European Commission

J R C   T E C H N I C A L   R E P O R T S

Development of European Ecolabel and Green Public Procurement Criteria for Televisions

TECHNICAL REPORT, TASK 4

Improvement potential

(Draft) Working Document

Dritan Osmani, Oliver Wolf (JRC-IPTS)

Kathrin Graulich, Rita Groß, Ran Liu, Andreas Manhart, Siddharth Prakash (Öko-Institut e.V. – Institute for Applied Ecology)

August 2013

Joint Research Centre

European Commission
Joint Research Centre
Institute for Prospective Technological Studies (IPTS)

Contact information
Dr. Dritan Osmani
Address: Joint Research Centre, Edificion EXPO, Calle Inca Garcilaso 3, E-41092 Sevilla, Spain
E-mail: dritan.osmani@ec.europa.eu
Tel.: +34 954 488 288

http://ipts.jrc.ec.europa.eu/

This publication is a Technical Report by the Joint Research Centre of the European Commission.

Table of Contents

List of Tables

List of Figures

INTRODUCTION

This draft Task report is intended to provide the background information for the revision of the EU Ecolabel criteria for Televisions. The study has been carried out by the Joint Research Centre's Institute for Prospective Technological Studies (JRC-IPTS) with technical support from the Öko-Institut e.V. (OEKO). The work is being developed for the European Commission's Directorate General for the Environment.

The EU Ecolabel criteria form key voluntary policy instruments within the European Commission's Sustainable Consumption and Production and Sustainable Industrial Policy (SCP/SIP) Action Plan and the Roadmap for a Resource-Efficient Europe. The Roadmap seeks to move the economy of Europe onto a more resource efficient path by 2020 in order to become more competitive and to create growth and employment. The EU Ecolabel promotes the production and consumption of products with a reduced environmental impact along the life cycle and is awarded only to the best (environmental) performing products in the market.

An important part of the process for developing or revising Ecolabel criteria is the involvement of stakeholders through publication of and consultation on draft technical reports and criteria proposals and through stakeholder involvement in working group meetings. This document sets the scene for the discussions planned to take place at the two working group meetings planned in 2013/2014.

This draft preliminary Task 4 report addresses the requirements of the Ecolabel Regulation No 66/2010 for technical evidence to inform criteria revision. It consists of background information regarding the improvement potential. Together with the description of the scope and legal framework (Task 1), the market analysis (Task 2), and the technical analysis (Task 3) as well as input from stakeholders, the information will be used to determine the focus for the revision process and present an initial set of criteria proposals (Task 5).

Scope for Task 4 “Improvement Potential”

As stated in the previous technical report Task 1 of the revision process for the development of EU Ecolabel criteria for televisions, there is a functionality overlap between television sets and computer monitors placed on the EU market. Television sets are increasingly enabled for web browsing and computer monitors are being used to watch content normally only viewed on televisions. Thus, it is becoming more and more difficult to distinguish between the two product categories. In the current review process of the EU Ecodesign and Energy Labelling Regulations for televisions, the discussion paper proposed to change the scope from solely “televisions” to “electronic displays”, including television sets, television monitors, and external computer displays (EU Ecodesign Review TVs 2012). Considering the general desire for harmonised approaches and coherent product policy, this approach has also been proposed to apply also to the parallel revision process of the EU Ecolabel for Computers (so far including computer displays) and Televisions. Within Task 1 of the EU Ecolabel revision studies for computers and televisions, different options for an integrated approach of the scope have been presented and stakeholders were asked to provide initial feedback on these proposals.

Most feedback from answering stakeholders followed the option to harmonize with the upcoming Ecodesign and Energy Label regulations for Displays (including both televisions and external computer displays), thus integrating external computer displays in the television documents, but to base the “new” display group on the existing set of criteria used in the ecolabel for televisions.

The following sections take up this approach, by pointing out the improvement potential for both, televisions and external computer displays and investigating conclusions for using synergies in a joint criteria development.

4. IMPROVEMENT POTENTIAL

4.1 Background – key environmental issues of televisions and computer displays

The technical analysis of LCA studies on televisions (see Task 3 report) revealed that the use phase and the production phase have the highest environmental impacts. The use phase is very sensitive to consumer behaviour. Significant environmental benefit can be achieved from stimulating "best case" user behaviour, especially reducing the standby consumption by putting the device into off mode after usage. Many present debates on the environmental impacts attributable to televisions still focus strongly or only on the use phase. 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.

According to Hischier & Baudin 2010, within the manufacturing phase of LCD televisions, the assembly process of the LCD display module as well as the used amount of chrome steel in the housing and the Printed Wiring Board are the main contributors to the environmental impacts. Exemplarily, for PDP televisions, the main components contributing to the environmental impacts are presented in Figure 1.

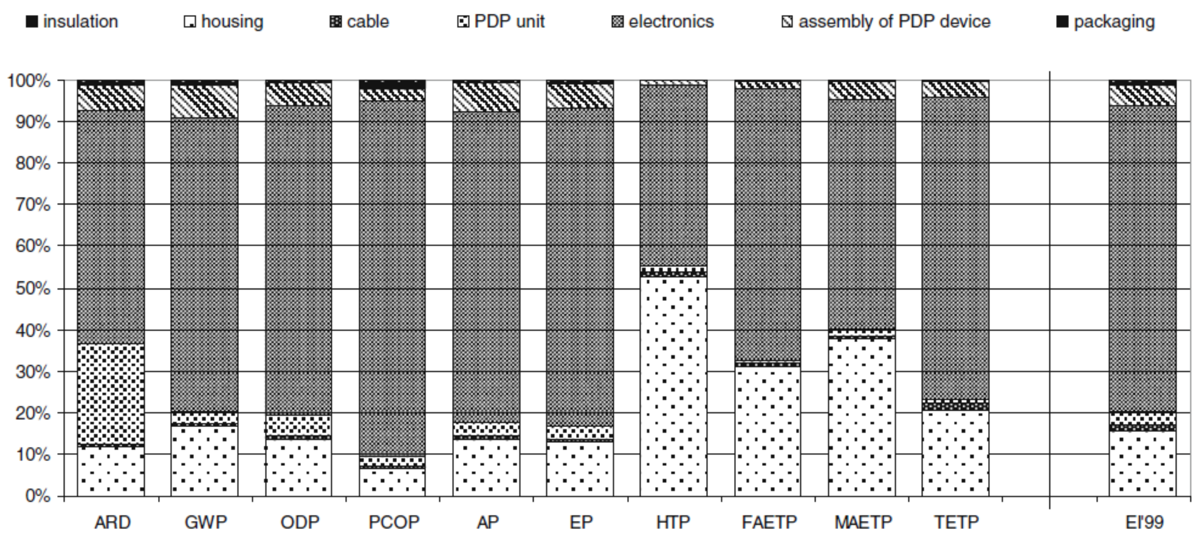

Figure 1: The production phase of a PDP television (Source: Hischier & Baudin 2010)

Televisions contain a great number of important metals such as gold, silver, copper, palladium, gallium etc. While the amounts of these metals are very low in a single product (cf. Table 8), the overall content for all televisions sold worldwide sums up to several tons[1]. Furthermore, as a result of performance improvements in microelectronics, the diversity and purity of necessary elements has increased greatly, most of which are “rare metals” (UBA 2009; Graedel 2008). The extraction and processing of these metals is associated with major material requirements, appropriation of land and consumption of energy, and 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 comminution, 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). Not least, unsuitable recovery techniques for these metals, such as the use of mercury to recover gold from electroscrap, generate major adverse effects for people and the environment (Prakash & Manhart 2010).

Most of the critical raw materials are concentrated in the following components of televisions (cf. Table 10 and Table 11): Printed Circuit Board (silver, gold, and palladium), display (indium) and background illumination (yttrium, europium, gallium, etc.) which also most contribute to the environmental impacts of the manufacturing phase of televisions (see above).

The direct influence of ecolabel criteria on the production of single TV components is rather limited. However, the impacts of the manufacturing phase can be reduced by improving design (e.g. design for disassembly and recycling) or indirectly by extending the lifetime. The shorter the life span, the more likely it is that the dominant environmental impacts shift to the manufacturing phase (cf. Task 3 report).

---

[1] For desktop and notebook computers, for example, the overall content of valuable metals for all appliances sold worldwide sums up to approximately 225 t silver, 50 t gold, 18 t palladium, and 113,000 t copper (Hagelüken and Buchert 2008). For televisions, similar dimensions are assumed.

The market analysis (Task 2 report) of this study indicated that the replacement cycle for televisions decreased on a global scale from 8.4 to 6.9 years, compared to the previous 10 to 15 year average for CRT to CRT replacement (see Task 2). This trend generates an increasing amount of electrical and electronic waste as well.
The technical analysis of LCA studies also reveals as improvement potential that the environmental impacts of the manufacturing phase of televisions can be reduced, if the end-of-life (EoL) treatment is in a sound management, since the secondary resources from recycling can avoid primary production (see Task 3).
The main components of televisions and external computer displays do not differ significantly, they consist of:

- Chassis: cabinet, stand, speaker unit, control keys, small parts (especially screws);
- Display module including drivers, backlighting, front glass and frame;
- Power supply unit including PCB and cord
- Electronics Boards including populated printed circuit boards, sensors, connectors, heat sinks and cooling elements, and other electro mechanics.

Thus it is supposed that the general areas for improvement are rather similar for both televisions and external computer displays. However, the detailed criteria might differ according to respectively different functionalities of both product categories.
The following table provides an overview how the key environmental issues of televisions (manufacturing impacts of components, use phase) will be addressed by the areas for improvement and ecolabel criteria which will be further elaborated in the following sections of this report.

Table 1: Key environmental issues of televisions and computer displays 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>• Design for disassembly and recycling</td><td rowspan="3">Lifetime extension
• Upgradeability
• Repairability
• Service (availability of spare parts)
• Second-hand usage
• User instructions</td></tr>
<tr><td>Display</td><td>• Hazardous substances
• F-gases during production
• Design for disassembly and recycling</td></tr>
<tr><td>Chassis</td><td>• Recycled content
• Hazardous substances
• Design for disassembly and recycling
• Material recovery</td></tr>
<tr><td colspan="3">Use-phase</td></tr>
<tr><td></td><td>Energy requirements
• Energy efficiency; power cap
• Power management
• User instructions</td><td></td></tr>
</table>

4.2 Improvement Potential

Aim of the Task 4 report is to evaluate and prioritise improvement options which could inform the revision of the existing criteria by using the findings of the market and the technical analysis (Task 2 and 3 reports).

Based on the environmental hot spots identified in the previous tasks, in this task the environmental improvement potential of the product group is analysed and prioritised. This includes best available standards or technologies (BAT) already available on the market, a comparison of requirements on certain issues as specified in other ecolabels, as well as challenges linked to some of the criteria revisions.

Further, during the course of the revision process two questionnaires were sent out to selected stakeholders. The target groups were industry, Member States, NGOs and research institutions. The specific suggestions from the individually answering stakeholders about certain criteria are reflected at the end of each improvement section. Further detailed feedback is expected from the Working Groups that will take place as part of the criteria revision process.

The results of this task will be compared with the current sets of criteria in a way which indicates how the improvement potential can be integrated into the revised set of criteria which will be provided in the following “Technical Report” (Task 5).

4.2.1 Energy requirements for televisions and computer displays

4.2.1.1 Televisions

The EU Ecolabel criteria for televisions have been effective since 2009. Since that time, major market developments have taken place (shift from CRT to more energy-efficient LCD technology, ever larger screen sizes, see Task 2 report “Market Analysis”).

Also in 2009, the EU Regulation 642/2009[2] on Ecodesign for televisions has been adopted, followed by the EU Regulation 1062/2010[3] on Energy Labelling for

[2] Commission Regulation (EC) No 642/2009 of 22 July 2009 implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for televisions

televisions one year later. Currently, these latter regulations are under review, merging the work on the draft Regulation on display products to prepare one overall set of ecodesign and energy labelling requirements for all electronic displays, including televisions and computer displays inter alia.

Further highly up-to-date energy requirements for televisions are subject of the following labelling schemes:

- TCO Certified Displays 6.0 (valid from March 2012, applicable to televisions): aligning energy criteria to the most recently published Energy Star standard.
- Blue Angel (valid from July 2012): aligning energy consumption criteria to the EU Energy Labelling Regulation 1062/2010, different energy efficiency criteria for smaller and larger TVs. Additional energy criteria regarding off mode and passive standby, wireless network connections, on/off-control, quick start and manual / automatic brightness control.
- Nordic Ecolabelling: The draft revised version 5.0, published in May 2013 aligns energy efficiency criteria to the EU Energy Labelling Regulation 1062/2010 (energy class A+ for all TV sets regardless screen size), and standby and off mode requirements to the EU Ecodesign Regulation 642/2009. A former criterion on a maximum energy consumption level for televisions in on mode has been removed.
- US Energy Star for Televisions 6.0 (valid from May 2013): It has to be noted that televisions are not included in the Agreement between the Government of the US and the European Community (EU) to co-ordinate the energy labelling of products. This covers only office equipment including the product categories computer equipment, displays, and imaging equipment.

---

[3] Commission Delegated Regulation (EU) No 1062/2010 of 28 September 2010 supplementing Directive 2010/30/EU of the European Parliament and of the Council with regard to energy labelling of televisions

4.2.1.2 External computer displays

For external computer displays, no explicit EU Ecolabel criteria exist; they are subsumed under the EU Ecolabel for personal computers, being effective since 2011. Further, no EU Regulation on ecodesign or energy labelling for displays is adopted to date. A draft of the ecodesign Working Document on displays was discussed at a Consultation Forum meeting back in 2009. However, it has been decided to merge the draft Ecodesign Regulation on displays with the review work on the television Regulations to prepare one set of ecodesign and energy labelling requirements for all electronic displays, including external computer displays and televisions inter alia.

So far, all relevant ecolabel (EU Ecolabel, Nordic Ecolabelling, TCO, Blue Angel, and EPEAT) refer to a specific version or, more generally, the most recently published Energy Star program requirements for displays.

Unlike televisions, external computer displays are included in the Agreement between the Government of the US and the European Community (EU) to co-ordinate the energy labelling, thus Energy Star criteria on displays are also valid in Europe[4].

The Energy Star Program Requirements for Displays (Version 5.1)[5] have been the most established benchmark for the energy requirements of computer displays. In 2011, on average 85 % of all new computer displays sold in the USA were already certified according to this specification (see Table 2). In general, the experience shows that approximately two years after a new Energy Star version becomes effective, a large proportion of devices fulfils the energy requirements, especially when they build the basis for Green Public Procurement (e.g. computer displays).

---

[4] Commission Decision of 26 October 2009 determining the Community position for a decision of the management entities under the Agreement between the Government of the United States of America and the European Community on the coordination of energy-efficiency labelling programmes for office equipment on the revision of the computer monitor specifications in Annex C, part II, to the Agreement (Text with EEA relevance) (2009/789/EC)

[5] See https://energystar.gov/products/specs/sites/products/files/Version_5.1_ENERGY_STAR_Displays_Program_Requirements_Post-Clarification.pdf

Table 2: Sales volumes and market-penetration of external computer displays certified according to Energy Star v 5.1 criteria in the USA in 2011

Product Category	Units shipped in the USA in 2011 [thousand devices]	Estimated market penetration in the USA in 2011
External computer displays: *LCD Monitors*	*22,922*	*85%*

Source: Energy Star 2012

The new Energy Star Program Requirements for Displays, Version 6.0 became effective from June 2013 (Energy Star Displays 2013[6]).

According to Energy Star 2012a, the Version 6.0 specification establishes new On Mode power consumption requirements for displays with a viewable diagonal screen size from 12 to 30 inches and for computer displays greater than 30 inches. It also establishes a new maximum Sleep Mode power requirement of 0.5 watts for all displays, and a power management requirement that all computer displays must enter Sleep Mode after the connection to a host is discontinued. In addition, this specification

- Establishes an allowance in Sleep Mode for multiple networking and control protocols, including Gigabit Ethernet or Wi-Fi protocols, and additional capabilities, such as occupancy sensors or memory, implemented in a single product;
- Adds a definition for enhanced-performance displays and establishes an allowance in On Mode for products that meet that definition;
- Establishes a hierarchy under the Test Method for testing network connected products in Sleep Mode and lighting conditions for testing products with automatic brightness control (ABC) enabled by default.

6 http://energystar.gov/products/specs/sites/products/files/Final_Version_6%200_Displays_Program_Requirements.pdf?8a38-1944

4.2.1.3 Conclusions and recommendations

The following table compares the existing energy requirements for televisions and external computer displays in the different labelling schemes EU Ecolabel, Energy Star and Blue Angel. It shows that they rather vary, both within one product category and between televisions and computer displays (for example different definitions for power modes like “sleep mode” for displays and “standby-passive mode” for televisions). On the other hand, as stated in EU Ecodesign review TVs (2012), designing separate measures for televisions and computer displays has proven to be difficult because the convergence of products has made it difficult to clearly define separate product categories.

Table 3: Comparison of energy requirements for televisions and external computer displays in different labelling schemes

Requirements / Label	Televisions			External Computer Displays		
	EU Ecolabel (2009)	US Energy Star (2013)	Blue Angel (2012)	EU Ecolabel (2011)	EU Energy Star (2013)	Blue Angel (2012)
On Mode	X	X	X	X	X	X
"Sleep Mode"[7]	n.a.	n.a.	n.a.	X	X	X
"Standby-Passive Mode"[8]	X	X	X	n.a.	n.a.	n.a.
Download Acquisition Mode[9]		X		n.a.	n.a.	n.a.
Off-Mode			X	X	X	X
Maximum energy consumption	X		X	X		
Power Management				X	X	X
Manual / Automatic Brightness Control		X	X		X	X
Luminance		X			X	
On/off control			X			
External Power Supply		X			X	
Wireless Network Connections			X			
Quick Start / Fast Start			X			

Generally, it is recommended to follow a harmonised approach between the various European policies. For televisions, mandatory EU regulations on ecodesign and energy labelling apply (EU 1062/2010 and EU 642/2009, currently under revision), for computer displays the latest EU Energy Star version 6.0.

[7] Sleep Mode: The power mode the product enters after receiving a signal from a connected device or an internal stimulus. The product may also enter this mode by virtue of a signal produced by user input. The product must wake on receiving a signal from a connected device, a network, a remote control, and/or an internal stimulus. While the product is in this mode, it is not producing a visible picture, with possible exception of user-oriented or protective functions such as product information or status displays, or sensor-based functions (Source: Energy Star Displays, Version 6.0).

[8] Standby-Passive: Mode, in which the TV is connected to a power source, produces neither sound nor picture but can be switched into another mode with the remote control unit or an internal signal (Source: Energy Star Televisions, Version 6.0).

[9] Download-Acquisition Mode (DAM): Part of "Standby-Active, High Mode"; the power mode, in which the product is connected to a mains power source, produces neither sound nor picture, and is actively downloading data. Data downloads may include channel listing information for use by an electronic programming guide, TV setup data, channel map updates, firmware updates, monitoring for emergency messaging communications or other network communications (Source: Energy Star Televisions, Version 6.0).

Both, the Ecodesign and Energy Labelling Regulations for televisions and the Energy Star for displays are part of the European product policy mix. Proceeding from the assumption that the review and merging process of the Ecodesign and Energy Labelling Regulations for televisions and displays will be finished within the revision process of the EU Ecolabel, we propose the following:

It is generally recommended that the EU Ecolabel for televisions shall follow the current European discussions and approach of the revised EU Ecodesign and Energy Labelling Regulations on televisions to integrate external computer displays into the scope: Removing external computer displays from the scope of the EU Ecolabel for personal computers and developing a new EU Ecolabel for "Displays" including televisions and external computer displays (cf. Task 1 report "Scope").

Energy efficiency

According to Topten.eu (2013), the average on mode power of televisions has continuously been decreasing since during the last years (see Figure 2)[10].

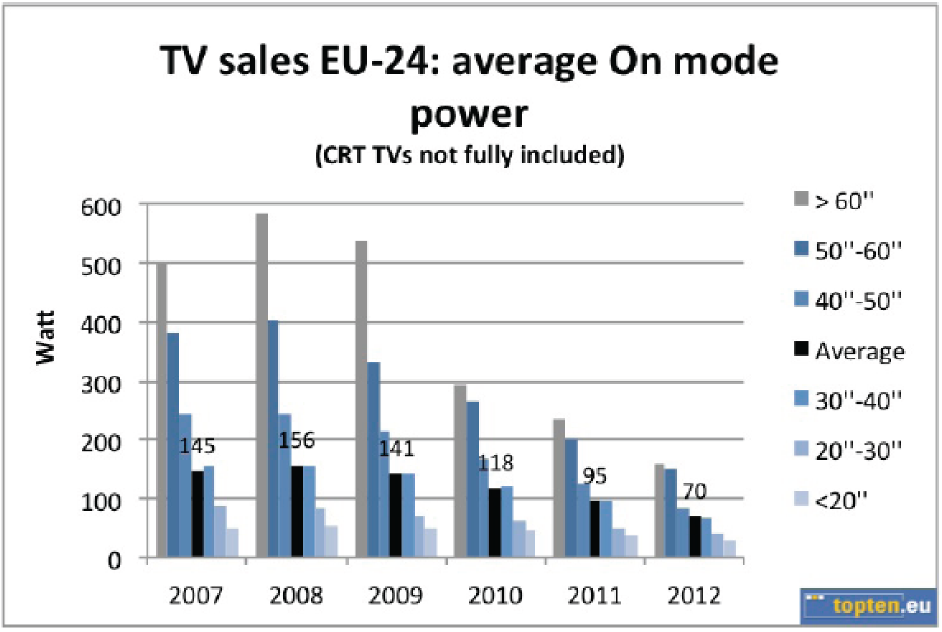

Figure 2: Average on mode power of TV sales EU-24 between 2007 and 2012; data source: GfK

---

10 Source: http://www.topten.eu/uploads/File/TV_market_2007–2012_Topten.pdf

This trend is expected to continue due to further market penetration of LED backlights replacing CCFL-backlight technology, by implementing LEDs with local dimming technology (meaning that each LED or a specific group of LEDs can be turned on and off independently within certain areas of the screen, thus providing more control of the brightness and darkness for each those areas) and possibly by the market introduction of OLED technology.

Regarding the different technologies, today LED-LCD TVs have the lowest average power with 55 Watt, followed by CCFL-LCD TVs with 93 Watt and Plasma technology with 183 Watt (see Figure 3)[10].

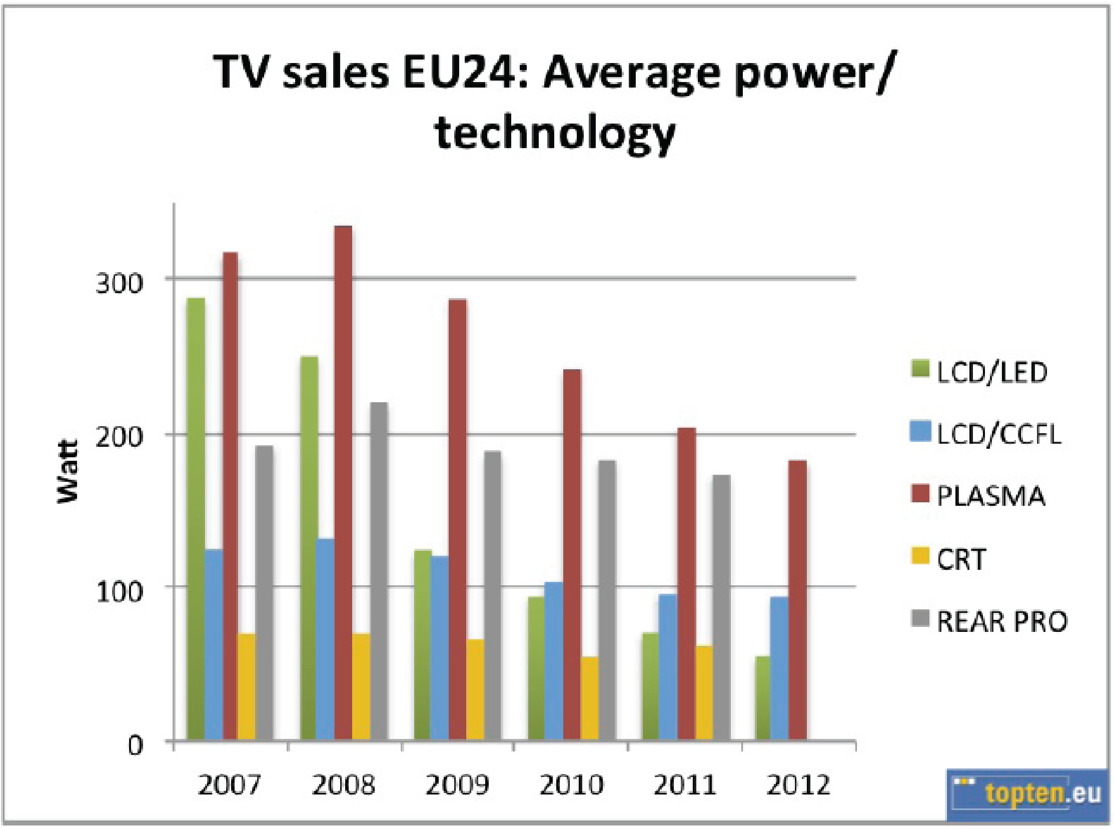

Figure 3: Average power of different TV technologies; data source: GfK

Task 2 report (market analysis) revealed that within the sales of new televisions models that were put on the market in 2012 already 13% achieved the A+ class, and together 53% of the new models sold in 2012 were classes A or better (see Figure 4)[10]. In May 2013, there were more than 200 A+ TVs and 21 A++ models on the lists of Topten.eu (including all similar models on the market).

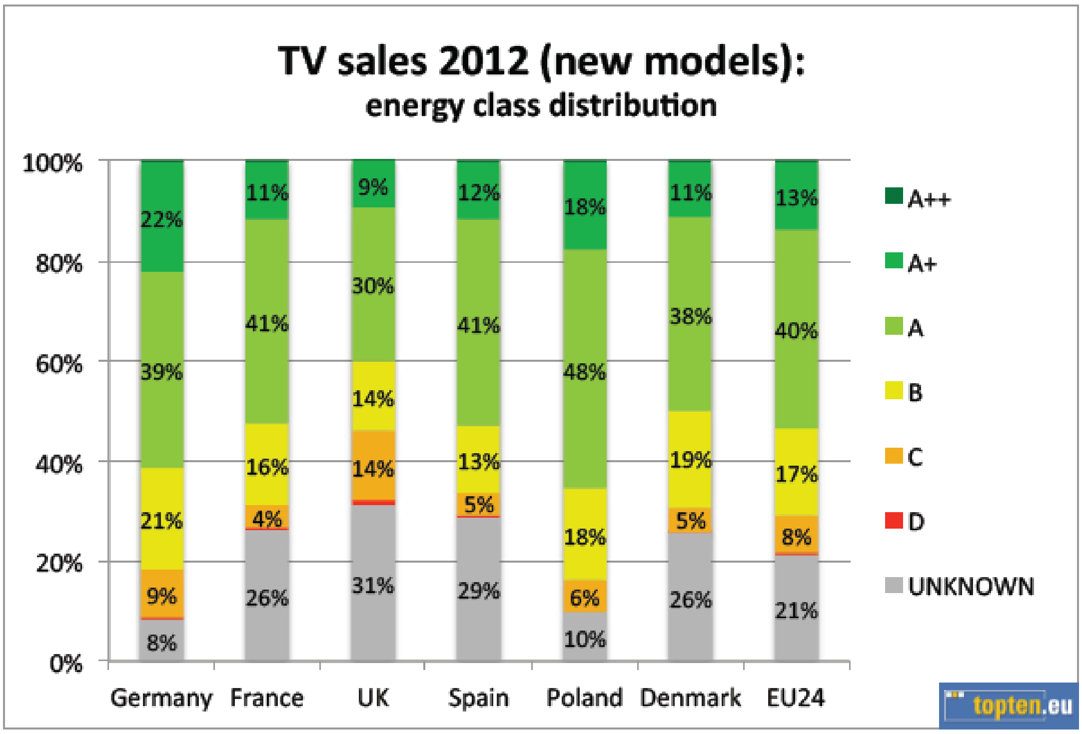

Figure 4: Distribution of Energy Classes of TV sales in 2012 for new models put on the market in 2012; data source: GfK

Further, the following Figure 5 and Figure 6 show that the most energy efficient televisions (A+ and A++) can be found at appliances with larger screen size. The average screen size of televisions correlates to the energy efficiency class. Larger TVs are more efficient than smaller TVs.

According to Topten.eu (2013) this is due to the effect that the TV efficiency, expressed with the Energy Efficiency Index EEI, compares the on mode power of a TV to the power of a reference TV of the same size. Thus, TV efficiency in on mode power is relative to the screen size which allows large TVs to reach a good energy class despite consuming more energy than smaller TVs which can get a worse classification (see Figure 6)

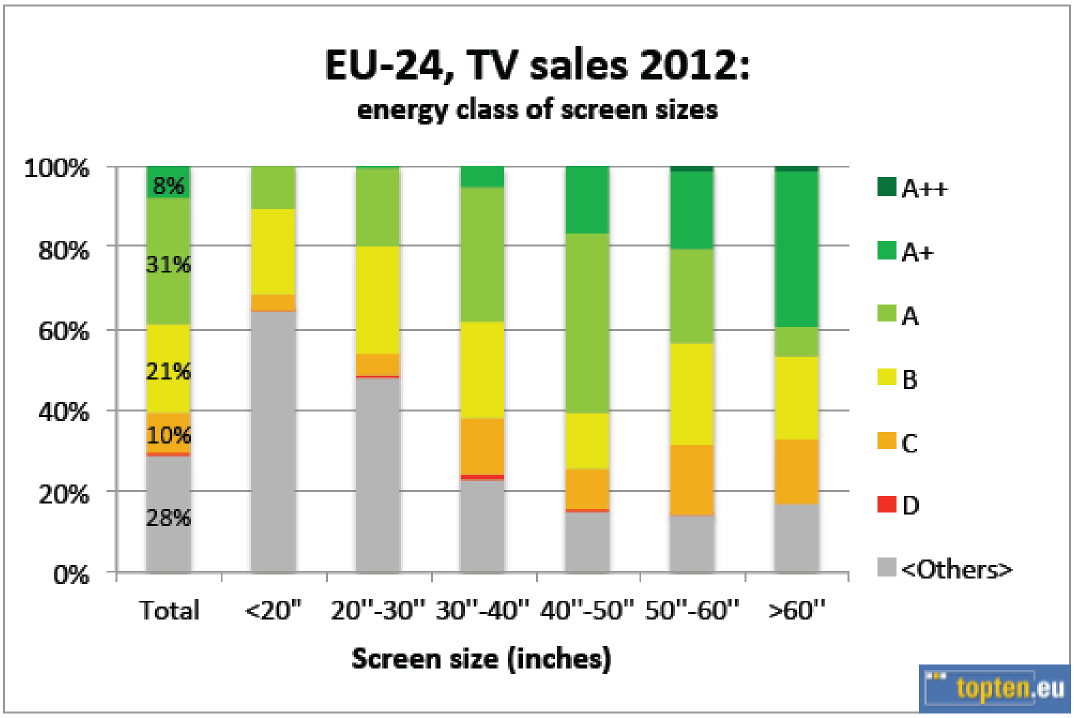

Figure 5: Energy class of screen sizes of TV sales 2012 in EU-24; data source: GfK

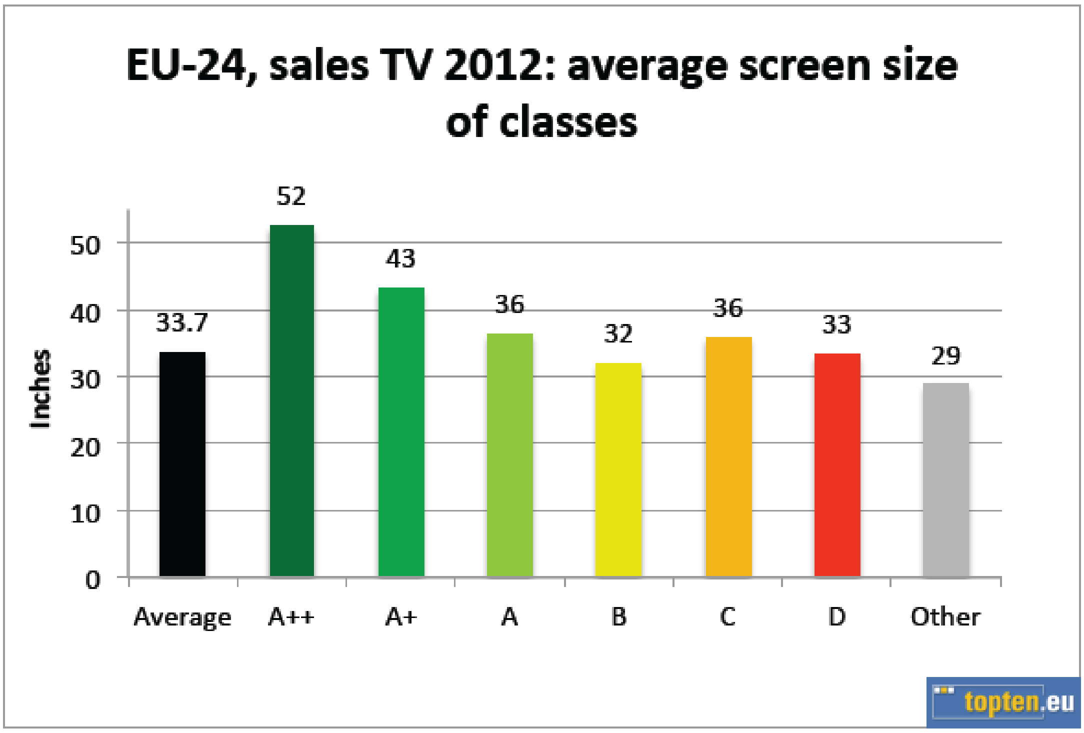

Figure 6: TV average screen size according to energy classes in 2012; data source: GfK

So far (as of July 2013), it is not known how the criteria on energy efficiency will be implemented in the revised Ecodesign and Energy Labelling Regulation on Televisions:

- One of the issues proposed is that rather than revising the Energy Efficiency Index (EEI) values associated with the energy classes, a more convenient way could be to **update the equation used to calculate the EEI** reflecting the current market data (EU Ecodesign review TVs 2012).
- Further, stakeholders recommended creating **separate calculation formulas for the EEI of televisions and computer displays** although falling under the same regulatory framework (BAM and UBA 2012, ANEC and BEUC 2012). This is due to the fact that
  - Computer displays without tuners are generally more energy efficient than televisions;
  - Computer monitors are used for displaying visual information, whereas televisions for displaying audio-visual information, thus computer monitors tend to have lower energy consumption than televisions due to the lack of sound or audio card.
  - Comparing televisions with computer monitors on the basis of same energy efficiency classes would discriminate against televisions which generally provide better picture quality than computer monitors, notably thanks to dedicated video-processing chips.
- Finally, ANEC and BEUC (2012) recommended developing "**progressive energy efficiency standards**" by developing less strict requirements for small and medium-sized televisions but stricter requirements for large televisions. This is due to the fact that the proposed EU Ecodesign tier 1 threshold would lead to extremely strict on-mode power requirements for smaller diagonal screen sizes which will not be met by the majority of televisions, and, at the same time, for medium to large diagonal screen sizes it would lead to extremely unambitious on-mode power requirements for computer monitors.

Some ecolabel and assessment schemes have already corresponded to this aspect: While the draft revised Nordic Ecolabelling criteria for audiovisual equipment require Energy Efficiency Class A+ for all screen sizes, the current Blue Angel criteria for televisions align to energy efficiency class A for appliances with a visible screen diagonal of up to and including 50 inches and class A+ for televisions with more than 50 inches screen size. In order to be displayed on topten.eu, a consumer information portal which regularly presents the most energy efficient products of Europe, televisions must comply with the following criteria[11]:

- Energy efficiency class A for appliances with a visible screen diagonal of up to and including 70 cm (or 27.5 inches);
- Energy efficiency class A+ for appliances with a visible screen diagonal of 70 cm (or 27.5 inches) to 119 cm (or 47 inches);
- Energy efficiency class A++ for appliances with a visible screen diagonal of equal or more than 120 cm (or 47.5 inches).

The application of progressive energy efficiency standards is also backed by stakeholder responses to the EU Ecolabel revision process for televisions (see section 0) as well as the market analysis on televisions (cf. Task 2 report), which indicates that large screen sizes are expected to continue to have strong growth as affordability improves due to rapidly falling prices of LCD TVs. Further, specifications like 21:9 cinema form factor or 4Kx2K resolution shall encourage end-users to choose larger sizes.

Another possibility to react to the higher impacts of larger screen sizes is by limiting the maximum energy consumption in on-mode to a certain level (current EU Ecolabel for televisions: ≤ 200 W; Blue Angel for television sets: ≤ 100 W; EU Ecolabel for computer displays: ≤ 100 W when set to maximum brightness; whereas Nordic Ecolabelling removed the maximum energy consumption criterion from the current revised version 5.0 for audiovisual equipment).

[11] Cf. http://www.topten.eu/english/criteria/selection_criteria_television_sets.html&fromid

Topten.eu so far has the strictest requirements with a maximum on mode power consumption of 64 Watt for all screen sizes which reflects the current market developments (see Figure 7).[11]

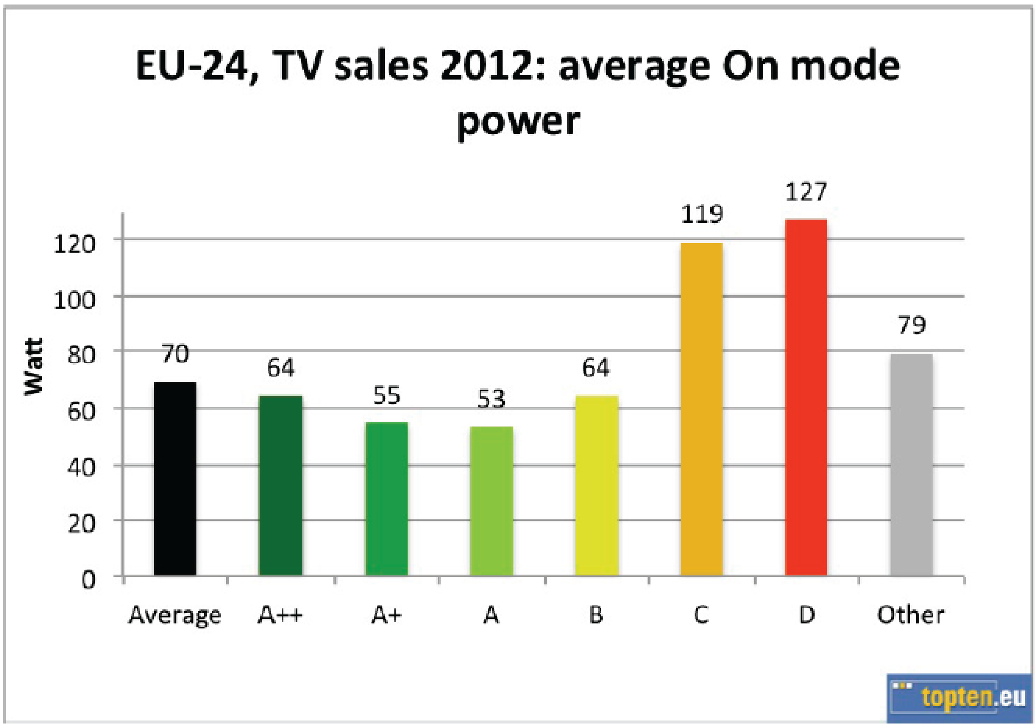

Figure 7: TV average on mode power according to energy classes in 2012; data source: GfK

Comparably, Topten.eu has maximum on mode power values in their selection criteria for external computer displays, see Table 4[12].

Table 4: Maximum on mode power values of Topten.eu for external computer displays according to different screen sizes

Diagonal (inches)	Max. On mode power
15 ≤ d < 17	13 W
17 ≤ d < 20	18 W
20 ≤ d < 22	20 W
d ≥ 22 inches	22 W

12 http://www.topten.eu/english/criteria/selection_criteria_computer_monitors.html&fromid=

Finally, another aspect influencing the power consumption of televisions is the **setting of the brightness and contrast**. According to Topten.eu (2013) a TV test in 2012 showed that changing settings such as brightness or contrast can lead to a power increase by 30% compared to the test settings. TVs are measured and declared the way they are shipped, which in most cases combines the settings ensuring the lowest possible power in on-mode. Often the brightness is rather low in these factory settings, close to the minimum of 65% of the maximum brightness which is stipulated by the Ecodesign Regulation for Televisions. Still, for many viewers the factory settings will be considered suboptimal, and all changes will most probably lead to an increase in power.'

Depending on the future revised proposal for the Ecodesign and Energy Labelling Regulation on Displays including televisions and external computer displays, the EU Ecolabel should (a) refer to a certain energy efficiency index (EEI) or energy efficiency class representing the 10 to 20% best performing products on the market; and (b) support smaller screen sizes by either limiting the maximum energy consumption in on-mode and/or by setting less strict requirements for small and medium-sized displays and stricter requirements for large displays. Further, it shall be discussed if the on mode should be measured at a predefined peak luminance value which better reflects 'real-life brightness settings.

<u>*Further specific energy requirements for televisions and external computer displays*</u>

Standby and off-mode power consumption / networked standby: The horizontal Ecodesign Regulation 1275/2008 on simple standby and off modes as well as the draft horizontal Ecodesign Regulation on networked standby so far cover all displays except televisions which have specific vertical requirements in the Ecodesign Regulation 642/2009 on TVs. In case of inclusion of external computer displays into the revised Ecodesign Regulation 642/2009, these specific vertical requirements on standby and networked standby will also apply to external computer displays.

Power management enables users to save energy by automatically switching a device into a mode with lower power consumption. For televisions and external computer displays, the following power management functions exist:

- Power management / Automatic power-down (APD) function: Products are required to automatically power down within a defined time period after the last user input has been received, when the product ceases performance of its primary functions, or for devices that process AV inputs from external sources, upon loss of signal (LOS) on all active AV inputs (e.g. display sleep).
- Automatic brightness control (ABC): A self-acting mechanism that controls the brightness of a display as a function of ambient light.
- Occupancy sensor: A device used to detect human presence in front of or in the area surrounding a display in order to switch a display between on mode and sleep or off mode.

Ecolabel criteria could either require power management functions to be enabled by default, set requirements for the time period within the device shall enter a mode with lower power consumption[13], or provide certain on mode power allowances for these functions when the overall energy savings are expected to exceed the slightly higher energy consumption of the function itself. Finally, the user manual should include information on the power management functions.

Depending on the future revised proposal for the Ecodesign and Energy Labelling Regulation on Displays including televisions and external computer displays, the EU Ecolabel should include additional criteria to enable automatic power management.

External power supplies (EPS): The efficiency of external power supplies is covered by the horizontal Ecodesign Regulation (EC) 278/2009 (EU Ecodesign EPS 2009). The requirements of Tier 2, being valid since April 2011, are harmonized to Level V requirements of the *International Efficiency Marking Protocol* (see

Table 5).

[13] For this option it has to be noted that prescribing a certain time period for the different modes could lead to rebound effects in case users disable the power management function at all due to discomfort.

Also current Energy Star Criteria for Televisions and for Displays (each from 2013) set these requirements for Level V. According to Schnabel (2012), today the Level V requirements are the strictest and most ambitious ones, the European Union is currently the only governing body to enforce compliance with the Level V standard, and most EPS manufacturers are adjusting their product portfolios to meet these requirements.

Table 5: Current standards of the International Efficiency Marking Protocol for no-load power and efficiency of external power supplies (Source: ElectronicDesign 2012[14])

Level	No-load power* requirement	Average efficiency requirement
I	None of the cases below fit	
II	No criteria were ever established	
III	≤ 1 W	≥ power x 0.49
	≤ 10 W: ≤ 0.5 W of no-load power	1 to 49 W: ≥ [0.09 x Ln(power)]+0.49
	10 to 250 W: ≤ 0.75 W of no-load power	49 to 250 W: ≥ 84%
IV	0 to 250 W: ≤ 0.5 W of no-load power	≤ 1 W: ≥ power x 0.50
		1 to 51 W: ≥ [0.09 x Ln(power)]+0.5
		51 to 250 W: ≥ 85%
V	0 to 49 W: ≤ 0.3 W of no-load power	Standard voltage ac-dc models (>6 V_{out})
	50 to 250 W: ≤ 0.5 W of no-load power	≤ 1 W: 0.48 x power + 0.140
	50 to 250 W: ≥ 87%	1 to 49 W: [0.0626 x Ln(power)]+0.622
		Standard voltage ac-dc models (<6 V_{out})
	0 to 49 W: ≤ 0.3 W of no-load power	≤ 1 W: 0.497 x power + 0.067
	50 to 250 W: ≤ 0.5 W of no-load power	1 to 49 W: [0.0750 x Ln(power)]+0.561
	50 to 250 W: ≥ 86%	

* i.e. the power designated on the label of the power supply

Further, there exists an EU Code of Conduct (CoC) on the energy efficiency of external power supplies. The CoC run by the JRC is a voluntary initiative towards developing ambitious standards and references for industry self-commitment. Currently, the CoC is under revision, the draft Version 5 has been published in September 2012, containing rather tightened requirements compared to the above listed Level V requirements (EU Draft CoC EPS 2012).

[14] http://electronicdesign.com/energy/understanding-efficiency-standards-external-power-supplies

The Ecodesign Regulation (EC) 278/2009 on External Power Supplies is currently under regular revision due to being 4 years into force after its entry. In this context, a review study was launched to explore the additional saving potential as well as the appropriateness of the scope, the definitions and the requirements in view of technological progress. According to this review study it is estimated that 52% of the 2012 EPS models would need to be redesigned to meet tier 1 (effective from January 2014) and 93% redesigned to meet tier 2 (effective from January 2016) of the draft EU Code of Conduct (EU Staff WD EPS 2013).

The Commission proposed to tighten the existing ecodesign requirements for EPS along the lines of the draft Code of Conduct, version 5 (EU Staff WD EPS 2013). Against this background, it is recommended not to additionally develop specific EU Ecolabel criteria on external power supplies.

4.2.1.4 Stakeholder feedback on energy criteria

Energy efficiency

- In general: criteria shall be set that can be met by 10-20% of the best products on the market on the date of criteria adoption.
- Aligning the EU ecolabel to the EU energy labelling
- Consider BAT (A++); 13% are already A+ across EU (2012 sales); consider rapid efficiency development of recent years (OLED?)
- Energy efficiency A+ and A++
- To be in front of Energy Star or Energy Labelling, the requirement could be Energy Star or the respectively Energy Labelling requirements minus 10 (or 20%). It is also proposed to use dynamic criteria, e.g. 201X (X watt), 201Y (X watt - 5/10% energy use), 201Z (X watt - 10/20%) and so on, to secure a

progressive update of energy requirements.

- "Certain differences[15] between computer displays and televisions make it easier for computer displays to meet the Ecoflower requirements and as a result disrupt the level playing field. Additional requirements for computer displays can be considered to compensate for this."
- "We may need a transitional arrangement to differentiate between TV's and displays Ecolabel thresholds, noticeably with regard to energy efficiency, as displays could too easily comply with TV's requirements if the criteria are totally merged immediately."
- "The requirement for a "clearly visible" hard-off switch was hard to interpret. It is suggested to delete this requirement."

Measurement / calculations / allowances:

- "Calculations may be adapted not to give favour to larger screens (as was assessed in the on-going discussion for revising TV's Ecodesign): smaller TV's consume less energy, less material and should not be discouraged. As regard very large screens, it is proposed that they cannot be awarded with Ecolabel to discourage "rebound effect" linked to oversized models."
- Special features or screen size should be considered in the calculation of minimum requirements. E.g. 4K TVs might need more than 100W power consumption because of usually bigger screens and high speed signal processing.
- Brightness - pre-set and maximum (effective energy consumption after user's changes): apply IEC 62087 plus required 65% of max. brightness in factory setting

[15] A different viewing angle gives the computer display a benefit on power for the same amount of light output (measured perpendicular to the screen). A major difference is also the larger amount of processing and source selection functionality available in a TV display required to be able to select, decode and process the larger number of signal types covered by a TV (e.g. Broadcast signals, analog video input, HDMI, RGB, YPbPr; USB; Ethernet…). Functionality, which is not present in a computer *display* but in the attached computer.

▪ The resolution of the display should be considered as it keeps increasing and might (or might not) effect power consumption ▪ Power management ▪ Energy Saving functions such as Automatic Brightness Control (ABC) / Presence sensor are proposed
Power cap ▪ "The linear efficiency approach of the EU legislation favours too much large TVs. It is proposed to focus more on sufficiency and total energy consumption by setting a power cap (e.g. 90W)" ▪ "Maximum energy consumption 100 kWh/a, thus getting about 20% of best products on market, max. 100 kWh/a means also slightly beyond average of the market." ▪ The overall energy consumption criteria (200 W) to televisions, even though already too high in 2008, should be kept, of course at a lower level (e.g. 100 W, disregarding size). Level should be analysed more in depth. The maximum power consumption criteria kept power consumption for big screens down and thus have to some degree "saved" the reputation of the EU Ecolabel criteria for TVs, as the actual possible power consumption of many brands did decrease, but at the same time the overall size of TVs increased. ▪ "Due to market trend, bigger displays are in high demand. It isn´t foreseeable that these could meet a limit of 100 W despite improved efficiency. Therefore a power cap at 100 W is not supported. If in the current revision of the Ecodesign regulation for TVs a logarithmic logic to the EEI calculation would be introduced, the need for a power cap would disappear."

4.2.2 Environmentally hazardous substances

The section on environmentally hazardous substances will be presented in a separate document.

4.2.3 Life time extension

The technical analysis and literature review on LCA studies (see Task 3) shows that the raw materials and manufacturing phase of televisions have similar environmental impacts compared to the use phase.

It is assumed that the reason for this lies in the energy efficiency gains during the use phase due to new LED technology compared to former CRT technology, combined with the shorter getting product life cycle of televisions. The high rate of innovation leading to better picture quality and increasing sizes at slimmer form factors combined with falling prices for new units are causing the actual lifetime of flat panel televisions to become ever shorter. The global TV replacement cycle decreased from 8.4 to 6.9 years and is expected to become even lower as mature markets are already replacing their first-generation flat panel televisions (see Task 2).

From environmental perspective (with regard to global warming potential) it seems not reasonable to purchase a new television after a usage period of only a few years, even if the assumed energy efficiency of the new device exploits the full scope of cutting-edge technology[16].

Today's television products and external computer displays contain a number of valuable and scarce raw materials such as gold, indium, and rare earths. Many of these metals are needed in future technologies such as wind power, photovoltaic and electric mobility. However, their primary extraction entails substantial environmental and social impacts. For example, the production of one tonne of gold generates emissions of approximately 18,000 t CO_{2e} and has a cumulative resource requirement of almost 740,000 t (IFEU 2011). Further, unsuitable recovery techniques for rare metals, such as the use of mercury to recover gold from electro

[16] For comparison: A study by Prakash et al. (2011) revealed that the environmental impact associated with the production of a notebook is so great that it cannot be compensated in a realistic period of time by its savings through improved energy efficiency during the use phase. Assuming a realistic energy efficiency improvement of 10% between two notebook generations, the amortisation periods would be between 33 and 88 years, while if energy efficiency improves by 20% the period would be between 17 and 44 years, depending upon the data source used to analyse notebook production. It is assumed that for televisions, in general these results revealed for a notebook will be similar.

scrap, generate major adverse effects for people and the environment (Prakash & Manhart 2010).

Most of these raw materials are largely irretrievably lost for the industrial cycle because of existing inefficiencies in the recycling infrastructure, particularly as regards collection and pre-treatment, even in modern technology-based European countries. Table 6 exemplifies this effect for notebooks, but due to similarities in design, material and components as well as collection and recycling approaches it is assumed that the losses are similar for televisions. Ever shorter lifecycles and continually manufacturing of new television and display products increase the pressure on the so far environmentally and socially burdening primary extraction (Prakash et al. 2011, Buchert et al. 2012).

Table 6: For comparison: Losses of rare metals during collection, pre-treatment and final treatment of notebooks in Germany (Source: Öko-Institut)

Metal		Content in all notebooks sold in Germany in 2010 [t]	Losses during collection	Losses during pre-treatment	Losses during final treatment	Recovery in Germany [t]
Cobalt	Co	461.31	50%	20%	4%	177
Neodymium	Nd	15.16		100%	100%	0
Tantalum	Ta	12.06		100%	5%	0
Silver	Ag	3.11		70%	5%	0.443
Praseodymium	Pr	1.94		100%	100%	0
Gold	Au	0.74		70%	5%	0.105
Dysprosium	Dy	0.43		100%	100%	0
Indium	In	0.29		20%	100%	0
Palladium	Pd	0.28		70%	5%	0.040
Platinum	Pt	0.028		100%	5%	0
Yttrium	Y	0.012		40%	100%	0
Gallium	Ga	0.010		40%	100%	0
Gadolinium	Gd	0.0048		40%	100%	0
Cerium	Ce	0.00069		40%	100%	0
Europium	Eu	0.00028		40%	100%	0
Lanthanum	La	0.00008		40%	100%	0
Terbium	Tb	0.00003		40%	100%	0

Based on these findings, decision makers should pay attention to the extension of the lifetime of televisions (see following sub-sections), as well as facilitating a proper end-of-life management (see section 0).

In the following, different measures aiming at increasing the longevity of television and display products are discussed.

4.2.3.1 Upgradeability

For computer products, upgradeability is an important issue influencing products' lifetime, as technology advances (or – the other way round – defects) of single hardware components like working memory, hard drives for storage, or CD / DVD drives combined with changing consumer needs (e.g. rising amount of data to be stored due to digital audio, video and pictures, or switch to HD, Blu-ray or 3D-technology etc.) often urge consumers to replace the whole product in case these components cannot be exchanged individually. Existing ecolabel criteria correspond to this issue by requiring modular designed computer products that facilitate the replacement of single modules and thus an upgrade and prolonged lifetime of the existing product.

For televisions, this issue seems not relevant at first glance. The functionality of TVs is closely tight to picture quality which is influenced by screen technology, screen size, and resolution. These factors are also the most important decision criteria for consumers regarding the purchase of a new television (cf. Task 2), and indeed cannot be satisfied by upgrading single hardware components of an older television. Thus it is understandable that none of the existing ecolabelling schemes on televisions contain criteria on upgradeability.

On the other hand, there is a growing trend of televisions becoming so called "Smart TVs" providing users with integrated internet capabilities to check emails and social networking websites, browse the internet including app stores, or watch programmes via internet (cf. Task 2). In this context, some manufacturers offer possibilities to upgrade electronics and software of the television in use (for example "Smart Evolution Kit"[17], "Smart TV Upgrader"[18]). The additional plug-in devices shall provide regular TV owners access to Smart TV functions including premium online content, offering the latest TV features and services, building out app capabilities, or integrating more advanced game/3D functions into the panel.

---

[17] http://www.samsung.com/us/aboutsamsung/news/newsIrRead.do?news_ctgry=irnewsrelease&news_seq=20329

[18] http://www.lg.com/de/tv/lg-ST600-upgrade-box

With hardware enhancements, such as Central Processing Unit (CPU), memory and Graphics Processing Unit (GPU) up to the level of the latest Smart TV, users can use faster speeds for browsing the Internet and using apps while watching TV.

This kind of upgrading possibility only addresses specific aspects of televisions, mainly the “smart” functionality. It is assumed that the above indicated factors driving consumers to (early) replace their TVs (screen technology, screen size, form factor and resolution) cannot be influenced by these upgrade devices. Further, the additional modular device initially adds material and energy consumption to the existing television.

It is recommended to further explore and discuss the meaningfulness of and possibilities for a criterion on upgradeability for TVs at the stakeholder meeting.

4.2.3.2 Repairability / Warranty / Service

Products shall be repairable, if certain components break down. A case study by WRAP (2011) of three LCD television models to illustrate and encourage the durability and repair summarizes the following most common faults that cause failure and shorten the product’s lifetime:

- Screen faults – due to damage, sometimes caused by impact;
- Power circuit board faults;
- Main circuit board faults – including hardware and microchip software;
- Damage to connections – often between circuit boards; and
- Damage to television stands.

Assemblies such as the screen that are fragile and critical to use, are particularly susceptible to damage. Damage occurs through strains on connectors and PCBs (printed circuit boards) that are subject to flexing, causing strain on soldered joints. Electronic components and solder can also become damaged by variations in temperature and humidity for example, that exacerbates poorly soldered joints and corrupts chips.

In case of defective individual hardware components, different approaches might be effective not to replace the whole product:

- (User) repairability: In case of minor defects, end-users might engage professional repair services. In this context, provision of service agreement and/or consumer information on technical support or professional repair possibilities can contribute to extend the product life.
- Prolonged warranty: According to the European Directive 1999/44/EC on Sale of Consumer Goods and Guarantees[19], the seller has to guarantee the conformity of the goods with the contract for a period of two years after the delivery of the goods. If the goods are not delivered in conformity with the sales contract, consumers can ask for the goods to be repaired, replaced, reduced in price, or for the contract to be rescinded (legal guarantee, warranty). The final seller, who is responsible to the consumer, can also hold the producer liable in their business relationship.
  "Commercial guarantees" are made voluntarily by the trader and can only be in addition to the legal warranties[20]. A warranty going beyond the minimum legal requirements of two years might facilitate the extension of the lifetime of products as it could be interpreted, that those goods covered might be of a better quality. However, pre-condition for a *real* extension of lifetime is that sellers ensure returned products to be repaired and not only replaced in case of defect within the warranty times.
- Service: For example, Ospina et al. 2012 describes the possibility of accessible upgrade services and guaranteed take-back for re-use.
- Pre-condition for the above repairability approaches:
  - Design for repair: Relevant components have to be easily accessible and exchangeable.
  - Availability of replacement parts: Spare parts have to be available for a certain time, also after the end of the product's production. From the perspective of lifetime extension, this time period should not be too short.

---

[19] http://ec.europa.eu/consumers/cons_int/safe_shop/guarantees/

[20] However, experience of manufacturers shows that a two-year warranty of the *manufacturer* is not liked in the case that a *retailer* offers (= sells) an extended warranty, as it diminishes the incentive for a customer to purchase the extra warranty.

– Reasonable repair costs: The costs for spare parts and repair should be appropriate related to the purchase costs for a new device.

The following table provides an overview how the various ecolabel criteria implement the different requirements for repairability / warranty and service.

Table 7: Existing repairability, warranty and service requirements in ecolabel criteria

EU Ecolabel	Blue Angel	Nordic Swan	TCO	EPEAT
• Warranty: The applicant shall offer a commercial guarantee to ensure that the television will function for at least two years. • Availability of replacement parts: The applicant shall ensure that spare parts are available for at least seven years from the end of the product's production • Consumer information: Information should be included in the user instructions and the manufacturer's website to let the user know where to go to obtain professional repairs and servicing of the product, including contact details as appropriate.	• Warranty: --- • Availability of replacement parts: Provision of spare parts for appliance repair is guaranteed during production period and for at least 5 years from the time that production ceases. • Consumer information: The product information shall include information on the above requirements.	• Warranty: The applicant shall offer a commercial guarantee to ensure that the product will function for at least two years • Availability of replacement parts: The applicant shall ensure that spare parts are available for at least seven years from the end of the product's production • User information: Information should be included in the user instructions and the manufacturer's website to let the user know where to obtain professional repairs and servicing of the product, including contact details as appropriate. • Quality of the product: The licensee must guarantee that the quality in the production of the ecolabelled product is maintained throughout the validity period of the license. Verification: Procedures for collating and where necessary, dealing with claims and complaints regarding the quality of the ecolabelled product. • Service and support: The licensee shall offer the possibility of service and support in the official Nordic language where the ecolabelled product is sold.	• Warranty: The brand owner shall provide a warranty for a period of at least one year. • Availability of spare parts: The brand owner shall guarantee the availa-bility of spare parts for at least 3 years from the time that production ceases.	• Warranty: --- • Service information readily available • Early failure process

It is recommended to keep the existing EU Ecolabel criteria on consumer information and spare parts. They could be complemented by criteria on "design for repair" and "reasonable repair costs". The time period for the availability of replacement parts should not be shortened. It should be discussed if the criterion on prolonged warranty appear to be targeted against the background that it does not guarantee defect taken-back products being repaired instead of being replaced by a new one.

4.2.3.3 Second hand usage

A second usage of televisions and computer displays can prolong the use time of these devices for some years.

Regarding computer displays, especially in the business sector it is a usual practice that leased devices are refurbished after a first usage and resold as second hand IT. For televisions, as described in Task 2, the global TV replacement cycle decreased from 8.4 to 6.9 years. However, the existing TV being outdated or broken is not one of the top reasons. The most important drivers for replacing an existing television are the desire to trade up in size followed by wanting to own a flat panel TV with improved picture quality. Most households, especially in mature markets, own more than one TV (mature markets: 2.4; emerging markets: 1.8 TVs per household on average). Thus it might be assumed that in case of purchasing a new television (e.g. for the living room), some of the older, still functioning devices are further used (e.g. in the bedroom, kitchen or children's' room). However, it has to be noted that the advantages of second hand usage become worthless when additional devices and usage lead to an overall increasing energy consumption (rebound effects).

Excursus: Second-hand usage in non-European countries

A large number of European Waste Electrical and Electronic Equipment (WEEE) is exported to non-European countries, for example to West-Africa which developed to a primary destination (Pucket et al. 2005; Greenpeace 2008). Within West-Africa, the megacity Lagos (Nigeria) serves as a major hub for imported second-hand goods. For used televisions and computer displays, the Alaba International Market and Ikeja

Computer Village are the major clusters where 15,000 people in 5,500 workshops repair used equipment, mainly imported from overseas. The repaired and functioning televisions and monitors are sold to the domestic market as well as to other West-African countries (Manhart et al. 2011). Amoyaw-Osei et al. (2011) found out that the market-share of used televisions reaches approximately 51% in Ghana[21].

At first sight, the export and reuse of European worn-out televisions and computer displays seems advantageous regarding the extension of the use-phase which is known to be a decisive factor for reducing the overall environmental burden of these products (see Task 3). However, the end-of-life treatment of these products changes for the worse when being exported from Europe, as in most West-African countries no environmentally sound end-of-life management of waste electronic equipment is established (see section 4.2.4.2).

4.2.3.4 Universality in design

Ospina et al. (2012) describe the advantages of universality in the design and connections exemplified for computers, e.g. in the housing, chassis or in other parts and components, so that the same parts can be re-used in different models. This aspect seems also valid for televisions, however, feeds rather indirectly into the criteria on repairability or on end-of life management, both requiring components being easily accessible and removable. For example, one of the manufacturer reports that harmonisation of fixing types per design (typically cross-head steel screws) of industry standard sizes enables the use of universally available standardised tools for disassembly.

It is recommended not to develop an own criterion on universality in design but to define exact conditions for the structure and joining techniques enabling a quick and safe separation of components for a separate reuse/recycle or a treatment of components containing harmful substances.

[21] Depending on their financial resources, the high income earners may prefer to buy new EEE whereas the majority with low income may only able to afford second hand EEE.

4.2.3.5 Stakeholder feedback on lifetime criteria

Warranty/guarantee:

- A consumer guarantee (of 1-2 year) besides the general warranty period of two years is supported. A guarantee is a more safe instrument than a warranty for the consumer if they want to complain, and should have the effect that manufacturers actually manufacture products to work for a longer period.
- The current 2-year warranty: In the case that a *retailer* offers (= sells) an extended warranty, a 2-year warranty of the *manufacturer* is not liked as it diminishes the incentive for a customer to purchase the extra warranty.
- “It was already a challenging task to increase the warranty period for some countries due to the ecolabel criteria. Therefore further extensions to this requirement would not be supported.”

Spare parts:

- Requirements for replacement parts are supported, e.g. 7 (?) years for TVs
- “It was already a challenging task to increase the availability of spare parts for some countries due to the ecolabel criteria. Therefore further extensions to this requirement would not be supported.”

4.2.4 Resources and end-of-life management

End-of-life management of televisions and computer displays is widely determined and regulated on the basis of the content of resources as well as hazardous substances. While hazardous substances will be described in detail in a separate report, the following sections provide an overview of the material composition as well as European and non-European end-of-life management paths.

4.2.4.1 *Material composition of televisions*

Manhart et al. (2011) provides a detailed material breakdown of a CRT television, EU Ecodesign Lot 5 (2007) provides a rough material composition for an average 42'' LCD TV display module (see Table 8).

Table 8: Mean material composition of an average CRT TV

	Amount contained in a CRT TV		Amount contained in a LCD TV display module	
	[g/unit]	[%]	[g/unit]	[%]
Glass	17,043	57,0%	2,371	18%
Plastics	6,880	23,0%	4,197	31%
Steel	2,990	10,0%	6,831	51%
Copper	900	3,0%	67	0,5%
Aluminium	598	2,0%	not specified	not specified
Tin	31	0,1%	not specified	not specified
Lead	22*	0,1%	not specified	not specified
Nickel	6.7	0,0%	not specified	not specified
Silver	0.62	0,0%	not specified	not specified
Gold	0.04	0,0%	not specified	not specified
Palladium	0.02	0,0%	not specified	not specified
Chromium	0.02	0,0%	not specified	not specified
Ceramics & others	1,434	4,8%	not specified	not specified
Sum	**29,905**	**100 %**	**13,466**	**100**

* Only lead contained in the TV board
Sources: CRT TV: Manhart et al. 2011; LCD TV: EU Ecodesign Lot 5 (2007), Task 5

Although the data still reflect a pre-RoHS television (lead content), the principal material composition is comparable to other televisions. The following variations are likely to be observed with other types of televisions:

- Different product weight, especially between the different technologies;
- Reduced concentration of glass in LCD devices compared to CRT technology;
- Reduced concentration of plastics and increased concentration of steel in devices with steel casing;
- Significantly reduced concentration of lead on post-RoHS devices.

For example, Ardente & Mathieux (2012) presented a detailed bill of material for a LCD-TV weighting 7.19 kg (see Table 9).

Table 9: Bill-of-Material of an average LCD TV

Component	Materials	Mass [g]	Treatments	Disassembly
Components: Frames / covers				
Back cover	ABS	920	mechanical treatments	Full manual disassembly: about 7 minutes
Main front cover	ABS	340		
Support	ABS	250		
Secondary front covers	PC	15		
	plastic (unspecified)	98		
Main metal frame	Iron/steel	1580	Separation for recycling	
Metal frames (n°2)	Iron/steel	261		
PCB support	Iron/steel	48		
Support for cable plugging	Iron/steel	34		
	plastic (unspecified)	38	mechanical treatments	
Internal support	Aluminium	353	Separation for recycling	
Lamps support	Aluminium	30		
Components: PCBs and connectors				
Main PCB	Various (rich in precious metal)	245	Separated on the basis of richness of precious metals and addressed to further treatments for recycling	
PCB (secondary)		61		
PCB (secondary) *		1		
PCB	Various (very rich in precious metal)	55		
film connectors: n° 4		4		
PCB (secondary)	Various (poor in precious metal)	300		
PCB (secondary)		8		
Component: LCD screen				
LCD (larger than 100 cm^2)	Glass, plastics, others (indium: 48.2 mg)	473	Landfill	
Plastic light guide	PMMA	1565	Sorted during the disassembly for further treatments	
Plastic foils	Plastics	100		
Fluorescent lamps (n° 2)	Glass + various (Hg: 8mg; rare earths: 5.8mg)	8	To special treatments for Hg extraction	
Other components				
Capacitors (n°2, diameter larger than 2.5cm)	Various	9	Landfill	
Fan	plastic; steel	19	mechanical treatments	
External cables	Copper; plastic	120	For recycling	
Internal cables		25	For recycling	
Speakers	Steel; plastics	196	Separation for recycling	
Screws	Iron/steel	30		

* PCB smaller than 10 cm^2

The breakdown makes clear that TVs and computer displays – as well as many other electronic devices – contain various materials regarded as critical in the EU (e.g. palladium and rare earths) and metals with high intrinsic material value (gold, silver, and palladium).

Thus, the metal content and in particular the content of precious and critical metals is one of the key drivers of e-waste recycling. However, the general bill of materials such as those presented in Table 8 and Table 9 mostly do not account for all trace-elements und thus might mislead.

In the course of the debate on critical metals in the EU, which was stimulated by the *Report of the Ad-hoc Working Group on defining critical raw materials* (EU 2010), detailed surveys were conducted in order to quantify the contents of critical and precious metals in electronic products. Table 10 and Table 11 present data compiled by Buchert et al. 2012 on critical and precious metal concentration in LCD televisions and computer monitors.

Table 10: Mean content of critical raw materials in LCD televisions

Metal		Content per LCD television (CCFL[22]) [mg]	Content per LCD television (LED[23]) [mg]	Occurrence
Silver	Ag	580	580	PCB and contacts (100%)
Indium	In	260	260	Internal coating on display (100%)
Gold	Au	140	140	PCB and contacts (100%)
Yttrium	Y	110	4.80	Background illumination (100%)
Palladium	Pd	44	44	PCB and contacts (100%)
Europium	Eu	8.10	0.09	Background illumination (100%)
Lanthanum	La	6.80	0.00	CCFL background illumination (100%)
Cerium	Ce	4.50	0.30	Background illumination (100%)
Terbium	Tb	2.30	0.00	CCFL background illumination (100%)
Gallium	Ga	0.00	4.90	LED background illumination (100%)
Gadolinium	Gd	0.63	2.30	Background illumination (100%)
Praseodymium	Pr	< 0.13	0.00	CCFL background illumination (100%)

Source: Buchert et al. 2012

[22] LCD TVs with CCFL background illumination (approx. 70% of all new LCD televisions in 2010)
[23] LCD televisions with LED background illumination (approx. 30% of all new LCD televisions in 2010)

Table 11: Mean weight of critical raw materials in LCD PC monitors

Metal		Content per LCD monitor (CCFL) [mg]	Content per LCD monitor (LED) [mg]	Occurrence
Silver	Ag	520	520	PCB and contacts (100%)
Gold	Au	200	200	PCB and contacts (100%)
Indium	In	79	82	Internal coating on display (100%)
Palladium	Pd	40	40	PCB and contacts (100%)
Yttrium	Y	16	3.20	Background illumination (100%)
Gallium	Ga	0.000	3.30	LED background illumination (100%)
Europium	Eu	1.200	0.06	Background illumination (100%)
Lanthanum	La	1.000	0.00	CCFL background illumination (100%)
Cerium	Ce	0.680	0.20	Background illumination (100%)
Gadolinium	Gd	0.096	1.50	Background illumination (100%)
Terbium	Tb	0.340	0.00	CCFL background illumination (100%)
Praseodymium	Pr	< 0.019	0.00	CCFL background illumination (100%)

Source: Buchert et al. 2012

The data provided in Table 10 and Table 11 indicate the high potential for secondary resources from these product groups, which was also confirmed by other studies (Hagelüken 2006, Schluep et al. 2009). Nevertheless, not all of these materials can currently be recycled. As illustrated by Buchert et al. (2012), only some of the contained silver, gold, and palladium are recycled in the established management paths in the EU (see section 4.2.4.2).

4.2.4.2 End-of-life management of televisions and computer displays

End-of life management in the EU

Televisions are classified under category 4 “Consumer Equipment”, and external computer displays are classified under category 3 “IT and telecommunication equipment” of the WEEE-Directive. This means that special collection and management systems for end-of-life televisions and computer displays are in place within the EU. However, the 2008 review of the WEEE-Directive 2002/96/EC for example revealed that less than half of the arising waste of these product-categories was collected within the formal system in the EU in 2005 (see Table 12).

Table 12: Collection rates for IT and telecommunication equipment in the EU in 2005

Category		% collected of WEEE arising in 2005
4B	CRT TV's	29.9%
4C	Flat Panel TV's	40.5%
3B	CRT monitors	35.3 %
3C	LCD monitors	40.5 %

Source: Huisman et al. 2007

According to Digital Europe et al. (2013a), currently in most Member States the collection rate based on official data of WEEE separately collected by systems set up by producers is on average 1/3 of electronic and electrical equipment sold. However, recent research in several Member States has revealed that there are large flows of WEEE beyond the producer take back systems which are collected and recycled for a profit. In addition to this 1/3 managed by producer take-back systems, on average, a further 1/3 is also collected and treated by treatment operators. So in fact 2/3 of the WEEE is being treated by treatment operators.

The fate of devices not collected cannot be exactly quantified. Nevertheless, the following pathways are believed to be responsible for the majority of not collected items:

- Prolonged storage in households and offices;
- Disposal via the municipal waste stream;
- Export as used or end-of-life equipment to non-European destinations.

While exports to non-European destinations and their implications are analysed in more detail below, disposal via municipal waste stream is regarded as not appropriate disposal. Prolonged storage in households and offices represents a delay of the end-of-life management and is typically not associated with significant negative environmental impacts[24].

[24] Although the impacts of prolonged storage have not yet been quantified, it is sometimes argued that storage on large scale leads to significant secondary resource-stocks that cannot yet be utilised by industry/society. On the other side, it is argued that such storage could also benefit recycling as end-of-life management will take place several years in the future when – probably – recycling systems are better prepared to recover critical raw materials. Another factor to be considered is the fact that reuse

The devices collected within the formal WEEE-System in the EU undergo recycling activities, which can be classified into the following steps:

- Preparation for reuse;
- Pre-processing / dismantling (including detoxification);
- End-processing and final disposal.

While reuse is mostly conducted with devices handed in from corporate consumers[25], the majority of end-of-life televisions and computer displays are passed-on to the pre-processing stage, which involves detoxification (displays across 100 cm^2 and CFL-backlight-units) followed by dismantling and/or shredding and sorting.

Many European recycling enterprises focussing on consumer equipment such as TVs utilise manual pre-treatment technologies (Böni & Widmer 2011; Ardente & Mathieux 2012), which – according to Ardente & Mathieux (2012) mostly – involves the following steps:

- The disassembly of external cables and of front / back covers;
- The disassembly of internal frames;
- The disassembly of main printed circuit boards and internal cables;
- The removal and further dismantling of the LCD screen (including the separation of frames, plastic boards and sheets, and secondary printed circuit boards);
- The disassembly of the backlight system;
- The disassembly and sorting of some additional parts (e.g. large homogenous plastic parts);
- The further disassembly of other components (e.g. speakers, fans, if any).

Typically, parts like speakers and fans are further pre-treated in shredders to liberate the various materials (copper, steel, aluminium).

---

activities depend on high quality used equipment of moderate age. Thus, devices entering WEEE collection after prolonged storage are typically less attractive for the reuse market.

[25] External computer displays collected from corporate consumers typically come in large batches of identical models, which facilitates repair and reuse activities.

Various studies showed that manual dismantling of IT, telecommunication and consumer equipment leads to significantly higher recovery rates for precious metals (Hagelüken 2006, Chancerel & Rotter 2009; Chancerel 2010, Ardente & Mathieux 2012). This goes back to the fact that mechanical pre-processing technologies are not capable of liberating and separating all precious metals bearing components into one homogenous output fraction. As an example, many printed circuit boards (with high concentrations of precious metals) are mounted with aluminium or steel parts. In the mechanical processes, the printed circuit board parts with steel and aluminium are often sorted into the steel- and aluminium-fraction. In the subsequent end-processing facilities for steel and aluminium, all precious metals are lost. Manual pre-processing is often applied in the recycling of LCD-monitors (Ardente & Mathieux 2012).

While some of the above mentioned fractions can undergo further pre-treatment and/or sorting[26], the outputs are generally fed into end-processing units, which can be described as follows:

- Ferrous-metals are fed into secondary steel plants;
- Aluminium is fed into secondary aluminium smelters;
- Copper is fed into copper-refineries;
- Printed circuit boards and IC-contacts are fed into integrated smelters to recover copper, precious metals and other metals as by-products (e.g. lead, tin, indium);
- Plastics are either recycled (material recovery of thermoplastics) or incinerated (energy recovery);
- Display units are landfilled or incinerated (no material recovery)[27];
- CFL-backlights are treated as hazardous waste (mercury recovery, disposal)[28]

[26] Examples: Liberation of insulated copper-cables, sorting of aluminium in different grades, further sorting of plastics according to colour and polymer-types.

[27] Recycling of metals from display units such as indium is currently not established on an industrial scale. As indium is widely regarded as critical metal, some recyclers and policy-makers consider temporal storage of display-units anticipating future recycling options (Böni & Widmer 2011, Ardente & Mathieux 2012).

Excursus: Recycling of plastics

While most of the above listed end-processing steps are well developed and lead to high recycling rates, the field of plastics recycling requires special attention. According to MBA-Polymers (2012), less than 10% of higher value plastics from complex waste streams such as durable goods are currently recycled. In comparison, over 90% of the metals, such as steel, copper and aluminium, are recycled from these same complex waste streams.

While downstream markets for material recovery of thermoplastics (e.g. ABS) were a major problem due to the risks of cross-contamination, this situation is undergoing significant changes stimulated by new sorting technologies (see Ardente & Mathieux 2012) as well as high resource prices. Amongst others the company MBA-polymers recycles mixed plastics from WEEE. Plastics-sorting is fully carried out automatically within the facilities of MBA-polymers located in Austria and China. These facilities produce secondary-plastics of high quality which can be used in the production of new products. According to MBA-Polymers (2012), their processes to recycle plastics use less than 20% of the energy needed to produce virgin plastics from petro-chemicals, saving between 1-3 tons of CO_2 for every ton of replaced virgin plastics.

The following table provides an overview how the various ecolabel criteria implement different requirements for recycling of plastics for each televisions and external computer displays. Blue Angel and TCO do not have any criteria on recycled content and material recovery of plastics, neither for televisions nor for displays.

[28] Although the company Rhodia (part of the Solvay-Group) started as first company the recovery of rare earth elements from CFLs on an industrial scale in beginning 2012 in France (Grafenstein 2013), these operations are more addressing CFL with bigger form-factors (e.g. energy-efficient lamps).

Table 13: Existing requirements for recycled content and material recovery of plastics in ecolabel criteria

	TELEVISIONS	COMPUTER DISPLAYS
Recycled content		
EU Ecolabel	---	The external plastic case of the monitor shall have a post-consumer recycled content of not less than 10% by mass.
Blue Angel	---	---
Nordic Swan	---	---
TCO	---	---
EPEAT	*Required (R)*: Declaration of postconsumer recycled plastic content; declaration of biobased plastic materials content. *Optional (O)*: minimum 5% to 10% content of postconsumer recycled plastic; minimum 25% content of postconsumer recycled plastic; minimum content of biobased plastic material.	R: Declaration of postconsumer recycled plastic content (%); declaration of renewable / biobased plastic materials content (%). O: minimum content of postconsumer recycled plastic; higher content of postconsumer recycled plastic; min. content of renewable / biobased plastic material.
Material recovery		
EU Ecolabel	---	---
Blue Angel	---	---
Nordic Swan	---	90% by weight of plastics and metals in the enclosure and chassis must be technically suitable for material recovery. Material recovery does not include the recovery of thermal energy through incineration.
TCO	---	---
EPEAT	Required: minimum reusable / recyclable rate based on EU WEEE Directive Optional: minimum 90% reusable / recyclable	Required: min. 65% reusable / recyclable Optional: minimum 90% reusable / recyclable

For televisions and external computer displays, the use of post-consumer recycled plastics in manufacturing products seems to be rather at the beginning. Cross-checking corporate information of those manufacturers being awarded with an ecolabel (LG Electronics, Philips, Samsung, Sharp, Sony, Toshiba; cf. Task 2) revealed that for example *LG Electronics*[29] applied around 20% of post-consumer recycled plastics to three of its monitor products; *Samsung*[30] has not applied the use of post-consumer recycled plastics in televisions or displays so far.

29 http://lg.com/global/sustainability/environment/take-back-recycling

30 http://www.samsung.com/us/aboutsamsung/sustainability/environment/takebackrecycling/recyclingperformance.html

Sony[31] has developed an own recycled plastic material with 99% recycled content, with only 1% containing flame retardants and other additives. According to Sony, other typical recycled plastic only had 30% recycled content or less, around 55% oil-based virgin material and 15% flame retardants and other additives. Post-consumer recycled plastics are used in the screen frame and in the bezel, rear cover and stand of some selected television models. *Sharp*[32] states that they developed and implemented a technology for closed-loop material recycling enabling the repeated reuse of scrap plastic components that consist of a single resin material recovered waste appliances into new home appliances as LCD TVs.

Philips[33] manufactures some products containing recycled plastic and / or bio based plastics, but none of their televisions. However, Philips conducted a trial in which back covers from Philips flat screen TVs (FTVs) were closed loop recycled. Within this trial, the plastic back covers were manually disassembled from the current FTVs waste stream, and remoulded to produce new back covers from 100% recycled PC/ABS[34] with phosphorus based flame retardants. As result of the trial, the back covers obtained have met manufacture's strength and flammability specifications and legal hazardous substances levels. Furthermore, no clear difference was found between components made of a single material blend and of mixed plastic blends.[35]

Toshiba[36] started an initiative with the aim of increasing the overall percentage of recycled plastics to 3% by 2015. However, no breakdown information of the content of certain product categories could be found.

---

31 http://www.sony.net/SonyInfo/csr/SonyEnvironment/products/resource/recycled_plastic.html

32 http://www.sharpdirect.co.uk/environment/recycling-technologies/page/recyclingtechnologies

33 http://www.philips.com/about/sustainability/ourenvironmentalapproach/greeninnovation/closingthematerialsloop.page

34 Polycarbonate/Acrylnitril Butadien Styrol

35 https://lirias.kuleuven.be/bitstream/123456789/348773/1/CLOSED+LOOP+RECYCLING+OF+PHILIPS+TV+HOUSING+PLASTICS.pdf

36 http://www.toshiba.co.jp/env/en/products/resource.htm

Generally, using post-consumer recycled plastics in IT products presents significant challenges due to the unique structural, performance (safety, surface quality, and mechanical stability), and cosmetic requirements associated with these applications. For meeting ecolabelling criteria, recycled plastics must also fulfil requirements with regard to hazardous substances. Experience from manufacturers show that several sources of recycled plastics contain flame retardants (e.g. for compliance with safety regulations for audio, video and similar electronic apparatus according to EN 60065) which could include DecaBDE[37] that is prohibited for use after July 2008. So using recycled plastics has the risk of mixture of hazardous substances.

According to manufacturers' general experience, sources that meet these criteria can hardly be identified. On the other hand, the use of recycled plastics provides important environmental benefits e.g. in terms of CO_2-savings compared to the use of virgin plastics.

It is recommended to introduce a new requirement regarding the content of recycled plastics into the EU ecolabel criteria for televisions and computer displays.

[37] Decabromdiphenylether

Design for disassembly to facilitate recycling

Recycling of used electronic products is an important environmental issue (cf. section 4.1). Material recycling and reuse are the best options to counterbalance the overall impacts caused by the production of televisions and displays. Design for easy disassembly facilitates the recycling possibilities and thus are a key factor, also in existing ecolabel criteria, see Table 14.

Table 14: Existing design for disassembly requirements of plastics in ecolabel criteria

	TELEVISIONS	COMPUTER DISPLAYS
Variety of plastics		
EU Ecolabel	• Plastic parts shall be of one polymer or be of compatible polymers for recycling.	• Plastic parts shall be of one polymer or be of compatible polymers for recycling.
Blue Angel	• Plastics should consist of only one polymer.	• Plastic components weighing more than 25 grams may consist of a maximum of 2 different polymers. (Aligned to TCO 5.2)
Nordic Swan	• Plastic parts shall be of one polymer or be of compatible polymers for recycling.	• Plastic parts heavier than 25g must compose of one polymer or compatible polymers, except for the enclosure, which shall consist of no more than two types of polymers that are separable.
TCO	• Each product unit shall have no more than two different types of plastic materials for parts weighing more than 100 grams. The light guide in FPD panels and PWB laminates are exempted	• Each product unit shall have no more than two different types of plastic materials for parts weighing more than 100 grams. The light guide in FPD panels and PWB laminates are exempted
EPEAT	• Optional: One recyclable plastic type per rigid plastic part > 25g • Restriction on materials not compatible with reuse and recycling	• Optional: reduced number of plastic material types
Metal inlays in plastic parts		
EU Ecolabel	• Metal inlays that cannot be separated shall not be used.	• Metal inlays that cannot be separated shall not be used.
Blue Angel	• ---	• There shall be no internal or external metallisation of the plastic cases of the flat-panel monitors. (Aligned to TCO 5.2)
Nordic Swan	• Metal inlays that cannot be separated shall not be used.	• Plastic parts (>25g) may contain metallic inlays provided that these can easily be separated without the use of special tools.
TCO	• In-Mould Insert Moulding or glued metal parts are not accepted	• In-Mould Insert Moulding or glued metal parts are not accepted
EPEAT	• Optional: Moulded/glued in metal eliminated or removable	• Optional: Molded/glued in metal eliminated or removable

	TELEVISIONS	COMPUTER DISPLAYS
Surface coating		
EU Ecolabel	• ---	• All plastic materials in covers/housings shall have no surface coatings incompatible with recycling or reuse.
Blue Angel	• ---	• There shall be no internal or external metallisation of the outer plastic cases of the flat-panel display. (Aligned to TCO 5.2)
Nordic Swan	• ---	• Large plastic parts (>25 g) must not be painted or metallized. Exempted from this requirement are: Fog paint with max. 1w-% paint per plastic part and coatings made from the base polymer.
TCO	• There shall be no internal or external metallisation of the outer plastic cases of the flat-panel display.	• There shall be no internal or external metallisation of the outer plastic cases of the flat-panel display.
EPEAT	• ---	• Required: Elimination of paints or coatings that are not compatible with recycling or reuse
Material coding		
EU Ecolabel	• Plastic parts shall have the relevant ISO 11469 marking if greater than 25 g in mass.	• Plastic parts shall have the relevant ISO 11469 marking if greater than 25 g in mass.
Blue Angel	• Plastic parts greater than 25 grams in mass shall be marked in according to ISO 11469 to allow for a sorting of plastics by type.	• Plastic parts weighing more than 25 grams shall be material coded in accordance with ISO 11469 and ISO 1043, sections 1-4. • Carrier materials of the Printed circuit boards are exempted from this requirement (Aligned to TCO 5.2)
Nordic Swan	• Plastic parts shall have the relevant ISO 11469 marking if greater than 25 g in mass.	• Plastic parts heavier than 25g must carry permanent labelling specifying the material in accordance with latest versions of ISO 11469 and ISO 1043, sect. 1-4. • This criterion does not apply to extruded plastics or the light conductors in flat panel displays. • Plastic parts covering a flat surface of less than 200mm² are also exempted from this requirement.
TCO	• Plastic parts weighing more than 25 grams shall be material coded in accordance with ISO 11469 and ISO 1043, sections 1-4. • Exempted are PWB laminates.	• Plastic parts weighing more than 25 grams shall be material coded in accordance with ISO 11469 and ISO 1043, sections 1-4. • Exempted are PWB laminates.
EPEAT	• Required: Plastic markings • Required: Notification regarding and the identification of materials and components with special handling needs • Optional: Marking provided on the product identifying items containing materials with special handling needs	• Required: Marking of plastic components • Required: Identification and removal of components containing hazardous materials • Optional: Marking of plastics

Manufacturers, for example, claim the following activities with regard to design for disassembly:

- Minimising the number of fixings used per unit by more strategic consideration of their location in the design and more advanced casing designs which require less fixing points to maintain rigidity; number of screws is reduced year by year;
- Markings in rear cover showing the location of screws;
- Use of new types of adhesives enables labels and seals to be separated or removed more easily;
- Marking plastic polymer types on major parts; all mechanical plastic parts >25g have a marking;
- TV plastic parts have no painting and if possible no metal inlays.

According to one manufacturer's feedback, the most efficient and industry preferred method for recycling of end-of-life flat panel displays with no hazardous parts (e.g. mercury-based CCFL lamps), is to process the whole unit by mechanical shredding, followed by automated separation of components with targeted materials like CRMs[38] (e.g. copper-rich PCBs, or loudspeaker electro-magnet coils). In this case, designing for easy dismantling or disassembly would become irrelevant.

On the other hand, the European Flame Retardants Association (EFRA) has conducted a project to evaluate the presence and behaviour of plastics containing flame retardants to study separation methods and challenges of mixed plastics streams and to use these plastics again as recyclates into the same application[39]. Several routes have been explored with the different stakeholders involved in the product life (presently with Flat panel Display). The study revealed following results:

- When going via manual dismantling of the TV recycling rate can be excellent.
- Shredding including a separation process with today's state-of-the-art alighted issues and challenges. It appeared less easy to obtain the same high quality plastics with the same physical properties when producing new plastics containing some portions of recycled material than with manual dismantling.

[38] CRM: Certified reference material

[39] Source: Direct information from EFRA's Stakeholder Questionnaire answer.

This was due to the presence of mainly black plastics as the identification and separation techniques are not good enough at present time for a complete separation. Technology progress shows that separation improvement is likely to occur soon. Also the scale of economy is not very large today, due to the low volume of WEEE plastics available (recycling 5000 tons/year versus production of 200,000 tons/year).

Further, EFRA found out that the marking of plastics, as for example required in ecolabel criteria to facilitate the dismantling and recycling processes (see Table 14), was not correct in more than 20% of 500 verified television products.
According to manufacturers' experience[40], sometimes the marking is difficult to apply to some parts, especially in cases that

- Marking could impact the performance or functionality of the plastic part because of the marking itself,
- There is not enough available appropriate surface area for marking,
- Marking is technically not possible due to the moulding method, or
- The addition or location of marking causes unacceptable defect rates under quality inspection, leading to unnecessary wastage of materials.

Design for disassembly requirements should generally be retained in the revised EU ecolabel criteria, but the formulation and the verification procedures are proposed to be revised regarding practicability experiences.

<u>Excursus: End-of-life management in selected non-European countries</u>

Regarding the exports of WEEE to non-European countries, West-Africa developed to a primary destination. However, in most West-African countries no environmentally sound end-of-life management of waste electronic equipment is established[41].

[40] Source: Direct information from Stakeholder Questionnaire answer

[41] There is currently only one registered and operating e-waste recycler in West-Africa. This is City Waste Recycling Ltd. located in Accra, Ghana.

In turn, e-waste is commonly handled and recycled by the informal sector with adverse impacts on human health and the environment. In addition, it is known that working conditions in this informal recycling sector are below international standards (Manhart et al. 2011; Prakash & Manhart 2010). While the sources of pollution are numerous, the following processes have been identified as major concerns related to devices such as televisions and computer displays:

- Open burning of cables to retrieve copper;
- Breaking and uncontrolled disposal of CRTs;
- Dismantling of flat screen monitors with CFL-backlights;
- Uncontrolled disposal / burning of plastics;
- Hydrochemical leaching of printed circuit boards (not observed in West-Africa).

Amoyaw-Osei et al. (2011) quantified the total dioxin emissions from open cable fires in five West-African countries (Liberia, Côte d'Ivoire, Ghana, Benin, and Nigeria) based on field studies in the greater Accra Region (Ghana). This quantification suggests that open cable fires caused 3 to 7 % of the total European dioxin emissions in 2005 (EU15). According to the authors, around 10 to 20% of these emissions can be attributed to cables from waste electrical and electronic equipment (WEEE), the remaining 80 to 90% mainly to cables from waste vehicles.

Reports from these informal recycling practices in West-Africa stimulated policy action in the EU resulting in Annex VI of the new WEEE-Directive (2012/19/EU), which lays out minimum requirements for shipments. This Annex – amongst others – contains the requirement that exporters claiming to export used equipment (*not* waste) have to provide evidence of evaluation or testing, which states that the devices for export are fully functional. Compared to the previous legal situation (where the burden of proof was on the side of customs and inspection authorities), this represents a major policy shift, which is likely to significantly reduce the export of non-functional equipment (e-waste). Nevertheless, exports of functional used equipment remain legal.

4.2.4.3 Stakeholder feedback on end-of-life criteria

<u>Re-used parts</u>:

- Criteria should also address reuse/recyclability
- Use of secondary material should be encouraged (if relevant), but, in general, must meet the same requirements as other material.
- Starting with a maximum of 5% recycled material would be excellent for developing a European process. Although tests show that it was possible to get workable materials with more recycled plastics, several questions still need to be further worked such as for example maintaining the fire safety level as it requires to follow a complicated process.
- Verification: requiring declarations from material suppliers. Implementing further verification measures could result in the use of recycled source plastics becoming even more economically unattractive compared to virgin materials.

<u>Design for disassembly</u>:

- “Please do not apply **marking** requirements to the following cases:
  - Where marking would impact on performance or functionality of the plastic part because of the marking itself (e.g. on optical layers like PMMA, or lens sheet, etc. where any embossed or raised lettering could impact the channelling of light or interfere with the screen image quality);
  - Where parts cannot be marked because there is not enough available appropriate surface area for marking to be of a legible size where it could be seen by a recycling operator;
  - Where marking is technically not possible due to the moulding method (e.g. compression or vacuum moulding with granulated materials, which cannot guarantee that materials will fill the small detailed cavities of lettering); or
  - Where the addition or location of marking causes unacceptable defect rates under quality inspection, leading to unnecessary wastage of materials, (e.g. where releasing the plastic part from a complex robotic mould design is not possible without incurring surface defect/cosmetic

damage to the part.)"

- To be able to recycle the plastics from an LCD TV it is important not to use **laminated or coated plastics**. Additionally to focus on a **single type of plastics** for the housing preferred designed would be favourable to manual dismantling, which is allowing to remove the high quality plastics back covers and make recycling simpler and easier as well as more performing.
- Focus in the revision must be development of requirements that regulates the **time that it takes to dismantle** the printed circuit boards.
- Focus in the revision must be development of requirements that regulates the time that it takes to dismantle the TV. It is proposed that the **criteria for an easy and effective disassembly** of televisions should be tested and verified by independent dismantling and E-waste companies.
- A standardized method for disassembly efficiency measurement is necessary for product development and for verification by market surveillance. By avoiding hazardous components e.g. mercury backlights, an automated disassembly to become standard practice is expected. Disassembly times will not be relevant any more.
- The proposal to intensify design for EOL improvements by setting a time-based target for dismantling or disassembly has too many uncontrollable factors to be useful or effective. The designer cannot know the method that will be followed by the dismantling operator, the purpose of the dismantling (simple repairs versus EOL treatment), his level of knowledge of the product type and the location of components, the level of skills or training, the tools to be used, or the workplace environment, etc. This means that designers would need to enable a minimum time to be much lower than the target to allow for the average time taken to be within the target. A possible acceptable alternative could be to allow manufacturers to arrange for disassembly assessment of products by 3rd party recyclers, who would then generate an assessment report that could be submitted to the Eco-Label verification bodies (a similar approach is adopted in the USA by the US EPA's Eco-label EPEAT).

4.2.5 Corporate environmental and / or social responsibility

4.2.5.1 General CSR criteria: Challenges for the implementation into ecolabels

Many product groups, also concerning computer products, are associated with both, environmental and social impacts in their life-cycle. Within this context, it is discussed that also the EU Ecolabel should gradually introduce social requirements into their criteria documents.

A main reference point during the revision process will be the EU Ecolabel's Social Task Force, which to date has had two meetings. Any proposals arising from this revision will need to be checked against and should align with the recommendations emerging from the Task Force and the EUEB. Early findings include reference to ILO Core Labour Standards and the need for clear communication to license holders that non-compliance could lead to license revocation.

For this general discussion, Manhart and Prakash (2012) have elaborated specific recommendations regarding the integration of social criteria into the EU Ecolabel. Some of these will be reflected in the following for the revision of the EU Ecolabel criteria for desktop and notebook PCs.

- When integrating social criteria in the EU Ecolabel, in general two different (or as recommended: combined) approaches are conceivable: product or on company related criteria[42].
  - While some product-specific environmental standards directly influence social standards (e.g. elimination of the use of hazardous substances in a product leads to safer working conditions for the employees), it has to be understood that compliance with social standards is generally a process-based approach, and has to be formulated at the company level. Thus, it is important to also consider criteria which address the improvement of social standards in a process-oriented manner in a company.

[42] While some social aspects are tightly bound to the product level (e.g. health impacts of products on end consumers), others are bound to production processes and cannot be assessed by analysing a product itself. In the latter case, criteria and verification mechanisms need to go beyond products and ask for conditions in and/or around a certain production facility. Thus, the Ecolabel will in any case have to envisage a mix of product- and facility/company-related criteria.

- As social concerns vary from product group to product group, also varying approaches and criteria must be chosen to best address the issues of concern. It is believed that a copy-paste paragraph on social aspects to be used in all criteria documents of different product categories will fail to have a desired positive impact on sustainable production and consumption. A three-step approach is suggested:
  - In a first analytical step, social hot spots of a product life-cycle should be identified using a standard methodology[43].
  - In a second step, it should be tried to derive specific criteria for each of the identified hot spots. Or alternatively, to concentrate on the most important hotspots and define few (1-2), but most relevant social criteria. As the EU Ecolabel is primarily an *eco*label, there is no general obligation to fully integrate all social hot spots (as this is the case e.g. with fair-trade-labels).
  - In a third step, existing approaches and initiatives to resolve the identified hot spots and corresponding verification mechanisms should be collected and evaluated.
- If the methodology as proposed above will be applied, verification mechanisms will vary und will include – depending on the type of hotspot, the level of the supply chain and the existence of approaches and initiatives:
  - Self-declaration,
  - Industry code of conduct (CoC), e.g. Electronic Industry Citizenship Coalition EICC[44]
  - Membership in industry initiatives, addressing certain global environmental and social issues for improvement[45]
  - Membership in multi-stakeholder initiatives (e.g. Fair Labor Association)[46],

[43] This could be done for example by applying aspects of Social Life Cycle Assessment (s-LCA) or Product Sustainability Assessment (PROSA). See: UNEP-SETAC Guidelines for Social Life Cycle Assessment of Products, Paris, 2010 and PROSA – Product Sustainability Assessment – Guideline (http://www.prosa.org/fileadmin/user_upload/pdf/leitfaden_eng_final_310507.pdf).
[44] www.eicc.info
[45] See for example: www.eicc.info/initiatives.shtml

– Third-party verified certifications, e.g. SA8000 for manufacturing processes[47],
– Commissioning or carrying out own audits.

- Depending upon the identified hotspot and corresponding social criteria, one or more of the above mentioned mechanisms could be selected. Each verification mechanism has its strengths and weaknesses, which have to be kept in mind and communicated transparently in order to avoid any misunderstanding in product marketing. For example, though a criterion requiring the membership in a certain industry initiative could lead to increased membership numbers, but it will not necessarily boost the effectiveness of the initiative.

So far, Nordic Swan, EPEAT as well as the TCO ecolabel contain corporate social responsibility criteria (see Table 15).

Table 15: Existing corporate social requirements in ecolabel criteria

TCO	Nordic Swan	EPEAT
Displays / Televisions: The Brand owner shall demonstrate the TCO Certified product is manufactured under working practices that promote good labour relations and working conditions by proving accordance with the following: • ILOs eight core conventions 29, 87, 98, 100, 105, 111, 138, and 182. • UN Convention on the Rights of the Child, Article 32. • the health and safety legislation in force in the country of manufacture, and • the labour law, including rules on minimum wage and the social security protection in the manufacturing country. 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. Reasonable effort shall be made to ensure that the requirements of this standard are being met by suppliers and subcontractors throughout the supply chain. The brand owner accepts that TCO Development may conduct/commission on-site inspections and receive full audit reports as part of the application to verify that the Brand owner is fulfilling its obligations according to this Mandate. For the social audit reports and on-site-inspections, the requirement is limited to the 1st tier production facility. The following information shall be submitted to an approved verifier:	Displays: The licensee must have a code of conduct that required adherence to the ten principles of the UN Global Compact. (Including description of how suppliers and manufacturers are informed of this code of conduct.) Televisions: The license holder must have a code of conduct in place in accordance with the ten principles provided for in the UN Global	Displays: Required: Corporate report consistent with Performance Track or GRI Optional: Corporate report based on GRI Televisions: only environmental corporate performance criteria

[46] See for example www.fairlabor.org
[47] www.sa-intl.org/sa8000

TCO	Nordic Swan	EPEAT
1. The requirement is fulfilled by one of the following options (a-d): a) The Brand owner is a member of EICC and provides documented proof of third party audits conducted at production facilities of TCO certified products. b) The Brand owner is SA8000 certified or carrying out the production at SA8000 certified facilities and provides documented proof of third party audits conducted at production facilities of TCO certified products. c) The Brand owner shall complete the Self-documentation according to a questionnaire provided by TCO Development and provide documented proof of third party audits conducted at production facilities of TCO certified products. d) The Brand owner applies for a 12 month grace period by sub-mitting a signed declaration stating which option above (a, b or c) shall be implemented by them and an estimation of when all the necessary documented proof will be available. 2. A written guarantee that the above mandate is fulfilled. The guarantee shall be signed by the responsible person at the Brand owner company.	Compact. The license holder must ensure that the code of conduct is communicated to all suppliers / subcontractors together with a wish that these should also comply with a code of conduct that follows the ten principles provided for in the UN Global Compact. If the licensee violates this code of conduct, Nordic Ecolabelling may revoke their licence.	

The most current TCO Development criteria from 2012 have been introducing a comprehensive mandate regarding supply chain responsibility, inter alia focusing on working conditions in the production of TCO certified products (see above). However, for awarding its first “Sustainability Certification” to a smartphone, TCO has strongly been criticised by occupational and environmental health and justice and workers’ rights groups throughout the world due to the dismal occupational safety and health conditions at the production sites[48].

It is recommended not to require general social criteria for televisions and external computer displays at this point of time as guaranteeing compliance throughout the supply chain is very difficult and it would lead to a general image problem for the whole ecolabel if a licensed product was found to be produced under severe social conditions. Social criteria might be proposed as option for those licensees that are able to guarantee compliance by third-party verified certification.

Alternatively, process-oriented criteria could be drafted requiring that applicants

[4848] See: http://www.amrc.org.hk/system/files/Global%20health%20and%20justice%20groups%20demand%20that%20TCO%20withdraw%20Samsung%20certification.pdf *(a) have a code of conduct in place (e.g. based on ILO) ensuring that it is communicated to all suppliers / subcontractors together with a wish that these should also comply, or (b) shall be members of an initiative addressing certain specific hotspots of the product group and working with their suppliers on continuous improvement (see examples below).*

4.2.5.2 Examples: Industry initiatives on hotspots in the electronics industry

4.2.5.2.1 Minimizing the risk of use on "conflict metals" in electronics

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

The Nordic Ecolabelling for Displays discusses to include a criterion to minimize the risk of use of "conflict metals" in electronics within the next revision round of the regulation. For example, there are two voluntary industry initiatives that started to implement conflict-free sourcing programs.

Solutions for hope initiative

The 'Solutions for Hope Project'[49] was launched in 2011 as a pilot initiative to source conflict-free tantalum from the Democratic Republic of Congo (DRC). Tantalum is a metal used in capacitors for electronic products and is derived from the mineral coltan, which is in rich supply in the DRC. Section 1502 of the so called US Dodd-Frank Act[50] requires that companies publicly traded in the U.S. disclose the use of certain conflict metals, including tantalum, in their products and describe the process used to ensure that the purchase of these minerals does not fund the illegal armed groups operating in the DRC. Some have raised concerns that without a recognized industry standard for verification of mineral sourcing, there is the potential for a de facto embargo of minerals from the region. Thousands of people in the DRC, many operating outside of the conflict regions, depend on artisanal mining of coltan and

[49] http://solutions-network.org/site-solutionsforhope/
[50] http://www.sec.gov/about/laws/wallstreetreform-cpa.pdf

other minerals. Through the Solutions for Hope Project, a program of responsible sourcing of coltan from the DRC has been created and tested to promote economic stability of the area.

Conflict-free tin initiative

To support responsible sourcing and economic development in the Democratic Republic of Congo (DRC), industry partners convened by the Dutch government have started a conflict-free tin sourcing program in the province of South Kivu in October 2012[51]. Since the start, the situation at the mine site has changed substantially; employment rates increased, the income of miners has more than doubled, depending on the quality of the tin and the world price. Due to the increased cash flow in the region, women networks have started saving to buy products which they can sell to the miners in order to support their families. Furthermore, working conditions and the security situation at the mine site has improved since local cooperatives buy equipment such as helmets, boots and water pumps for the miners and stabilize mineshafts with wooden piles in order to prevent accidents. Finally, an interesting side effect of the project is the formalization of the sector, allowing the Congolese government to tax the materials sourced due to the improved transparency.

4.2.5.2.2 Minimizing the use of F-gases in the production

Fluorinated gases (F-gases), such as Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs), Sulphur hexafluoride (SF_6), or Nitrogen trifluoride (NF_3), are a family of man-made gases used in a range of industrial applications. Because they do not damage the atmospheric ozone layer, they are often used as substitutes for ozone-depleting substances. However, F-gases are powerful greenhouse gases, with a global warming effect up to 23 000 times greater than carbon dioxide (CO_2), and their emissions are rising strongly[52].

---

[51] http://solutions-network.org/site-cfti/

[52] Source: http://ec.europa.eu/clima/policies/f-gas/index_en.htm

SF_6 and NF_3 emissions occur during the manufacture of LCD screens for use in monitors and televisions. LCD manufacturers use F-GHGs to clean chemical vapour deposition chambers and plasma etch silicon containing materials.

After introduction of NF_3 into the production of flat panel displays (TFT-LCD), and the rapid expansion of the sector after 2000 in Korea, Japan, and Taiwan, the demand for NF_3 rapidly increased and caused quadrupling of the production capacities for NF_3 in the USA and East Asia. The gas replaced step by step SF_6 which had initially been used as main cleaning agent in this sector. NF_3 emissions from the East Asian LCD production were considered the main cause of the steep increase in measured atmospheric concentrations NF_3 production is estimated to range around at least 6,000 t/y. Almost 5,000 t are used in LCD manufacturing in Korea, Taiwan and Japan. NF_3 is used in the production of thin-film-transistor flat panel displays (LCDs). For a long time the global warming potential of NF_3 had been considered tolerable compared to that of SF_6 which is also widely used in the manufacture of LCDs. However, the global warming potential of NF_3 (17,200) comes close to that of SF_6 (22,200), so that the gas shows the second highest GWP value of all known greenhouse gases[53].

In summary, fluorinated greenhouse gases (F-GHGs) are among the most potent and persistent GHGs contributing to global climate change. These gases are relevant in the manufacture of semiconductors, light emitting diodes, and liquid crystal display (LCD) flat panel displays, inter alia for televisions, computer monitors or tablet PCs. Over the last decade, major flat panel suppliers as well as the semiconductor industry have taken voluntary steps to reduce their F-GHG emissions.

Voluntary industry initiatives

- *Semiconductor industry*: In April 1999, members of the World Semiconductor Council (WSC) announced a goal of reducing PFC emissions by at least 10 percent below the 1995 baseline level by year-end 2010[54]. This target has been reached; for example, the European semiconductor industry[55] has met and surpassed the voluntary reduction goal by reducing absolute emissions by 41% from the 1995 baseline to 2010. A new voluntary agreement for the post-2010 period is currently being elaborated

53 Source: http://ec.europa.eu/clima/policies/f-gas/docs/2011_study_en.pdf
54 www.epa.gov/semiconductor-pfc/resources/indx.html
55 https://www.eeca.eu/esh_pfc/

- *LCD industry*: According to US EPA (2013), in 2001 the World LCD Industry Cooperation Committee (WLICC) agreed to voluntary reduction activities and set a goal to reduce F-GHG emissions to at least 0.82 million tons CO_{2eq} by 2010. This goal had not been achieved due to a rise in emissions resulting from a rapid increase in production for LCD flat panels. As their worldwide demand continues to increase, also by new emerging suppliers with growing market share, F-GHG emissions are also projected to rise.

However, the goals and results are published at sectoral not at manufacturers' or product level so that it is not possible to propose, for example, a certain limit value as criterion for the EU ecolabel.

As it is currently difficult to compare panel suppliers' F-GHG emissions due to a lack of consistency in estimating emissions, estimating emissions reductions, and monitoring the efficacy of installed abatement systems, US EPA has developed sets of questions that are intended to be a starting point to help panel purchasers and retailers to understand how their suppliers are reducing their F-GHG emissions and identify opportunities for discussions to target and implement further mitigation efforts[56].

For ICT products, indirect emissions as F-gases occurring in the supply chain (so called "scope 3 emissions") are most relevant; thus they should be recorded and reported according to a defined standard (e.g. GHG Protocol Scope 3 Standard), e.g. within the annual environment report.

F-gases addressed in current ecolabel criteria

For computer displays, no current ecolabel criteria address the F-gas aspect. However, for televisions, EPEAT as well as within the Nordic Ecolabelling revision process, criteria for reducing F-gases in the production are implemented or discussed:

- *EPEAT*: The Television Criteria contain the following optional criterion: "Reduce fluorinated gas emissions resulting from flat panel display manufacturing" (however, not defining a certain baseline or target for the reductions).

[56] http://www.epa.gov/climateleadership/documents/questions_for_suppliers.pdf

- *Nordic Ecolabelling*: According to Nordic Ecolabelling (2013), it is planned to introduce a requirement on usage of abatement system for NF_3 and SF_6 when/if these gases are involved in the production of LCD panels that are used in TVs that will be licensed for Nordic Ecolabelling. As Nordic Ecolabelling is the first environmental labelling organization suggesting such a requirement, from the producer of the LCD/TFT-cell a declaration of how much kg of the gas is purchased per annum in relation to how many m^2 of displays are produced shall be required so that Nordic Ecolabelling can then in the next revision have a relevant picture of where to aim a potential limit value. Nordic Ecolabelling is aware that this requirement is coupled to some difficulties regarding the sub suppliers declaring data and understands that the requirement is not formulated as an absolute requirement with limit values.
  - Proposed criterion: "*Nitrogen trifluoride (NF_3) and sulphur hexafluoride (SF_6) emission during LCD production*: The LCD panel must be produced in such a way that the Greenhouse gases NF_3 and SF_6, if part of the production process, are abated by a system that is an integrated part of the production process. It is the responsibility of the manufacturing company to ensure that the abatement system is installed, operated and maintained in accordance with the manufacturers (of the abatement system) specifications. The manufacturer of the LCD shall declare the amount of NF_3 and SF_6 purchased in relation to amount of LCD (m^2) produced over one year.

In general, product assemblers/brands can play an important role in reducing the climate impacts of the products they sell by sourcing from suppliers with a demonstrated commitment to reducing F-GHG emissions.

4.2.5.3 Stakeholder feedback on production criteria

- It is proposed to introduce requirements for the use of NF_3 and SF_6 greenhouse gases at the production of the LCD panels.
- "NF_3 should be addressed in order to either disregard its potential danger, or to include measures to reduce emissions of NF_3 during the production of ecolabelled products."
- LCD module suppliers use PFC in their manufacturing processes and are trying to minimize PFC emissions. However, it seems impossible for a TV manufacturer to restrict or control suppliers' PFC usage since the parts delivered do not contain PFC as a substance.

4.2.6 Further stakeholder feedback

- **Harmonization with** the current and recently revised criteria from **TCO** for monitors is suggested.

4.3 Focus for the revision

Based on the technical analysis of LCA literature on televisions and displays, revealing environmental hotspots during the lifecycle (see Task 3 report and summary in section 4.1 of this report), and the improvement potentials derived from these findings (see section 4.2), a framework is proposed for the criteria revision. It is suggested to re-allocate the current structure and approach of the existing criteria document to better align the criteria to the identified hotspots.

The revision of criteria and new criteria proposals will focus in particular on these issues highlighted as environmental hotspots. For other relevant issues, not listed as hotspots, relevant criteria would be set but based more on an industry average. It is also to be considered whether all the criteria should be retained.

The following Table 16 gives an overview on the existing criteria within the EU Ecolabel for external computer displays (left column) and televisions (right column). So far, the EU ecolabel criteria for displays are subsumed under the EU ecolabel criteria for personal computers. The lines crossed out indicate those computer criteria that are explicitly not applied to displays.

Table 16: Current EU ecolabel criteria for external computer displays and televisions

Current EU ecolabel criteria *Displays*	**Current EU ecolabel criteria *Televisions***
Criterion 1 – Energy savings (specific for displays)	Criterion 1 – Energy savings
Criterion 2 – Power management	---
~~Criterion 3 – Internal power supplies~~	---
Criterion 4 – Mercury in fluorescent lamps	Criterion 2 – Mercury Content of Fluorescent Lamps
Criterion 5 – Hazardous substances and mixtures	Criterion 5 – Heavy Metals and Flame Retardants
Criterion 6 – Substances listed in accordance with Article 59(1) of Regulation (EC) No 1907/2006	---
Criterion 7 – Plastic parts	---
~~Criterion 8 – Noise~~	---
Criterion 9 – Recycled content	---
Criterion 10 – User instructions	Criterion 6 – User instructions
Criterion 11 – User repairability	---
Criterion 12 – Design for disassembly	Criterion 4 – Design for disassembly
~~Criterion 13 – Lifetime extension~~	Criterion 3 – Life-time extension
Criterion 14 – Packaging	---
Criterion 15 – Information appearing on the Ecolabel	Criterion 7 – Information appearing on the Ecolabel

Crossed out lines: EU ecolabel criteria for personal computers, explicitly not applied to displays

Table 17 shows a proposal for a new systematic to cluster and allocate the single criteria to certain thematic fields and/or environmental hotspots.

Table 17: New proposed criteria cluster and allocation of sub-criteria for the revision of the Ecolabel criteria for televisions and displays

New proposed criteria cluster	Proposed allocation of sub-criteria
1 Energy consumption	Criterion 1.1 – Energy savings
	Criterion 1.2 – Power management
2 Environmentally hazardous substances	Will be presented in a separate document
3 Life time extension	Criterion 3.1 – Commercial guarantee
	Criterion 3.2 – Repairability
	Criterion 3.3 – Upgradeability
4 End-of-life management: Design and material selection	Criterion 4.1 – Material selection and material information
	Criterion 4.2 – Design for disassembly and recycling
	Criterion 4.3 – Packaging
5 Corporate Responsibility (new)	Criterion 5.1 – Social labour conditions during manufacture
	Criterion 5.2 – Emission of fluorinated GHG during LCD production
	Criterion 5.3 – Use of “conflict-free minerals” during production
6 Further criteria	Criterion 6.1 – Ergonomics
7 Information	Criterion 7.1 – User instructions
	Criterion 7.2 – Information appearing on the Ecolabel

Finally, the introduction of a modular and dynamic criteria approach should be discussed for the criteria revision of televisions and displays, e.g.:

- Blue Angel divides the requirements into “M”-requirements, which must be fulfilled, and “S”-requirements, which should be fulfilled.
- EPEAT differs between “R” (required) and “O” (optional) criteria, the latter being more advanced.
- EU Ecodesign uses different “Tiers” to secure a progressive update, especially of energy requirements, e.g. 201X (X watt energy use), 201Y (X watt minus 5 or 10%), 201Z (X watt minus 10 or 20%) and so on.
- The Nordic Ecolabelling requirements for Televisions will be valid for a shorter period due to fast technical developments.

LITERATURE

Amoyaw-Osei et al. 2011	Amoyaw-Osei, Y.; Agyekum, O.O.; Pwamang, J.A.; Müller, E.; Fasko, R.; Schluep, M.: Ghana e-waste country assessment. Accra, 2011. http://ewasteguide.info/files/Amoyaw-Osei_2011_GreenAd-Empa.pdf
ANEC and BEUC 2012	ANEC and BEUC: Consumer organisations' comments on the review of Ecodesign and Labelling rules for Televisions and on the draft Regulation on electronic displays; Ref.: ANEC-PT-2012-ErP-026; http://www.eupconsumer.eu/download/ANEC-BEUC-lot5-comments-5Oct2012.pdf
Ardente & Mathieux 2012	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.
BAM and UBA 2012	BAM (Federal Institute for Materials Research and Testing, Germany) and UBA (Federal Environment Agency Germany): Comments on the Eco-design Directive (2005/32/EC) Working Document on possible ecodesign requirements for televisions. Version 1, Fassung des UBA vom 17.09.2012
Blue Angel Monitors 2012	Basic Criteria for Award of the Environmental Label, Computer Monitors, RAL-UZ 78c, 2012, http://www.blauer-engel.de/en/products_brands/search_products/produkttyp.php?id=619
Blue Angel Televisions 2012	Basic Criteria for Award of the Environmental Label, Television Sets, RAL-UZ 145, 2012, http://www.blauer-engel.de/en/products_brands/search_products/produkttyp.php?id=668
Böni & Widmer 2011	Böni. H.; Widmer, R.: Disposal of Flat Panel Display Monitors in Switzerland. EMPA, St. Gallen, 2011.
Buchert et al. 2012	Buchert, M.; Manhart, A.; Bleher, D.; Pingel, D.: Recycling critical raw materials from waste electronic equipment. Öko-Institut e.V., Darmstadt, 2012.
Carroll et al. 2009	Carroll, D.; Dorsey, J.; Ferguson, J.; Harris, J.: Energy Star Program Integrity can be enhanced through expanded product testing. USEPA, Washington, 2009.

Chancerel 2010	Chancerel, P.: Substance flow analysis of the recycling of small waste electrical and electronic equipment. An assessment of the recovery of gold and palladium. PhD thesis at the TU Berlin [Berlin University of Applied Sciences], Berlin, 2010.
Chancerel & Rotter 2009	Chancerel, P.; Rotter, V.S.: Edelmetallrückgewinnung aus Elektro- und Elektronikaltgeräten durch Aufbereitung [Recovering precious metals from waste electrical and electronic equipment by pre-processing]. In: Müll & Abfall 02/2009.
Digital Europe et al. 2013a	Guidance document on measuring all WEEE flows and establishing WEEE treatment standards under the WEEE recast implementation. February 2013; http://www.digitaleurope.org/DocumentDownload.aspx?Command=Core_Download&EntryId=514
Energy Star 2012	Energy Star: Energy Star Unit Shipment and Market Penetration Report Calendar Year 2011 Summary. Internet: http://www.energystar.gov/ia/partners/downloads/unit_shipment_data/2011_USD_Summary_Report.pdf?c31c-0585 (Retrieved: 12.03.2013).
Energy Star 2012a	Energy Star Final Version 6.0 Displays Cover Letter; https://energystar.gov/products/specs/sites/products/files/Final_Version_6.0_Displays_Cover_Letter.pdf
Energy Star Displays 2013	Energy Star Program Requirements for Displays. Version 6.0, effective from 01 June 2013 http://energystar.gov/products/specs/sites/products/files/Final_Version_6%200_Displays_Program_Requirements.pdf?8a38-1944
Energy Star Televisions 2013	Energy Star Program Requirements Product Specification for Televisions. Version 6.0, effective from 15 May 2013 http://www.energystar.gov/ia/partners/prod_development/revisions/downloads/television/Final_Version_6_TVs_Program_Requirements.pdf?adec-4dc3
EPEAT Displays 2012	EPEAT Computer-Display Criteria, http://www.epeat.net/resources/criteria-discussion/pc-display-criteria/
EPEAT Televisions 2013	EPEAT Television Criteria, http://www.epeat.net/resources/criteria-discussion/television-criteria/
EU 2010	European Union: Report of the Ad-hoc Working Group on defining critical raw materials. Brussels, 2010.

EU Draft CoC EPS 2012	Draft Commission Code of Conduct on Energy Efficiency of External Power Supplies, Version 5. Brussels, 2012 http://iet.jrc.ec.europa.eu/energyefficiency/sites/energyefficiency/files/code_of_conduct_for_ps_version_5_-_draft_120919.pdf
EU Ecodesign EPS 2009	Commission Regulation (EC) No 278/2009 of 6 April 2009 implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for no-load condition electric power consumption and average active efficiency of external power supplies. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:093:0003:0010:EN:PDF
EU Ecodesign Lot 5 (2007)	EuP Preparatory Studies "Televisions" (Lot 5); Final Report; compiled by Fraunhofer IZM 2007, http://www.ecotelevision.org/finalised_documents.php
EU Ecodesign review TVs 2012	Discussion paper on the review of the Ecodesign and Energy Labelling Regulations for televisions and on the draft Regulation on electronic displays, including computer monitors. To be presented and discussed with stakeholders at the Consultation Forum meeting of 8 October 2012. August 2012, http://www.ebpg.bam.de/de/ebpg_medien/tren5/005_workd_12-08_revision.pdf
EU Ecolabel PC 2011	European Commission: Commission Decision of 9 June 2011 on establishing the ecological criteria for the award of the EU Ecolabel for personal computers (2011/337/EU). http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2011:151:0005:0014:EN:PDF
EU Staff WD EPS 2013	Commission Staff Working document (report to the Ecodesign Consultation Forum) on the Review of Regulation (EC) No 278/2009 regarding External Power Supplies, http://www.eup-network.de/fileadmin/user_upload/Staff_Working_Document_ReviewExternal_Power_Supplies_18032013final.pdf?PHPSESSID=21f67f1c0bec512409242156ca3cf6b4
Graedel 2008	Graedel, T.E.; Defining critical materials, Centre for Industrial Ecology, Yale School of Forestry & Environmental Studies, presentation to Wuppertal Colloquium Sustainable Growth, 17-19 September 2008

Grafenstein 2013	Grafenstein, E.: Säckeweise Rohstoffe. In: Recycling Magazin 01/2013, p. 10-13.
Greenpeace 2008	Greenpeace: Poisoning the poor. Electronic waste in Ghana. Amsterdam, 2008.
Hagelüken 2006	Hagelüken, C.: Improving metal returns and eco-efficiency in electronic recycling – a holistic approach to interface optimization between pre-processing and integrated metal smelting and refining. Proc. 2006 IEEE International Symposium on Electronics and the Environment, 08.-11. May 2006, San Francisco.
Hagelüken and Buchert 2008	Hagelüken, C.; Buchert, M.; The mine above ground – Opportunities and challenges to recover scarce and valuable metals from EOL electronic devices; presentation to IERC Salzburg, 17 January 2008
Hischier & Baudin 2010	Hischier R.; Baudin I.; LCA study of a plasma television device, Int J Life Cycle Assess (2010) 15:428–438, DOI 10.1007/s11367-010-0169-2
Huisman et al. 2007	Huisman, J.; Magalini, F.; Kuehr, R.; Maurer, C.; Ogilvie, S.; Poll, J.; Delgado, C.; Artim, E.; Szlezak, J.; Stevels, A.: 2008 Review of Directive 2002/96 on Waste Electrical and Electronic Equipment (WEEE), Bonn 2007. http://ec.europa.eu/environment/waste/weee/pdf/final_rep_unu.pdf
IFEU 2011	Rohstoffdatenblätter, Institut für Energie- and Umweltforschung (IFEU); Heidelberg 2011
Manhart et al. 2011	Manhart, A.; Osibanjo, O.; Aderinto, A.; Prakash, S.: Informal e-waste management in Lagos, Nigeria – socio-economic impacts and feasibility of international recycling co-operations. Öko-Institut e.V. & BCCC Nigeria, 2011.
Manhart & Prakash 2012	Manhart, A.; Prakash, S.: Integrating social criteria into the EU Ecolabel. Freiburg 2012
Martens 2011	Martens, H.: Recyclingtechnik. Fachbuch für Lehre und Praxis. Heidelberg, 2011.
MBA-Polymers 2012	MBA-Polymers: Because sustainability matters – corporate profile. Internet: http://www.mbapolymers.com/home/images/PDF/mba-corp-brochure.pdf (retrieved: 21.02.2013).
Nordic Ecolabelling 2013	About Nordic Ecolabelling of TV and Projector; Version 5.0; Background; 21 May 2013

Ospina et al. 2012	Ospina J.L.; Maher P.; Schischke K.; Schlösser A.; Environmental product assessment for small computer and laptop companies – MicroPro's Experience with Eco-Design of product service systems, paper in EGG 2012 conference.
Prakash et al. 2011	Prakash, S.; Liu, R; Schischke, K. and Stobbe, L.; Timely replacement of a notebook under consideration of environmental aspects – life-cycle analysis using the data basis of the EuP preparatory study, ProBas, and Ecoinvent; Öko-Institut e.V. in cooperation with Fraunhofer IZM; 2011
Prakash et al. 2011a	Prakash, S.; Gensch, C.-O.; Liu, R.; in collaboration with Schischke, K. and Stobbe, L.; Öko-Institut e.V. in cooperation with Fraunhofer Institut für Zuverlässigkeit und Mikrointegration (IZM): Establishing a data base for the evaluation of ecological and economic effects of ICT products. Study in the context of the UFO-Plan 2009 research project "Resource conservation in the field of information and communication technologies (ICT)" – FKZ 3709 95 308. 2011
Prakash & Manhart 2010	Prakash, S.; Manhart, A.: Socio-economic assessment and feasibility study on sustainable e-waste management in Ghana. Öko-Institut e.V., 2010.
Pucket et al. 2005	Pucket, J.; Westervelt, S.; Gutierrez, R.; Takamiya, Y.: The digital dump. Exporting re-use and abuse to Africa. Seattle, 2005.
Schluep et al. 2009	Schluep, M.; Hagelüken, C.; Kühr, R.; Magalini, F.; Maurer, C.; Meskers, C.; Müller, E.; Wang, F.: Recycling – from e-waste to resources. Bonn 2009.
Schnabel 2012	Schnabel, J.: Understanding efficiency standards for external power supplies. July 2012 http://electronicdesign.com/energy/understanding-efficiency-standards-external-power-supplies
TCO Cert. Displays 2012	TCO Development – TCO Certified Displays 6.0 of 05.03.2012, http://tcodevelopment.com/files/2013/02/criteriadocument_displays_v60_2012-03-05_tcodevelopment.pdf
TCO Cert. Edge Displays 2012	TCO Development – TCO Certified Edge Displays 1.2 of 15.11.2012, http://tcodevelopment.com/files/2012/11/TCO-Certified-Edge-Displays-1.2.pdf

Topten.eu 2013	European TV market 2007 – 2012; Energy efficiency before and during the implementation of the Ecodesign and Energy Labelling regulations; http://www.topten.eu/uploads/File/TV_market_2007–2012_Topten.pdf
UBA 2009	Green IT: Zukünftige Herausforderung and Chancen, Hintergrundpapier für die BMU/UBA/BITKOM-Jahreskonferenz 2009, Umweltbundesamt 2009
US EPA 2013	F-GHG Emissions Reduction Efforts: Flat Panel Display Suppliers; http://www.epa.gov/climateleadership/supplychain/sector.html
WRAP 2011	WRAP; case study; Specifying durability and repair for in LCD televisions; June 2011; A case study of three LCD televisions to identify end encourage durability and repair; http://www.wrap.org.uk/sites/files/wrap/TV%20case%20study%20AG.pdf