marking and the provision of information about the FR's used as being important to facilitate recovery and recycling[91].
- Printed Circuit Boards (PCB's): The main economic aim of recovering PCB's is to recover the copper, gold, silver and palladium. However, other critical metals such as tantalum in capacitors are lost in this process – so-called 'dissipative losses'.
- LCD/LED display units: Display organic components (liquid crystals, polarisation filters, resins) are generally shredded and may then be incinerated. The indium contained in the displays is generally lost through dissipation[92]. Germany is understood to be considering storage of dismantled display units for recycling at a later date. Several mobile pilot plants are being developed to recover metals like copper, manganese, zinc, yttrium, indium from WEEE by hydrometallurgical processes.
- LED backlights: The CRM's and rare earth metals used in the manufacture of LED backlight units are related to doping and luminescence. They can include indium, gallium, cerium, europium, yttrium and gadolinium.

[90] C. Hagelüken and C. E. M. Meskers, *Complex life cycles of precious and special metals*, Chapter 10 from *Linkages of Sustainability* (2010) Strüngmann Forum Report, Edited by Thomas E. Graedel and Ester van der Voet.
[91] EFRA (2013) *Recycling of plastics from LCD television sets*
[92] See Oeko Institut (2012)

- PMMA display light guide: The plastic light guides within an LCD display constitute a large proportion of the plastic used in a TFT display. It is readily identified however without prior manual separation it may be dispersed among other shredded fractions
- Hard Disk Drives (HDD's): HDD contain Rare Earth Metals such as neodymium from magnets. Larger 3.5 inch HDD formats used in desktop computers, servers and datacentres are of interest in terms of the quantity of materials for recovery. Their physical design can, however, hamper recovery. Industry initiatives to recover REE's from HDD's are being developed by Hitachi amongst others.
- Lithium ion batteries: Lithium ion batteries are addressed by the collection requirements under the Batteries Directive 2006/66/EC but it is understood that their recovery rate is currently low, with a recent report claiming as low as 5%[93].

Assessment and verification of the dismantling test

It is proposed to modify the time-based criterion developed for Displays to focus on applicants carrying out a disassembly test in order to measure:

- how many steps are required,
- their complexity, and
- the associated tools required.

The benefit of this knowledge was demonstrated by JRC-IES's (2014) analysis of battery extraction summarised in Section 3.3.2.4 and the study by Fraunhofer IZM (2013) used as evidence for tablet computers. By carrying out the test knowledge would be gained on potential problems relating to the extraction of valuable sub-assemblies and components.

[93] ENDS Europe, *Low recycling rates for lithium batteries criticised*, 14th February 2013

The proposed test protocol has been revised accordingly and is presented in Box 3. In-line with comments from stakeholders the forms of verification accepted have been expanded to include disassembly by the manufacturer (or their designer/fabricator) in their own laboratory.

Box 3. Revised outline protocol for a product disassembly test

Terms and definitions

- Target parts and components: Parts and/or components that are targeted for the extraction process.
- Disassembly step: An operation that finishes with the removal of a part or with a change of tool.

Operating conditions for the extraction

- Personnel: The test shall be carried out by one person.
- Test sample: The sample product to be used for the test shall be undamaged.
- Tools for extraction: The extraction operations shall be performed using manual or power-driven standard commercially available tools (i.e. pliers, screw-drivers, cutters and hammers as defined by ISO 5742, ISO 1174, ISO 15601).
- Extraction sequence: The extraction sequence shall be documented and, where the test is to be carried out by a third party, information provided to those carrying out the extraction.

Recording of the test conditions and steps

- Documentation of steps: The individual steps in the extraction sequence shall be documented and the tools associated with each step shall be specified.
- Recording media: Photos shall be taken and a video recorded of the extraction of the components. The video and photos shall enable clear identification of the steps in the extraction sequence.

3.4.2.2 Final proposal for design for disassembly and recycling criterion

Final criteria proposal
4(b) Design for disassembly and recycling For recycling purposes computers shall be designed so that target components and parts can be easily extracted from the product. A disassembly test shall be carried out according to the test protocol in Appendix 3. The test shall record the number of steps required and the associated tools and actions required to extract the target components and parts identified in (a) and (b). (a) The following target components and parts, selected as relevant to the product, shall be extracted during the disassembly test: All products (i) Printed Circuit Boards relating to computing functions >10 cm² Stationary computer products (i) Internal Power Supply Unit (ii) HDD drives

Portable computer products
(i) Rechargeable battery

Displays (where integrated into the product enclosure)
(i) Printed Circuit Boards >10 cm2
(ii) Thin Film Transistor unit and film conductors in display units >100 cm2
(iii) LED backlight units

(b) At least two of the following target components and parts, selected as relevant to the product, shall also be extracted during the test, following-on in the test from those in (a):

(i) HDD drive (portable products)
(ii) Optical drives (where included)
(iii) Printed circuit boards ≤ 10 cm2 and > 5 cm2
(iv) Speaker units (notebooks, integrated desktops and portable all-in-one computers)
(v) Polymethyl Methacrylate (PMMA) film light guide (where the screen size is >100 cm2)

Assessment and verification: The applicant shall provide a 'disassembly test report' to the competent body detailing the adopted disassembly sequence, including a detailed description of the specific steps and procedures, for the target parts and components listed in (a) and (b),

The disassembly test may be carried out by:
(i) The applicant, or a nominated supplier, in their own laboratory, or;
(ii) An independent third party testing body, or;
(iii) A specialised recycling firm that is a permitted treatment operation in accordance with Article 23 of Directive 2008/98/EC or certified under national regulations.

3.4.2.3 Summary rationale for the final criteria proposal

Summary rationale for the criterion proposal
The proposal updates the previous 'design for recycling' criterion with a new and more specific criterion addressing 'design for disassembly and recycling'. The criterion requires a targeted disassembly of the product to be undertaken and recorded, with the aim of checking and recording the ease of extraction for specific sub-assemblies and component parts. This will in turn provide information to manufacturers and their designers on the ease (or otherwise) of dismantling their products. This approach is considered by DG ENV and JRC to be an important means of encouraging cost effective first stage (manual or robotic) dismantling and to support

better product design. First stage disassembly then allows valuable subassemblies and components such as PWB, HDD, batteries and LCD units which contain precious metals and critical raw materials. These subassemblies can then be aggregated for more cost effective reprocessing. It would also allow for the separation of plastic casings.

It is proposed that a core set of the highest value components are set as a requirement for all computer products. A separate, optional list of sub-components that are more challenging to extract are also identified. In order to draw attention to their importance extraction shall be demonstrated for a minimum number of these sub-assemblies, which in some cases are specific to computer form factors.

The final proposal has been modified to focus on dismantling steps and tools rather than the timing of extraction, as is currently proposed for the EU Ecolabel for Displays. This will serve to highlight problematic and time consuming steps in the dismantling of computers.

3.5 Cluster 5 – Corporate social responsibility

Within the hotspot analysis for computer products, some additional issues concerning social as well as environmental impacts were identified. Within this context it was agreed with stakeholders that the EU ecolabel for computers shall also introduce new requirements on corporate responsibility, meaning that they cannot be implemented and verified at product level but would need to be implemented at production and supply chain level.

3.5.1 Criterion 5(a) – Use of 'conflict-free minerals' during production

3.5.1.1 Technical background to the new criteria proposal

Computer products contain a wide range of scarce resources which are largely mined in the Democratic Republic of Congo, a conflict region, and according to sources under dangerous conditions, without sufficient maintenance of health and safety standards and in some cases by children.

However, instead of a criterion to exclude of the use of conflict minerals, bearing in mind the potential impact of a de facto embargo of minerals from a whole region that is economically and socially dependent on the mining industry, for the EU ecolabel revision a process oriented approach has been proposed to stimulate sustainable sourcing.

Responsible sourcing projects can be specified geographically by defining activities carried out within on the fringes of the resource-conflict hot spot (the eastern parts of the Democratic Republic of the Congo) and by their compliance with the *OECD Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas,* which was specifically tailored to the responsible sourcing of tin, tantalum, tungsten and gold.

The activity in this area was stimulated by the US Dodd-Frank Act which requires disclosure of the source of metals. Example projects on the ground included those working to establish traceability systems at a general level, such as the Public-Private Alliance for a responsible minerals trade and Solutions for Hope, and those

focussed on specific minerals, such as the Conflict-free tin initiative, the Tin Source Initiative and the Tantalum Initiative. Major computer manufacturers (.e.g. Acer, Apple, Dell, HP, Toshiba), final product assemblers (e.g. Foxconn, Flextronics) and sub-assembly/component manufacturers (e.g. Intel, NVIDIA, Motorola, AVX) are amongst the active members of these projects.

Towards an integrated EU approach

At the AHWG2 DG Trade outlined work by the Commission to address the Conflict-free sourcing for end-products containing tin, tantalum, tungsten and gold. The proposed approach is outlined in Joint Communication JOIN(2014)8 [94] which includes proposals for public procurement guidance.

Although the Communication highlights the significance of the OECD's Due Diligence guidance as a framework for action it cites fragmented compliance efforts, including a wide range of public and private initiatives, as well as the limited incentives to act, as barriers to further progress. Moreover, membership of existing projects supposes a substantial investment of time and resources which may be a barrier to smaller manufacturers.

A draft Regulation is proposed which would introduce a requirement for due diligence along the supply chain for EU importers, reflecting the approach promoted by the OECD. It describes a responsible importer due diligence self-certification requirement linked to the establishment of a list of responsible smelters and refiners. However, implementation will take some time so any Ecolabel criteria must therefore be pragmatic in the form of assessment and verification.

The Commission also proposed to broaden the geographical scope of conflict areas adopted under the Dodd Frank Act to any '*areas in a state of armed conflict, fragile post-conflict as well as areas witnessing weak or non-existing governance and security, such as failed states, and widespread and systematic violations of international law, including human rights abuses*.'

[94] Joint Communication to the European Parliament and the Council on *Responsible sourcing of minerals originating in conflict-affected and high-risk areas: Towards an integrated EU approach*, JOIN(2014)8

3.5.1.2 Final proposal for conflict-free minerals criterion

Final criteria proposal
5(a) Sourcing of 'conflict-free' minerals The applicant shall support the responsible sourcing of tin, tantalum, tungsten and their ores and gold from conflict-affected and high-risk areas by: • Conducting due diligence in line with the OECD Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas, and • Promoting responsible mineral production and trade for the identified minerals used in components of the product in accordance with OECD and EU guidance within conflict-affected and high-risk areas. ***Assessment and verification:*** The applicant shall provide a declaration of compliance with these requirements together with the following supporting information: • A report describing their due diligence activities along the supply chain for the four minerals identified. Supporting documents such as certifications of conformity issued by the European Union's scheme shall also be accepted. • Identification of component(s) which contain the identified minerals, and their supplier(s), as well as the supply chain system or project used for responsible sourcing.

3.5.1.3 Summary rationale for <u>new criteria proposal</u>

Summary rationale for the final proposal
The proposed criterion takes a pro-active approach to the sourcing of tin, tantalum, tungsten and their ores and gold from conflict-affected and high-risk areas. This reflects the approach taken already by leading computer manufacturers, which rather than boycotting such areas seeks to support an improvement in working conditions. The requirements and verification have been aligned with the OECD's guidance on due diligence, with anticipation of the EU's certification scheme for conflict-free smelters which will introduce a third party verified supply chain conformity scheme. They also require applicants to demonstrate how they promote the sourcing of conflict-free minerals by providing verification of action for at least one mineral related to at least one component. This is deliberately flexible as it does not require applicants to join traceability projects. They can verify compliance at either: • final product level, as members of traceability projects (e.g. Apple, HP, Toshiba),

- by contracting final assemblers that are members of traceability projects (e.g. Foxconn), or;
- by specifying sub-assemblies or components manufacturer by suppliers who are members of traceability projects (e.g. Intel, NVIDIA, AVX)

In this way supply chain activity in conflict-affected and high-risk areas will be supported, supporting the development of traceability to improvement initiatives on the ground and demand for conflict-free minerals.

3.5.2 Criterion 5(b) – Labour conditions and human rights during manufacturing

3.5.2.1 Technical background to the new criteria proposal

Addressing key social hot spots and providing the right level of assurance

According to expert judgement, a basic linkage to the underlying principles of the 8 fundamental ILO labour conventions and (often weaker) national labour laws would not be sufficient enough to address the social hot spots specific to computers' manufacturing processes. Thus, as minimum criteria the underlying principles of the 8 ILO fundamental conventions should be supplemented by provisions in the underlying principles of further ILO conventions addressing working hours, remuneration and health and safety.

Reference to the underlying principles is important to emphasise in the criterion text, because ILO Conventions are intended to be ratified at national level, whereas for social auditing they are used as a reference at factory of company level.

In terms of remuneration, ILO's Minimum Wage Fixing Convention 131 (1970) specifies in Article 3 (a) and (b) that the following two elements are taken into consideration in determining the minimum wage:

- The Needs of workers and their families taking into account the general level of wages in the country, the cost of living, social security benefits, and the relative living standards of other social groups;

- Economic factors, including the requirements of economic development, levels of productivity, and the desirability of attaining and maintaining a high level of employment."

According to SA8000[95], in most countries these two considerations are odds and may not be weighted equally in the determination of the minimum wage. These wages also frequently do not reflect inflation and other factors that affect actual standards of living.

Lack of enforcement of even these minimal rates of pay is common, forcing workers to work excessive overtime just to earn the legal minimum wage. Due to this reason, the proposed EU Ecolabel criteria include an additional requirement on "living wage" being sufficient to meet the basic needs of personnel and to provide some discretionary income. For definition of "living wages", interpretations, implementation, auditing and evidence of compliance, reference is made to the SA8000 Consolidated Guidance on Remuneration[96].

Defining the scope of the criteria proposal

The social requirements are proposed only to address first-tier suppliers (final product assembly). This is due to the fact that first-tier suppliers (contract manufacturers) more and more act vertically within the supply chain from purchasing to final assembly. Moreover, social aspects regarding hotspots of raw materials extraction will be addressed more specifically by criterion 5(a) 'Use of conflict-free minerals'.

For most manufacturers, the final assembly of their ICT products takes place at a limited number of contract manufacturers. Providing a list of first-tier suppliers summing up to at least 90% of procurement expenditure for final assembly (see for example Apple's information on suppliers[97]) would facilitate the Competent Bodies to cross-check with the availability of independent audit reports as also being required

[95] Source: http://www.sa-intl.org/_data/n_0001/resources/live/SA8000Remuneration.pdf
[96] See http://www.sa-intl.org/_data/n_0001/resources/live/SA8000Remuneration.pdf
[97] Cf. http://www.apple.com/supplier-responsibility/our-suppliers/ and http://images.apple.com/supplier-responsibility/pdf/Apple_Supplier_List_2014.pdf

for verification. Online publication of audit reports would improve the overall transparency of the ICT supply chain.

Addressing perceived weaknesses with the industry Code of Conduct

Feedback from industry stakeholders requested alignment with the Electronic Industry Citizenship Coalition's (EICC) Code of Conduct. Although the EICC CoC provides a positive framework for action on social issues by manufacturers, it raises a number of concerns:

- The labour standards are not based on the fundamental ILO labour conventions but rather on the national laws which might be weaker in some countries.
  - The Freedom of Association and Right to Collective Bargaining requirements fall behind the Core ILO and SA8000 standards.
  - Moreover, the CoC only implies regional minimum wages and not wages sufficient to meet basic needs ("living wages").
  - Rights relating to employment security are not addressed.
- Monitoring is mainly based on self-evaluation and in the monitoring process, no independent trade unions or labour rights organisations are included. Controls of the self-evaluation of suppliers only take place on a random basis. Although EICC has a 'Validated Audit Process' (VAP) it is not a requirement.

Whilst explicit reference is not proposed to be made in the assessment and verification text, as all qualified social auditors should be promoted in order to support implementation of the Ecolabel, the intention is to recognise third party auditing by accredited SAAS (SA8000) and EICC VAP auditors . This is considered to provide greater scope for applicants who are members of EICC to comply with the criterion, albeit with stricter additional requirements relating to the audit process, ILO coverage and minimum/living wages.

Although the SA8000 audit process focusses in a similar way to the EICC VAP audit process on interviews with the employer and workforce, it also identifies consultation

with external stakeholders as being important. The SA8000 audit guidance describes how stakeholders shall be involved prior to the audit process [98]:

> *'The interested stakeholders to be consulted include: workers, trade unions, research institutions, NGOs, community organisations, and labor experts. The groups being consulted may be asked if any facility in the area has particular problems and/or for comments on a list of facilities including the audited facility, but auditors should not identify the applicant facility prior to certification.'*

This wider engagement is intended to assist auditors to 'build up a picture of working conditions at the enterprises in advance of the verification process'. The guidance specifically refers to the convening of meetings of local groups.

Cross-checking the provisions and safeguards against 'scandals'

Early in the revision process a case cited of a social criterion 'scandal' involved Samsung, who in May 2013 were awarded TCO certification for a Galaxy S4 smart phone model [99]. The scandal appears from NGO announcements to have related to the handling of chemicals (occupational health and safety) and workers rights (Freedom of Association).

A cross check of the provisions within the criterion proposal was made with the aim of ensuring that the issues raised in the cited Samsung case are addressed. The industry EICC code of conduct, TCO and SA8000 were also checked. This exercise highlighted that health & safety issues were not directly addressed within the criterion proposal, with chemical handling having been identified as a specific issue in the case of Samsung.

ILO Convention "Occupational Safety and Health" (No.155) and "Safety in the use of chemicals at work" (No.170) were identified as being relevant for the purposes of

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[98] Social Accountability International (2004) *Guidance document for Social Accountability 8000*,

[99] Uncited press release, *Global health and justice groups demand that TCO withdraw its sustainability certification award for Samsung's S4 smartphone* http://www.amrc.org.hk/system/files/Global%20health%20and%20justice%20groups%20demand%20that%20TCO%20withdraw%20Samsung%20certification.pdf

auditing. Convention No.155 has already been adopted for the EU Ecolabel for Textiles. Convention No 170 specifically addresses chemical handling and risk assessment in the workplace. Both provisions are specifically referenced in the consolidated guidance for the SA8000 standard [100].

How to address countries where collective bargaining is illegal

A cross check of the TCO criterion also highlighted a point raised in early discussions relating to countries where the right to freedom of association and collective bargaining via unions is restricted or banned, such as in China. The TCO social audit requirement 'Mandate A.7.1' states that *'in situations where the right to freedom of association and collective bargaining are restricted under law, workers shall be permitted to freely elect their own representatives*.' An alternative text proposed originates from UN guidance on implementation of the Global Compact [101],which states that "*the company shall recognise legitimate employee associations with whom it can enter into dialogue about workplace issues"*.

Introducing an option for verification by the public labour inspection system

During the consultation process it was proposed that the public labour inspection system could be used as a lower cost and more readily available alternative for verification of the criterion. The relationship between private CSR compliance schemes and public labour inspection systems implemented under the auspices of ILO Convention 1947 (No.81) [102] is the subject of current debate at international level. Concerns have also been raised about the cost of private compliance schemes being a potential barrier to SMEs, with the danger of a two tier system being indirectly promoted. On the other hand, in a joint statement made in April 2014, the European Commission and the ILO [103] stated that they:

[100] Social Accountability International, *Social Accountability 8000 International Standard*, http://www.sa-intl.org

[101] Castan Centre for Human Rights Law and the International Business Leaders Forum (2008) *Human rights translated: A business reference guide*, Office of the United Nations High Commissioner for Human Rights

[102] International Labour Organisation, C081 - Labour Inspection Convention, 1947 (No. 81), http://www.ilo.org/dyn/normlex/en/f?p=NORMLEXPUB:1:0

[103] European Commission, 28 April 2014. Press release http://europa.eu/rapid/press-release_IP-14-479_en.htm

'recognise the vital role played by labour inspectorates in prevention, advice and enforcement at enterprise level and acknowledge the complementary role that private compliance initiatives could play in improving working conditions. They both highlight the need to reinforce the capacity of labour inspection and enforcement institutions and the role of technical assistance and capacity building to that aim'.

This position clearly suggests that the criteria developed should recognise the potential for public labour inspectors to also provide verification. Part I, Article 3 of Convention No.81 states that the functions of a system of labour inspection are as follows:

(a) to secure the enforcement of the legal provisions relating to conditions of work and the protection of workers while engaged in their work, such as provisions relating to hours, wages, safety, health and welfare, the employment of children and young persons, and other connected matters, in so far as such provisions are enforceable by labour inspectors;

(b) to supply technical information and advice to employers and workers concerning the most effective means of complying with the legal provisions;

(c) to bring to the notice of the competent authority defects or abuses not specifically covered by existing legal provisions.

However, follow-up discussions with the ILO underlines that firstly, not all countries have ratified Labour Inspection Convention 1947 (No. 81)[104] (for example, China and Taiwan). Convention No.81 commits those ratifying it to put in place a labour inspection system. Secondly, that where Convention No.81 has been ratified there is the possibility of a lack of consistency in the quality of inspections between different countries and even localities.

In order to determine the robustness of a countries labour inspection system the first point of reference is proposed as ILO's NORMLEX database. This brings together supervision reports and comments on the status of implementation of Convention

[104] See ratifications by country, ILO NORMLEX http://www.ilo.org/dyn/normlex/en/f?p=1000:11001:0::NO:::

No.81 [105]. These can be used to form a general opinion, including highlighting potential areas of weaknesses or cause of concern, but may not in all cases provide a complete picture that can be useful at local level.

In order to provide a comparable level of verification with the private auditor option, and with reference to Articles 6, 7 and 12 of Convention No.81 it is considered that the following basic requirements would need to be fulfilled by a public inspector:

- Independence and impartiality from government and private influence;
- Adequately paid, with stability of employment and resourced to carry out the job;
- Adequately qualified and trained, with the ability to cover the relevant aspects i.e. labour conditions, worker's rights, health/safety;
- Knowledge of the local area and active engagement with wider stakeholders e.g. unions, employment agencies;
- Empowerment to enter premises freely and without prior notice any workplace liable to inspection (or audit) and to carry out any necessary enquiry to satisfy themselves that provisions are being observed..

Whilst these are fundamental requirements for a functioning labour inspection system, examination of example country profiles and supervision reports suggests that even in the EU some countries labour inspection system have been identified as having weaknesses. A summary comparison of the potential advantages and disadvantages of allowing verification by the public labour inspection system is presented in Table 3.19 below.

In order to ensure that (for the purpose of the EU Ecolabel) only audit reports are accepted from labour inspectors in countries where an adequate level of assurance is provided, it will be required that ILO supervision comments indicating whether the specific national labour inspection system is effective or not are taken into account. These are contained in the reports available in the ILO's NORMLEX database.

[105] See example for Korea, ILO NORMLEX, adopted in 2014, http://www.ilo.org/dyn/normlex/en/f?p=1000:13100:0::NO:13100:P13100_COMMENT_ID:3188497

Table 3.19 Comparison of the potential advantages and disadvantages of permitting verification by the public labour inspection system

Option	Potential advantages	Potential disadvantages
1. Reliance on third party, private verification	- Trained auditors, - Experienced in gathering evidence, - Vested interest in preventing scandals/securing further business - Already used by larger companies	- Implies higher costs for audits, - May not be familiar with local context, - Does not provide 100% prevention of 'scandals' occurring - The quality and reputation of the schemes used may vary
2. Allow for private *or* public verification	- Recognises complementary/preventative role for public inspectors, - Would reduce verification costs for SMEs and make the criterion more accessible, - Public inspectors may have longer term commitment to local improvement and can follow-up non-compliance with further enforcement action - Recognises the general position of the EC and ILO	- May not be possible to ensure that labour inspection system in a given local area provides adequate level of assurance (ILO monitoring information varies in its ability to provide accurate picture of local conditions), - Public system may only operate on a reactive basis (i.e. may not provide verification on demand), - Possible disparity in quality of verification if there is imperfect information on the public system.
3. Only allow public verification for SME applicants	- Reduces the barrier to those applicants with less financial resources, - Would allow existing compliance paperwork to be used.	- Marginalises the public sector role to small business, creating a two tier approach; - Relies on an effective local labour inspection system being available; - Possible disparity in quality of verification if there is imperfect information on the public system.

3.5.2.2 Final new criterion proposal

Final criteria proposal
5(b) Labour conditions and human rights during manufacturing Having regard to the International Labour Organisation's (ILO) Tripartite Declaration of Principles concerning Multinational Enterprises and Social Policy, the UN Global Compact (Pillar 2), the UN Guiding Principles on Business and Human Rights and the OECD Guidelines for Multi-National Enterprises, the applicant shall obtain third party verification supported by site audits that the applicable principles included in the ILO fundamental conventions and the supplementary provisions

below have been respected at the final assembly plant for the product.

Fundamental conventions of the ILO:

(i) Child Labour:
- Minimum Age Convention, 1973 (No. 138)
- Worst Forms of Child Labour Convention, 1999 (No. 182)

(ii) Forced and Compulsory Labour:
- Forced Labour Convention, 1930 (No. 29) and 2014 Protocol to the Forced labour Convention
- Abolition of Forced Labour Convention, 1957 (No. 105)

(iii) Freedom of Association and Right to Collective Bargaining:
- Freedom of Association and Protection of the Right to Organise Convention, 1948 (No. 87)
- Right to Organise and Collective Bargaining Convention, 1949 (No. 98)

(iv) Discrimination:
- Equal Remuneration Convention, 1951 (No. 100)
- Discrimination (Employment and Occupation) Convention, 1958 (No. 111)

Supplementary provisions:

(v) Working Hours:
- ILO Hours of Work (Industry) Convention, 1919 (No. 1)

(vi) Remuneration:
- ILO Minimum Wage Fixing Convention, 1970 (No. 131)
- Living wage: The applicant shall ensure that wages paid for a normal work week shall always meet at least legal or industry minimum standards, are sufficient to meet the basic needs of personnel and provide some discretionary income. Implementation shall be audited with reference to the SA8000 [106] guidance on "Remuneration";

(vii) Health & Safety
- ILO Occupational Safety and Health Convention, 1981 (No.155)
- ILO Safety in the use of chemicals at work Convention, 1990 (No.170)

In locations where the right to freedom of association and collective bargaining are restricted under law, the company shall recognise legitimate employee associations with whom it can enter into dialogue about workplace issues.

The audit process shall include consultation with external stakeholders in local areas around sites, including trade unions, community organisations, NGOs and labour experts. The applicant shall publish aggregated results and key findings from the audits online in order to provide evidence of their supplier's performance to interested consumers.

***Assessment and verification*:** the applicant shall certify compliance with these requirements by providing copies of certificates of compliance and supporting audit reports for each final product assembly plant for the model(s) to be ecolabelled.

Third party site audits shall be carried out by auditors qualified to assess the compliance of the electronics industry supply chain with social standards or codes of conduct or, in countries where ILO Labour Inspection Convention, 1947 (No 81) has been ratified, ILO supervision indicates that the national labour inspection system is effective and the scope of the inspection system covers the areas listed above 107, labour inspector(s) appointed by a public authority.

[106] Social Accountability International, *Social Accountability 8000 International Standard*, http://www.sa-intl.org

[107] See ILO NORMLEX (http://www.ilo.org/dyn/normlex/en) and supporting guidance in the User Manual

Valid certifications not older than 12 months prior to the application that are provided by schemes or processes that, together or in part, audit compliance with the applicable principles of the listed fundamental ILO Conventions and the supplementary provisions on working hours, remuneration and health & safety, shall be accepted.

3.5.2.3 Summary rationale of the final criteria proposal

Summary rationale for the criterion proposal

The proposal to address labour conditions during manufacturing reflects the significance of social issues in the computer manufacturing supply chain. This is evidenced by the investment made by industry to address working conditions through an industry Code of Conduct. In this respect, high level reference is made in both the Act and the Annex criteria to a number of reference documents, namely:

- the ILO Tripartite Declaration of Principles concerning Multinational Enterprises and Social Policy,
- the UN Global Compact (Pillar 2),
- the UN Guiding Principles on Business and Human Rights, and
- the OECD Guidelines for Multi-National Enterprises

The proposal seeks to provide a minimum acceptable level of assurance based on third party auditing of final assembly sites. Auditing would be carried out against the underlying principles of ILO fundamental conventions, which are commonly used a reference for social auditing. Specific additional ILO conventions and points for verification relating to working hours, remuneration and health & safety have been added, reflecting 'hot spot' social issues for computer manufacturing. A clause has also been included recognising that in some countries such as China, some flexibility is required because of laws restricting unions.

The form of verification addresses two key identified weaknesses of the industry Code of Conduct. Firstly, third party auditing is a requirement so as to ensure impartiality. Secondly, the stakeholders involved in the audit process have been expanded beyond the workforce so as to better detect possible breaches of the requirements, reflecting best practice from SA8000.

The use of auditors qualified to assess compliance of the electronics supply chain is promoted, with the intention to recognise accreditations such as those provided by SAAS (the accreditation boy for SA8000) and the EICC. It is considered important to support the industry's EICC initiative within the frame of the criterion proposal.

The complementary role of the public labour inspection system is also recognised, with site audits carried out by a public labour inspector being accepted where the country has ratified ILO Convention No.81 and the inspection system is considered based on ILO supervision to be effective. Allowing verification option would also allow existing, valid inspection reports to be used, potentially making compliance easier and lower cost.

3.6 Cluster 6 – User information

3.6.1 Criterion 6(a) – User instructions

Present criteria, Decisions 2011/337 and 2011/330
The computer shall be sold with relevant user information that provides advice on the environmental performance of the product. The information shall be located in a single, easy-to-find place in the user instructions as well as on the manufacturer's website. The information shall include, as minimum: (i) Energy consumption: TEC value in accordance with Energy Star v6.1, as well as the maximum power demand in each operating mode. In addition, instructions shall be provided on how to use the device's energy-saving mode; (ii) Information that energy efficiency cuts energy consumption and thus saves money by reducing electricity bills; (iii)The following indications on how to reduce power consumption when the computer is not being used: - Putting the computer into off mode will reduce energy consumption but will still draw some power; - Reducing the brightness of the screen will reduce energy use; - Screen savers can stop computer displays from powering down into a lower power mode when not in use. Ensuring that screen savers are not activated on computer displays can therefore reduce energy use; - Charging tablet computers via a USB-interface from another desktop or notebook computer may increase the energy consumption in case of leaving the desktop or notebook computer in an energy-consuming idle-mode for the sole reason of charging the tablet computer. (iv)For notebooks, tablets and two-in-one computers information that extension of the

computer's lifetime reduces the product's overall environmental impacts.

(v) The following indications on how to prolong the lifetime of the computer:

- Information to let the user know the factors influencing the lifetime of rechargeable batteries as well as instructions for the user facilitating prolongation of their life (only applicable to mobile computers powered with rechargeable batteries).
- Clear disassembly and repair instructions to enable a non-destructive disassembly of products for the purpose of replacing key components or parts for upgrades or repairs.
- Information to let the user know where to go to obtain professional repairs and servicing of the computer, including contact details. Servicing should not be limited exclusively to the applicant's Authorised Service Providers.

(vi) End-of-life instructions for the proper disposal of computers, including separate instructions for the proper disposal of rechargeable batteries, at civic amenity sites or through retailer take-back schemes as applicable, which shall comply with Directive 2012/19/EU of the European Parliament and of the Council ('the WEEE Directive').

(vii) Information that the product has been awarded the EU Ecolabel together with a brief explanation as to what this means together with an indication that more information on the EU Ecolabel can be found at the website address http://www.ecolabel.eu

(viii) Instruction and repair manual(s) shall be provided in print version and also online in electronic form for a period of at least five years.

Assessment and verification: The applicants shall declare the compliance of the product with these requirements to the competent body and shall provide a link to the online-version or a copy of the user instructions and repair manual to the Competent Body.

3.6.1.1 Technical rationale for the proposed revisions

In discussions with stakeholders a number of points were highlighted for amendment or addition in the criterion text:

- Aligning the information on energy consumption with the most current Energy Star version taken as basis for the energy criteria.
- Charging tablet computers via the USB-interface of another desktop or notebook computer can increase the energy consumption in case of leaving the desktop or notebook computer in idle-mode for the sole reason of charging the tablet computer.

- Inclusion of information requirements including detailed instructions for the extension of the computer's lifetime.
- Inclusion of information requirements regarding the proper disposal of rechargeable batteries
- Specifation of online versions of repair manuals instead of print-versions to save resources.

Following a review of the technical rationale the criterion the following provisions were deleted:

- Applying the disk defragmentation function: Increasingly the operating system and HDD/SSD are organising the data management by themselves.
- The provision of a list of available spare parts with current prices: This was not
- been seen as practicable by stakeholders as a basis for benchmarking prices cannot be established
- Clear instructions to enable a permanent deletion of personal data: This is considered to be difficult to specify and guarantee and is more important for public procurement.

3.6.1.2 Final proposal for 6(a) User instructions

Proposed revised criterion (third proposal)
The optional label with text box shall contain three out of the following texts: - High energy efficiency - Designed to be more durable *(applicable to portable devices only)* - Restriction of hazardous substances - Designed to be easy to repair, upgrade and recycle - Audited factory working conditions The following texts may be displayed if the plastic recycled content is greater than 25% as a percentage of the total plastic (by weight): - *Contains xy% post-consumer recycled plastic*

3.6.2 Criterion 6(b) – Information appearing on the Ecolabel

Present criteria, Decisions 2011/337 and 2011/330
Optional label with text box shall contain the following text: '- high energy efficiency - designed to facilitate recycling, repair and upgrading - mercury-free backlights (if computer displays)'. *Assessment and verification*: the applicant shall declare the compliance of the product with this requirement, and shall provide a copy of the Ecolabel as it will appear on the packaging and/or product and/or accompanying documentation to the competent body.

3.6.2.1 Technical rationale for the propose revisions

Discussions with stakeholders and new criterion proposals suggest that an explicit focus on extended lifetime (formerly described in terms of repair and upgrading) with a distinction made between '*durability'* and *'repair, upgrade and recycle'* is warranted.

Inclusion of criteria addressing plastic recycled content claims and factory working conditions also suggest that an option for inclusion of wording to used should be added. This would enable manufacturers with a specific focus of attention to choose the combination of wording they display.

3.6.2.2 Final proposal for information appearing on the Ecolabel

Proposed revised criterion (third proposal)
The optional label with text box shall contain three out of the following texts: - High energy efficiency - Designed to have a longer lifetime (applicable to notebooks, two-in-one notebooks and tablets only) - Restriction of hazardous substances - Designed to be easy to repair, upgrade and recycle - Audited factory working conditions The following texts may be displayed if the plastic recycled content is greater than 25% as a percentage of the total plastic (by weight): *- Contains xy% post-consumer recycled plastic*

4. WITHDRAWN CRITERIA PROPOSALS

4.1 Noise

Present criteria, Decisions 2011/337 and 2011/330
The 'Declared A weighted Sound Power Level' (re l pW) of the personal computer, in accordance with paragraph 3.2.5 of ISO 9296, shall not exceed (1) 40 dB (A) in the idle operating mode, (2) 45 dB (A) when accessing a hard disk drive. The 'Declared A weighted Sound Power Level' (re l pW) of the notebook computer system unit, in accordance with paragraph 3.2.5 of ISO 9296, shall not exceed (1) 32 dB (A) in the idle operating mode, (2) 36 dB (A) when accessing a hard disk drive. *Assessment and verification*: the applicant shall provide the competent body with a report, certifying that the levels of noise emissions have been measured in accordance with ISO 7779 and declared in accordance with ISO 9296. The report shall state the measured levels of noise emissions in both idle operating mode and when accessing a disk drive, which shall be declared in accordance with paragraph 3.2.5 of ISO 9296.

4.1.1 Technical rationale for the proposed revision

An initial comparison was made with noise criterion in other ecolabels in order to benchmark performance requirements (see Table 4.1.1

). . Although some ecolabels such as the Blue Angel have stricter limits, discussions at the first AHWG meeting, highlighted concerns that lowering the limit values could have very high costs, thus more market information was requested to support the case for stricter criteria. It was also noted that the Blue Angel has only a very small number of licenseholders.

Table 4.1.1

Existing noise requirements in ecolabel criteria

	EU Ecolabel	**Blue Angel**	**Nordic Swan**	**TCO**	**EPEAT**
Desktop PCs	• Idle operating mode: 40 dB (A) • HDD enabled: 45 dB (A)	• Idle operating mode: 38 dB (A) • HDD enabled: 42 dB (A) • Optical drive enabled: 50 dB (A)	• Idle mode: 38 dB (A) • Operating: 42 dB (A)	• Idle mode: 39 dB (A) • Operating mode: 44 dB (A) Valid for desktop PCs with integrated moving parts, such as motor driven HDD, fans etc. *If the product does not*	No noise criteria at all

	EU Ecolabel	Blue Angel	Nordic Swan	TCO	EPEAT
				emit prominent discrete tones a higher declared A-weighted sound power level is accepted but shall not exceed • Idle mode: 42 dB (A) • Operating mode: 47 dB (A)	
Notebook PCs including Tablet PCs	• Idle operating mode: 32 dB (A) • Hard-disk drive enabled: 36 dB (A)	• Idle operating mode: 35 dB (A) • Hard-disk drive enabled: 40 dB (A) • Optical drive enabled: 48 dB (A) • Netbooks: The sound power levels of the netbook shall be reported for statistical purposes in accordance with ISO 7779.	• Idle mode: 35 dB (A) • Operating: 40 dB (A) *Valid for Notebook PCs + Thin clients*	• Idle mode: 35 dB (A) • Operating mode: 39 dB (A) *Valid for notebook PCs with integrated moving parts, such as motor driven HDD, fans etc.* *If the product does not emit prominent discrete tones a higher declared A-weighted sound power level is accepted but shall not exceed* • Idle mode: 38 dB (A) • Operating mode: 42 dB (A)	No noise criteria at all

An indicative research was carried out to determine if there are any computer products on the market fulfilling the proposed requirements. It was found that data on noise emissions (i.e. sound power level measured in accordance to ISO 7779) are not commonly provided within the technical specifications of computer products. It was also noted that the requiremnts should be expressed in sound power and measured in bells and not decibels, as reflected in ISO and ECMA standards.

As the manufacturer HP provides a broad range of public available IT Eco declarations[108] for its products (Desktop PCs, Workstations, Notebook and Tablet PCs), an analysis of their product range was carried out working on the assumption that their products of other manufacturers have similar performances. The results showed that the majority of models were able to comply, even with a stricter criterion proposal.

[108] Cf. http://www.hp.com/hpinfo/globalcitizenship/environment/productdata/iteconotebook-o.html; http://www.hp.com/hpinfo/globalcitizenship/environment/productdata/itecoworkstatio.html; http://www.hp.com/hpinfo/globalcitizenship/environment/productdata/itecodesktop-pc.html

Position adopted with regards to the final criterion proposal

It was proposed following the AHWG2 to leave the proposal unchanged as it is considered to require low noise products, as evidenced by data analysed from models of HP who are understood to have invested in noise reduction. It was considered that the criterion already contains sufficient differentiation for tablet products given that those products without fans or mechanical (rotating) hard drives are excluded from part (b).

4.1.2 Final proposal for noise criteria

Third criteria proposal
6(a) Noise The 'Declared A weighted Sound Power Level' (re l pW) of the computer, in accordance with paragraph 3.2.5 of ISO 9296, shall not exceed: a) For desktop computers including integrated desktop computers and workstations i. Idle Mode: 3.8 bel ii. Operation mode: 4.2 bel b) For notebook computers including tablets, two-in-one computers and mobile workstations i. Idle mode: 3.2 bel ii. Operating mode: 3.6 bel The requirements shall not apply to Idle mode if no fan is installed (e.g. CPU fans, power supply fans, computer system fans) or to Operating mode if no mechanical hard disk drive is installed. ***Assessment and verification:*** The applicant shall provide the competent body with a test report, certifying that the levels of noise emissions have been measured in accordance with ISO 7779. The report shall state the measured sound power levels in idle and operating mode, which shall be declared in accordance with paragraph 3.2.5 of ISO 9296. In case of different configurations of identically constructed units the measurements have to be performed on the loudest individual components.

Summary rationale for the revised proposal

- Small scale servers are not covered by this requirement as it is assumed that they will generally be located in a separate room with no permanent workplaces.
- Thin Clients are indirectly excluded from this requirement as they are constructed with no fans or hard disks so that they do not create background noise emissions being typical for PCs.

- It is proposed to declare the measured sound power levels in Bel not Decibel as being common practice in ICT industry to avoid confusion between decibels for sound power level and decibels for sound pressure level.
- The optical drive measurement has been deleted as optical drives today are rarely and/or only for short, definite periods used (e.g. for installation purposes)
- The limit values of the first revised criteria proposals have been kept in the second proposal as indicative market research showed they can be reached by a number of products.

4.1.3 Summary rationale for withdrawal of the criterion

Summary rationale for withdrawing the criterion
Given the introduction of challenging new sub-criteria addressing product durability and lifespan, and the high ambition level of the hazardous substance criterion proposal, it is considered important to reduce the overall scope and number of criterion. Moreover, whilst noise minimisation is recognised as having been a priority for some manufacturers and as being important for consumers, it does not directly address product life cycle environmental issues and, moreover, is not addressed by the market leading electronics ecolabel EPEAT.

4.2 Visual ergonomics

4.2.1 Technical rationale for the proposed criterion

Currently, there are no fitness for use criteria associated with the EU Ecolabel. TCO Certified 2012 for Desktops, Notebooks, All-in-One PCs and Tablet PCs as well as TCO Certified Displays contain criteria regarding visual ergonomics (image detail, luminance, luminance contrast, reflection and screen colour) and work load ergonomics (inter alia vertical tilt and vertical height for AiO-PCs); the Nordic Swan ecolabel aligns to TCO Displays and Notebooks criteria with regard to ergonomics and includes some own requirements for tablet PCs.

During the consultation the general view was that the TCO criteria could form a good starting point and if the criteria proposal is adopted then harmonisation with TCO would be preferable. The cost benefits of certain criteria did, however, require careful consideration. This criteria area could be more relevant to GPP, where people are using computers for longer hours.

4.2.2 Summary rationale for withdrawal of the proposal

Despite stakeholders' feedback generally agreeing to add requirements on ergonomics, for example by aligning them to TCO criteria, it was decided in the light of the importance of a focus on environmental criteria areas such as hazardous substances and durability not to include a new criterion on ergonomics.

4.3 Emissions of fluorinated GHG during LCD production

4.3.1 First proposal for fluorinated GHG criteria

Proposed new criterion (first proposal)
Fluorinated GHG emission during LCD production Computers with integrated LCD panel must be produced in a way that the fluorinated greenhouse gases NF_3 and SF6, if part of the production process, are abated by a system that is an integrated part of the production process. *Assessment and verification*: The applicant shall declare the compliance with these requirements and shall additionally provide a description of the implementation process at suppliers/sub-contractors (i.e. LCD panel makers) to the competent body.

4.3.2 Technical rationale for the proposed criterion

Fluorinated greenhouse gases (GHG) are among the most potent and persistent GHG contributing to global climate change; they are relevant in the manufacture of semiconductors, light emitting diodes and LCD flat panel displays. However, it appeared difficult to set product-related criteria addressing these emissions. Difficulties cited related to the ability to make comparisons between panel suppliers' F-GHG emissions due to a lack of consistency in:

- estimating emissions,
- estimating emissions reductions, and

- in monitoring the efficacy of installed abatement systems.

A process oriented approach was instead proposed, based on a proposal in the current revision of the Nordic Ecolabelling criteria for television displays. This would encourage reporting on abatement systems.

4.3.3 Summary rationale for withdrawal of the proposal

In the view of the need to prioritise the focus on other new criteria proposals such as hazardous substances and durability, it was decided not to include a new criterion on fluorinated greenhouse gases. A criterion is, however, proposed for the Display product group, where the screen unit has a greater proportional contribution to the environmental impact of the whole product.

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