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 Desktop and Notebook Computers and Televisions

TECHNICAL REPORT

Hazardous Substances

Criteria Development

(Draft) Working Document

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INTRODUCTION

This draft Task report is intended to provide the background information for the revision of the EU Ecolabel and Green Public Procurement (GPP) 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 aim of this report is to inform discussions within the stakeholder group aimed at finding a workable approach to implementation of Articles 6(6) and 6(7) of the Ecolabel Regulation (EC) 66/2010. These two Articles place restrictions on the presence of hazardous substances in ecolabelled products, using REACH and CLP as their main reference points.

The requirement of the Ecolabel Regulation have up until now been interpreted by a standard legal text addressing 'hazardous substances and mixtures' which has, since 2010, been added as a criteria for each product group. This can be seen in Criteria 5 of Decision 2011/337/EU for personal computers and Criteria 4 of Decision 2011/330/EU for portable computers. The requirement has not yet been integrated into the television criteria.

Initial evidence from this revision process suggests that the current form of the hazardous substance criteria is not fully implementable by computer, display and television manufacturers. This is because its ambition level is too high and form of verification required, based on hazard classifications, is not a familiar one to the electronics industry.

This report proposes a framework for hazardous substance screening and criteria development for complex electronic equipment. It also provides an initial scoping of the bill of materials for computers, displays and televisions and, in an attempt to define the possible ambition level for the criteria, a screening of initiatives by the industry, government, ecolabels and NGO's.

1. BACKGROUND AND POLICY CONTEXT

Here we provide an overview of the current EU regulatory context for hazardous substances and background to the hazardous substance restrictions contained within the Ecolabel Regulation (EC) 66/2010 and their interpretation by the Commission.

1.1 Minimum producer requirements under REACH

Suppliers of electrical and electronic products or components are required to comply with the REACH regulation (EC) No 1907/2006. Substances meeting the criteria described in REACH Art. 57 may be identified as Substances of Very High Concern (SVHCs) and are then included in the 'Candidate List'. The inclusion of a substance in the Candidate List triggers additional duties for manufacturers and importers. Any producer and/or imported of a component or a complex article containing a SVHC on the 'Candidate List' in a concentration above 0.1 % (w/w) or in quantities in the produced or imported articles above 1 tonne per year has the duty to notify ECHA. Enforcement is carried out at Member State level. Whilst compliance with this requirement is understood by ECHA to vary across Europe evidence from large computer manufacturers suggests that verification of SVHC's is a major focus and is reflected by initiatives to ensure compliance by component suppliers.

Suppliers are also under a duty to provide the recipient of the article (downstream users) with sufficient information to allow safe use of the article. This information also needs to be provided to consumers within 45 days of a request.

The Candidate List is dynamic, with proposals for SVHC's submitted by Member States being entered onto the list prior to evaluation by ECHA. Included as of the last update on the 20th June 2013 in total 144 substances (including Dipentyl phthalate (DPP) and Pentadecafluorooctanoic acid (PFOA).

The Candidate List is the basis for the Authorisation process under REACH. SVHC included in the Candidate List will progressively be put forward for inclusion in the Authorisation List (Annex XIV of the REACH Regulation). SVHC that are included in

Annex XIV cannot be manufactured or imported in the EU from a specific date set by the Commission (the 'sunset date'), except if the companies have obtained an Authorisation for their specific use(s). Up until now, 14 substances have been included in Annex XIV[1] including, inter alia, brominated flame retardant HBCDD and the phthalate plasticizers DEHP, BBP, DBP and DIBP.

1.2 Progress achieved by regulation applying to the sector i.e. RoHS

Directive 2011/65/ EG on the restriction of the use of certain hazardous substances in electrical and electronic equipment (‘RoHS 2’) requests Member States to ensure that EEE placed on the market, including cables and spare parts for its repair, its reuse, updating of its functionalities or upgrading of its capacity, does not contain lead (Pb), mercury (Hg), Cadmium (Cd), hexavalent chromium (Cr VI), polybrominated biphenyls (PBB) and polybrominated diphenyl ethers (PBDE). The maximum concentration values of these substances tolerated by weight in homogeneous materials is 0.1%, except for Cd for which the maximum concentration value is 0.01%.

Exemptions from the substitution requirement are permitted if substitution is not possible from the scientific and technical point of view or if the negative environmental, health and consumer safety impacts caused by substitution are likely to outweigh the environmental, health and consumer safety benefits of the substitution or the reliability of substitutes is not ensured.

Currently, approximately 40 applications in electrical and electronic equipment are exempted from the restrictions of the use of the six hazardous substances listed above (see Annex III to Directive 2011/65/ EG)[2]. For these exemptions the maximum

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[1] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CONSLEG:2006R1907:20121009:DE:PDF

[2] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CONSLEG:2011L0065:20130107:EN:PDF

validity period varies between 5 years and 7 years from the relevant dates laid down in Article 4(3) to Directive 2011/65/ EG, unless a shorter period is specified.

The Directive on “Waste Electrical and Electronic Equipment” (WEEE Directive, 2002/96/EC) is relevant to the collection and reuse of EE articles, although it does not contain the names of any substances.

1.3 Possible future EU substance restrictions

1.3.1 Applying to substances / substance groups

Besides the above described legally binding producer requirements several further activities are ongoing with regard to potential future substance restrictions both on EU and Member State Level. These activities can be considered as possible areas of precautionary substance restrictions with regard to development of current ecolabel criteria.

Intentions to submit Annex XV dossiers

Member States and/or the European Chemicals Agency (ECHA) on request by the Commission may prepare Annex XV dossiers for identification of Substances of Very High Concern (SVHC). Authorities intending to submit Annex XV dossiers notify their intention to ECHA who lists all activities in a public registry of intentions:

(1) Registry of current SVHC proposals,

(2) Registry of registration proposal intentions (see http://echa.europa.eu/addressing-chemicals-of-concern/registry-of-intentions).

These substances may in the near future be included on the Candidate List and may finally end up on REACH Annex XIV (see section 1.1). The registry of current SVHC proposal intentions includes in total 13 different substances (inter alia Dihexyl phthalate; as on 22. August 2013).

EU Strategy for Endocrine disrupters

A priority list of endocrine disrupters has been established within the EU-Strategy for Endocrine Disruptors. From a total of 564 chemicals that had been suggested by various organisations or in published papers or reports as being suspected EDs, 147 were considered likely to be either persistent in the environment or produced at high volumes. Of these, however, in a first assessment clear evidence of endocrine disrupting activity was noted for only 66 (assigned Category 1 using the criteria adopted in the study). A further 52 chemicals showed some evidence suggesting potential activity (Category 2). In total 118 substances were categorised in the first exercise of priority setting.

Of the 66 chemicals in Category 1, humans were considered likely to be exposed to 60. In a follow-up to the first prioritising exercise, priority was being given to the conduction of an in-depth evaluation of 12 substances. Nine are industrial compounds for which there is scientific evidence of endocrine disruption or potential endocrine disruption and which were not restricted or being addressed under existing EU legislation. These substances include:

- 2,2-bis(4-(2,3-epoxypropyl)phenyl)propane (BADGE),
- carbon disulphide,
- 4-chloro-3-methylphenol,
- 2,4-dichlorophenol,
- 4-nitrotoluene,
- o-phenylphenol,
- resorcinol,
- 4-tert octylphenol,
- tetra BDE.

Three natural/synthetic hormones (oestrone, ethinyl oestradiol and oestradiol) have also been considered: oestrone, 17b-oestradiol and 17a-ethinyloestradiol.

Stakeholders are kindly asked to indicate which of these industrial compounds showing evidence of (potential) endocrine disruption are relevant for EEE, in particular for TVs and computers.

German UBA identification of CMR substances in EEE

Activities on the identification of substances of concern are also ongoing on Member State level. For example, the German Federal Environment Agency (UBA) commissioned a study on the identification of substances classified as carcinogenic, mutagenic and toxic for reproduction (CMR) and other substances of concern in consumer products including electrical and electronic equipment (EEE), toys and floor/wall coverings.[3]

The study identified the following substances of concern in EEE:

- Antimony
- Phthalates
  - Diethylhexyl phthalate (DEHP)
  - Dibutyl phthahlate (DBP)
  - Diisononyl phthalate (DINP)
  - Diisodeycl phthalate (DIDP)
- Lead compounds
- Cadmium compounds
- Chromium compounds
- Formaldehyde
- Nonylphenol
- Phenol
- Toluene

[3] http://www.umweltdaten.de/publikationen/weitere_infos/4092-0.pdf

- PAH[4]
- Decabromodiphenyl ether
- Benzene
- Cobalt
- Nickel
- Siloxane compounds

Most of these substances, however, are already regulated either by REACH or RoHS (see section 1.1 and 1.2) or any other key legal and regulatory or industry standard (see Joint Industry Guide (JIG); section 3.2.2).

1.3.2 Applying to materials

Current Ecolabel criteria for notebooks and personal computers require that the external plastic case of the system unit, monitor and keyboard shall have a post-consumer recycled content of not less than 10% by mass. Consequently, quality criteria for waste plastic are considered necessary.

The new Waste Framework Directive (2008/98/EC) introduces a procedure for defining end-of waste (EoW) criteria, which are criteria that a given waste stream has to fulfil in order to cease to be waste. Waste streams that are candidates for the EoW procedure must have undergone a recovery operation, and comply with a set of specific criteria. In this regard JRC-IPTS has developed end of-waste criteria for waste plastic[5] for conversion[6] (JRC-IPTS 2013).

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[4] Polycyclic aromatic hydrocarbons (PAH), which are found in numerous materials and are regarded as being of concern because of their carcinogenicity, were considered in detail. They enter articles either via contaminated plasticiser oils, which are used in elastic plastics (rubber and plasticised PVC), or via carbon blacks for blackening. For example, PAH were found in the following parts of electrical equipment: switches, cable sheathing, power supplies, hoses, etc.

[5] The term waste plastic is used as a generic term referring to plastic from industrial or household origin which is collected, sorted, cleaned and in general reclaimed and processed for recycling. Recycling is understood as the transformation of waste plastic material into finished and semi-finished plastic products. Other related terms in use in the industry to define one or more waste plastic types

End-of-waste criteria for a material should be such that the recycled material has waste status if regulatory controls under waste legislation are needed to protect the environment and human health. Criteria have to be developed in compliance with the legal conditions, be operational, not lead to new disproportionate burdens and undesirable side-effects, and consider that waste plastic collection and recycling is a well-functioning industrial practice today. Furthermore, criteria shall be simple and not duplicate existing legislation such as WEEE or ELV for waste, or RoHS, POPs, REACH, CLP and food contact for products.

With regard to hazardous substances, it can be summarised that waste plastic should cease to be waste when:

- Waste plastic includes precise information about the type(s) of polymer(s) contained, the additives contained (as these are required by REACH, CLP, POPs, RoHS and the food contact legislation once the plastic becomes a product), and has a known maximum content of non-plastic components, and unusable plastic types. Other properties of interest to the buyer such as moisture, density or melt mass flow rate may be added as non-compulsory information;
- Waste plastic has not hazardous properties, this being met by the producer ensuring a maximum content of hazardous substances in the mixture;
- Waste plastic is during processing not in contact with certain waste types that can cause cross-contamination, e.g. biowaste, oil waste, waste solvents, health care waste or mixed.

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are recovered plastic, plastic scrap, plastic recyclate, and in particular in CEN standards, recycled plastic and plastic waste (JRC-IPTS 2013a).

[6] Waste plastic for conversion refers to waste plastic that is reprocessed into a ready input for remelting in the production of plastic articles and products, because of its intrinsic plastic physical and chemical properties. Plastic conversion is understood as the transformation of waste plastic materials by application of processes involving pressure, heat and/or chemistry, into finished or semi-finished plastic products for the industry and end-users. The process normally involves sorting, size reduction operations to shreds, flakes or regrind, cleaning, agglomeration, and final shaping into granular (pellet) or powder form, although some of the mentioned steps may be omitted.

Based on the discussed issues, the criteria on quality proposed by JRC-IPTS are summarised in Table 1.

Table 1 Criteria on quality for waste plastic proposed by JRC-IPTS

Criteria	Self-monitoring requirements
1. Quality of waste plastic resulting from the recovery operation	
1.3 The waste plastic, including its constituents, • shall not be classified as hazardous following the definitions in Article 3 and Annex I of Regulation EC/1272/2008 (CLP). • shall not exceed the concentration of substances meeting the criteria(SVHC criteria) laid down in Annex XIII of Regulation EC/1907/2006(REACH).[7] • shall not exceed the concentration limits laid down in Annex IV of Regulation850/2004/EC (POPs)214.	The assessment of hazardousness has to be concluded from a quantitative characterisation of the plastic material in the consignment.
	At appropriate intervals subject to review if significant changes in the operating process are made, representative samples of each grade of waste plastic shall be analysed to measure the content and nature of hazardous substances. The appropriate frequencies of monitoring by sampling shall be established taking into account the following factors: (1) the expected pattern of variability (for example as shown by historical results); (2) the inherent risk of variability in the quality of the waste used as input for the recovery operation and any subsequent processing, for instance the higher average content of plastics containing hazardous substances; (3) the inherent precision of the monitoring method; and (4) the proximity of results to the concentration thresholds that render the material hazardous. The procedure of recognising hazardous materials shall be documented under the management system, and shall be available for auditing.

The above given quality criteria for waste plastic are proposed as point of reference for polymers with a recycled content.

Initial feedback from stakeholders has suggested that a simplified approach based on verification that SVHC's are not present could be accepted for EEE. Whilst it appears that this can readily be verified for virgin polymers the feasibility for recycled polymers is to be discussed with stakeholders.

[7] Annex XIII: Criteria for the identification of persistent, bioaccumulative and toxic substances, and very persistent and very bioaccumulative substances

1.4 What the Ecolabel Regulation (EC) 66/2010 requires

The Ecolabel Regulation (EC) 66/2010 contains in Article 6(6) and 6(7) specific requirements with respect to the presence of hazardous substances in ecolabelled products. These requirements have up until now been interpreted by a standard legal text addressing ‘hazardous substances and mixtures’ which has, since 2010, been added as a criteria for each product group. This can be seen in Criteria 5 of Decision 2011/337/EU for personal computers and Criteria 4 of Decision 2011/330/EU for portable computers.

1.4.1 Interpreting Article 6(6) and 6(7) of the Ecolabel Regulation

Article 6(6) and 6(7) stipulate that hazardous substances shall not be present in ecolabelled products. Article 6(6) refers to specific groups of classifications under the CLP Regulation (EC) No 1272/2008 and to substances which meet the criteria described in Article 57 of the REACH Regulation (EC) No 1907/2006. Article 57 describes substances that may be:

- Classified with Hazard Classes 1A and 1B for carcinogenicity, germ cell mutagenicity and reproductive toxicity according to the CLP Regulation;
- Persistent, bioaccumulative and toxic as defined by the criteria in Annex XIII;
- Substances identified on a case by case basis that may raise equivalent levels of concern.

The wording of Article 6(6) does not state explicitly that the substances should already have been identified according to the procedure in Article 59 or be already listed in Annex XIV. However, a fixed reference to the Candidate List is made in Article 6(7) – see Info-Box 1.

Info-Box 1: Article 6(6) of Ecolabel Regulation (EC) 66/2010

6. The EU Ecolabel may not be awarded to goods containing substances or preparations/mixtures meeting the criteria for classification as toxic, hazardous to the environment, carcinogenic, mutagenic or toxic for reproduction (CMR), in accordance with Regulation (EC) No 1272/2008 of the European Parliament and of the Council of 16 December 2008 on classification, labelling and packaging of substances and mixtures nor to goods containing substances referred to in Article 57 of Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals Agency".

Article 6(7) recognises that in certain circumstances there may be a technical or environmental justification for still using a substance restricted by Article 6(6). It describes how specific categories of goods containing substances referred to in Article 6(7) may be derogated under certain conditions.

The prospect of derogation is, however, ruled out for Substances that have been identified as Substances of Very High Concern according to Article 59 of the REACH Regulation and which are present in the final product at concentrations higher than 0.1% (see Info-Box 2).

Info-Box 2: Article 6(7) of Ecolabel Regulation (EC) 66/2010

7. For specific categories of goods containing substances referred to in paragraph 6, and only in the event that it is not technically feasible to substitute them as such, or via the use of alternative materials or designs, or in the case of products which have a significantly higher overall environment performance compared with other goods of the same category, the Commission may adopt measures to grant derogations from paragraph 6. No derogation shall be given concerning substances that meet the criteria of Article 57 of Regulation (EC) No 1907/2006 and that are identified according to the procedure described in Article 59(1) of that Regulation, present in mixtures, in an article or in any homogeneous part of a complex article in concentrations higher than 0,1 % (weight by weight).

1.4.2 Interpreting Article 6(6) and 6(7) of the Ecolabel Regulation

A standard legal interpretation of Articles 6(6) and 6(7) has been used to date in a number of product criteria, including the personal and notebook computers criteria documents. The text for the most part reflects the intention of the two Articles.

In accordance with Article 6(6) of Regulation (EC) No 66/2010, the product or any part of it shall not contain substances referred to in Article 57 of Regulation (EC) No 1907/2006 of the European Parliament and of the Council nor substances or mixtures meeting the criteria for classification in the following hazard classes or categories in accordance with Regulation (EC) No1272/2008.

The text recognises that substances may be transformed during manufacturing processes so that they are less likely to migrate from the product or they do not constitute anymore an inherent hazard.

The use of substances or mixtures which change their properties upon processing (e.g., become no longer bioavailable, undergo chemical modification) so that the identified hazard no longer applies are exempted from the above requirements.

A concentration limit cut-off is specified for REACH Article 57 substances that meet the criteria in Annex XIII, reflecting Articles 6(6) and 6(7). For substances that are classified under CLP, including substances that meet some of the criteria in REACH Article 57, reference is made to generic or specific concentration limits in the CLP Regulation.

Concentration limits for substances or mixtures meeting the criteria for classification in the hazard classes or categories listed in the table above, and for substances meeting the criteria of Article 57 (a), (b) or (c) of Regulation (EC) No 1907/2006, shall not exceed the generic or specific concentration limits determined in accordance with Article 10 of Regulation (EC) No1272/2008. Where specific concentration limits are determined, they should prevail over the generic ones. Concentration limits for substances meeting criteria of Article 57 (d), (e) or (f) of Regulation

(EC) No 1907/2006 shall not exceed 0,1% weight by weight.

As the main reference point for the criteria a selective list of hazard classifications and risk phrases has then been added (see Table 2). The list of hazard statements represents an interpretation of the classifications referred to in Article 6(6). As can be seen from Table 2 it is possible to distinguish between the nature of the different hazards included within the list and their hazard categorisation.

Table 2: Restricted hazard classifications and their hazard categorisation

Acute toxicity	
Category 1 and 2	**Category 3**
H300 Fatal if swallowed (R28)	H301 Toxic if swallowed (R25)
H310 Fatal in contact with skin (R27)	H311 Toxic in contact with skin (R24)
H330 Fatal if inhaled (R23/26)	H331 Toxic if inhaled (R23)
H304 May be fatal if swallowed and enters airways (R65)	EUH070 Toxic by eye contact (R39/41)
Specific target organ toxicity	
Category 1	**Category 2**
H370 Causes damage to organs (R39/23, R39/24, R39/25, R39/26, R39/27, R39/28)	H371 May cause damage to organs (R68/20, R68/21, R68/22)
H372 Causes damage to organs (R48/25, R48/24, R48/23)	H373 May cause damage to organs (R48/20, R48/21, R48/22)
Respiratory and skin sensitisation	
Category 1A	**Category 1B**
H317: May cause allergic skin reaction (R43)	H317: May cause allergic skin reaction (R43)
H334: May cause allergy or asthma symptoms or breathing difficulties if inhaled (R42)	H334: May cause allergy or asthma symptoms or breathing difficulties if inhaled (R42)
Carcinogenic, mutagenic or toxic for reproduction	
Category 1A and 1B	**Category 2**
H340 May cause genetic defects (R46)	H341 Suspected of causing genetic defects (R68)
H350 May cause cancer (R45)	H351 Suspected of causing cancer (R49)
H350i May cause cancer by inhalation (R49)	
H360F May damage fertility (R60)	H361f Suspected of damaging fertility (R62)
H360D May damage the unborn child (R61)	H361d Suspected of damaging the unborn child (R63)
H360FD May damage fertility. May damage the unborn child (R60, R60/61)	H361fd Suspected of damaging fertility. Suspected of damaging the unborn child (R62/63)
H360Fd May damage fertility. Suspected of damaging the unborn child (R60/63)	H362 May cause harm to breast fed children (R64)
H360Df May damage the unborn child.	

Suspected of damaging fertility (R61/62)	
Hazardous to the aquatic environment	
Category 1 and 2	**Category 3 and 4**
H400 Very toxic to aquatic life (R50)	H412 Harmful to aquatic life with long-lasting effects (R52/53)
H410 Very toxic to aquatic life with long-lasting effects (R50/53)	H413 May cause long-lasting effects to aquatic life (R53)
H411 Toxic to aquatic life with long-lasting effects (R51/53)	
Hazardous to the ozone layer	
EUH059 Hazardous to the ozone layer (R59)	

The assessment and verification requirements are specified to cover instances when substances are not classified, either due to lack of information or because they do not meet the criteria for classification. The criterion text places the burden of proof on the applicant, with reference to guidance in REACH on the scientific information required to support the notification of substances and the preparation of Safety Data Sheets (see Info-Box 3).

Info-Box 3: Assessment and verification

The applicant shall demonstrate compliance with this criterion by providing a declaration on the non-classification of each ingoing substance into any of the hazard classes associated to the hazard statements referred to in the above list in accordance with Regulation (EC) 1272/2008, as far as this can be determined, as a minimum, from the information meeting the requirements listed in Annex VII of Regulation (EC) 1907/2006. This declaration shall be supported by summarized information on the relevant characteristics associated to the hazard statements referred to in the above list, to the level of detail specified in section 10, 11 and 12 of Annex II of Regulation (EC) 1907/2006 (Requirements for the Compilation of Safety Data Sheets).

Information on intrinsic properties of substances may be generated by means other than tests, for instance through the use of alternative methods such as in vitro methods, by quantitative structure activity models or by the use of grouping or read-across in accordance with Annex XI of Regulation (EC) 1907/2006. The sharing of relevant data is strongly encouraged.

The information provided shall relate to the forms or physical states of the substance or mixtures as used in the final product.

For substances listed in Annexes IV and V of REACH, exempted from registration obligations under Article 2(7)(a) and (b) of Regulation 1907/2006 REACH, a declaration to this effect will suffice to comply with the requirements set out above.

An alternative text which presents a number of scenarios for information about the classification or non-classification of substances has recently been used in the rinse-off cosmetics and textile product groups.

It has previously been highlighted by stakeholder feedback that the electronics industry and its supply chain is not familiar with declaration of hazards in this format – although the criteria contained within standards such as EPEAT and TCO suggest that it is feasible for certain additives and treatments.

Info-Box 4: Technical information to be provided to support the declaration of classification or non-classification

The following technical information shall be provided to support the declaration of classification or non-classification for each substance:

(i) For substances that have not been registered under Regulation (EC) No 1907/2006 and/or which do not yet have a harmonised CLP classification: Information meeting the requirements listed in Annex VII to that Regulation;

(ii) For substances that have been registered under Regulation (EC) No 1907/2006 and which do not meet the requirements for CLP classification: Information based on the REACH registration dossier confirming the non-classified status of the substance;

(iii) For substances that have a harmonised classification or are self-classified: safety data sheets where available. If these are not available or the substance is self-classified then information shall be provided relevant to the substances hazard classification according to Annex II to Regulation (EC) No 1907/2006;

(iv) In the case of mixtures: safety data sheets where available. If these are not available then calculation of the mixture classification shall be provided according to the rules under Regulation (EC) No 1272/2008 together with information relevant to the mixtures hazard classification according to Annex II to Regulation (EC) No 1907/2006.

1.4.3 The Ecolabel Task Force on Chemicals

Recent experience with the implementation of Article 6(6) and 6(7) of the Ecolabel Regulation by Competent Bodies, applicants and JRC-IPTS, has demonstrated that in its current form, and as interpreted by the standard legal text, is it difficult to make work in practice. This is primarily because whilst the hazard list in Table 2 enables the inherent hazards within a product to be checked the CLP hazard system is not designed to apply to complex articles. Moreover, the complexity of the supply chain makes verification challenging.

Recognising the need for a more practical interpretation of Article 6(6) and 6(7) the EU Ecolabel Board established a Task Force in spring 2012 to address the issue. Discussions and feedback from Task Force members Austria, CEFIC, Denmark, DG ENV, EEB/BEUC, Eurometaux, Germany, Norway and the UK between March 2012 and May 2013, together with the Ecolabel Competent Body Forum and JRC-IPTS, now form the basis for a proposed new approach. This approach is to be adapted for use during the revision of the Computer and Television criteria.

As of the EUEB meeting of June 2013 the proposed framework has six steps, to which an additional focus on 'green chemistry and eco-innovation' is to be added. Each step represents a separate work package with different tasks that would need to be carried out. During this process stakeholder Ad Hoc Working Groups (AHWG's) and the EUEB would be consulted on key decisions relating to substitution potential, derogations (if required) and assessment/verification. The six steps are illustrated by Figure 1 below:

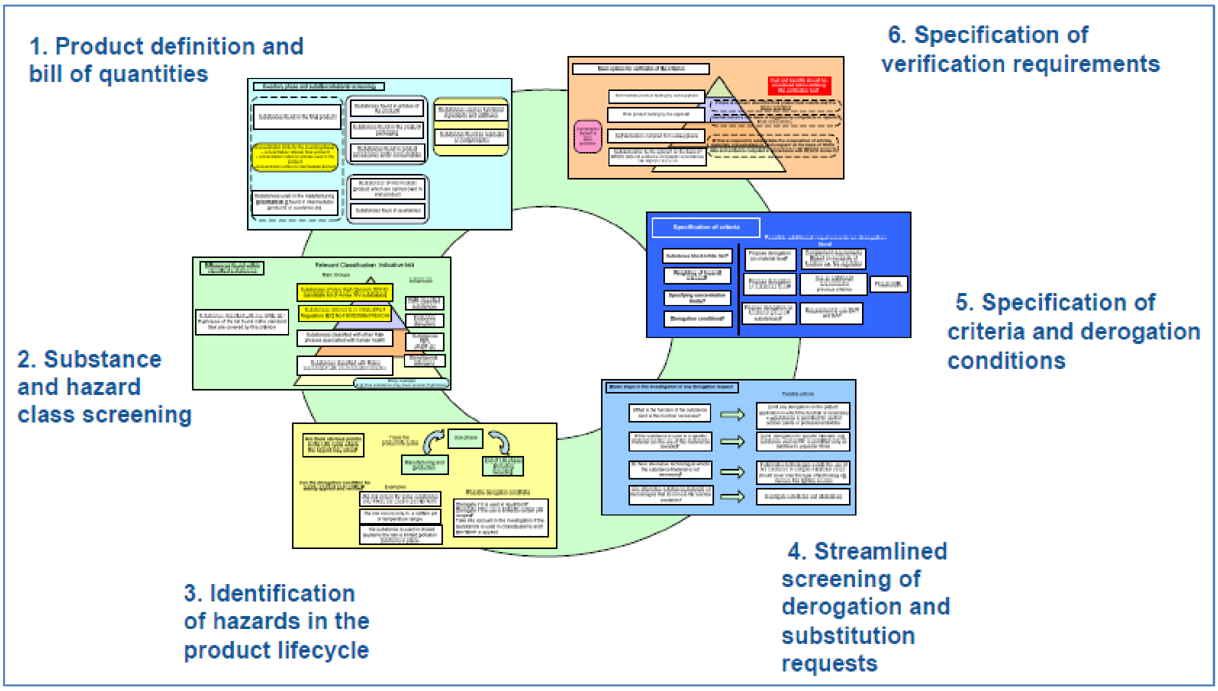

Figure 1: Proposed six steps in hazardous substance criteria development (JRC-IPTS 2013b)

The proposed approach is task-orientated and intended to achieve a high level of integration with a whole life cycle approach to criteria development. The proposed approach consists of the following 6 steps (JRC-IPTS 2013b):

1. Product definition and bill of quantities: A profile would be built up of the material and chemical composition of the product and associated articles, accessories, parts and consumables, or ingredients and mixtures. A clear distinction would be made between articles and mixtures, recognising that in some cases products may consist of both.

2. Substance and hazard class screening: An initial screening would be carried out of substances and mixtures (where supplied ready prepared) against the SVHC Candidate List, REACH Annex XIV and existing EU Ecolabel criteria that are relevant to the product group and the associated articles, accessories and mixtures. There would also be a screening with respect to the listed hazard classes, with the methodology for mixtures applying to aquatic toxicity for products that are themselves mixtures.

3. Identification of hazards in the product lifecycle: Identification of the points in the life cycle of the product where hazards classes related to substances in the product are most relevant e.g. manufacturing phase, use phase, end of life.
4. Streamlined screening of derogation requests and substitution proposals: A standard format would be used to concisely screen and investigate requests which may relate to specific materials, substances or groups of substances.
5. Specification of criteria and derogation conditions: Tailoring and specification of the criterion and any derogation conditions according to the findings of steps 14.
6. Specification of verification requirements: Tailoring and specification of the assessment and verification requirements according to the burden of proof required for the product and the constraints of disclosure along the supply chain.

In the final version of the proposal (October 2013), a second step is to be added in which green chemistry and eco-innovation is to be mapped and benchmarked for the each product. This will enable the ambition level of the criterion to be set based on industry front runner potential to fulfil the requirements. It will also enable the nature of substitutions to be identified from an early stage in the criteria development process.

2. HAZARDOUS SUBSTANCE APPROACH STEP 1: PRODUCT DEFINITION AND BILL OF MATERIALS

Here we collect together the information required under Step 1 of the JRC-IPTS hazardous substance criteria development process. We start by analysing the nature of the products, their status as 'complex articles' and their supply chains.

An approach to the screening of complex electronic products is proposed for discussion with stakeholders. Preliminary information on the assembly of components and the bill of materials for each product, as well as substance groups related to the components or materials and the risk of possible release of hazards have also been collated in order to further inform the discussion with stakeholders.

2.1 Defining computers and televisions as 'complex articles'

In order to apply Article 6(6) and 6(7) to computers and televisions the first step is to understand how different elements of the product are defined under EU chemicals legislation. REACH and CLP differentiate between two main physical forms of product:

- Articles: Defined as 'an object which during production is given a special shape, surface or design which determines its function to a greater degree than does its chemical composition'. The composition could therefore include further articles, parts, accessories, consumables and packaging;

  Examples: *battery, toner cartridge, bed mattress*

- Chemical mixture: Defined as 'a mixture or solution composed of two or more substances'. The composition could therefore include the different ingredients of the product that make up the products formulation, some of which may in turn consist of a number of mixtures or formulations.

  Examples: *soap, shampoo, paint, toner*

A computer or television comprises of a number of different articles, or components. For example, a computer may include a monitor, keyboard, hard drive, power cable and DVD reader/writer. In accordance with the Ecolabel Regulation it could therefore be considered to be a ‘complex article’ (i.e. an article composed of many individual articles) noting that under REACH and CLP there is no such formal definition.

The Ecolabel Regulation also refers to homogenous parts of a complex article which could be interpreted to homogenous plastic and metals components. Whilst no specific definition can be found in REACH or CLP, the RoHS Directive 2011/65/EU defines a homogenous material as:

> *'one material of uniform composition throughout or a material, consisting of a combination of materials, that cannot be disjointed or separated into different materials by mechanical actions such as unscrewing, cutting, crushing, grinding and abrasive processes'*

Components of a complex article may also be treated with or incorporate mixtures or additives that impart specific functions to the product. For example:

- circuit boards and plastic housings may be required to have flame retardant properties;
- Plastic housings may contain colorants such as pigments;
- Power cables may contain plasticizers such as phthalates;
- Solder may contain metals such antimony and beryllium;
- Lithium ion batteries contain hazardous electrolyte but are fundamental in achieving long notebook and tablet battery lives.

This distinguishment between articles, complex articles and chemical mixtures is important because it introduces additional complexity into the supply chain and the role of Original Equipment Manufacturer (OEM) in verifying the composition of each article or component.

2.2 The structure of the electronics supply chain

Electronics supply chains are very complex networks with many different (worldwide) participants performing many different functions. Here we briefly analyse each product in order to understand the nature of the supply chain.

Wood & Tetlow (2013) report that China functions as the 'epicenter' of electronics supply chains. The vast majority of assembly operations for finished electronic goods (FEG) are located in China, along with production of generally lower-value added parts. Korea also plays an important role producing high-value parts such as television and computer displays, and components including dynamic random access memory (DRAM)6 chips, and memory circuits.

Further important roles in the electronic supply chain are played by Malaysia (contract manufacturing of parts), Thailand (production of parts, especially data storage components), Vietnam and Indonesia (assembly of FEG) and the Philippines (production of intermediate electronic goods – IEG, notably HDDs and semiconductors).

2.2.1 Televisions and displays

According to DisplaySearch[8], the five major brands by revenue share in the flat panel TV market are Samsung (South Korea), LG Electronics (South Korea), Sony (Japan), Panasonic (Japan) and Sharp (Japan). Together, they cover around two thirds of the market.

Flat panel TVs contain more than a dozen major components of varying complexities and costs, with the display panel contributing the lion's share of value. LCD TVs are highly modular in construction, making assembly a relatively easy task (Wood &

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[8] Sources:
http://www.displaysearch.com/cps/rde/xchg/displaysearch/hs.xsl/120911_global_tv_shipments_decline_for_second_straight_quarter.asp;
http://www.displaysearch.com/cps/rde/xchg/displaysearch/hs.xsl/121120_north_america_and_china_tv_shipments_rise_ahead_of_holidays.asp

Tetlow 2013). The key components of flat panel TVs and their leading suppliers are presented in Table 3. As can be seen from Table 4 key parts and display modules tend to be made in Japan, Korea, Chinese Taipei, and China. Assembly of finished TVs occurs primarily in China.

Table 3: Key parts and leading suppliers for flat panel TVs

Value	*Part*	*Supplier*	*Headquarters*
High ($100 and up)	Display module	Samsung	Korea
		Innolux	Chinese Taipei
		AUO	
	Color filter	TPN	Japan
		Sintek	Chinese Taipei
Moderate ($20-$100)	Backlight	Formosa Epitaxy	Chinese Taipei
		Sharp	Japan
		Heesung	Korea
	Polarizer	Nitto	Japan
		Optimax	Chinese Taipei
	Glass	Corning	United States
		AGC	Japan
Low (under $20)	Driver IC	Samsung	Korea
		Novatek	Chinese Taipei

(Source: Jurichich (2007); taken from Wood & Tetlow (2013))

Table 4: Parts production and assembly locations for flat panel TVs

Production step	*Main locations*
Liquid crystal panels	Japan, Korea, Chinese Taipei, China
Power supplies	China, Chinese Taipei, India, Indonesia, Japan, Korea, Malaysia, Singapore, Thailand, Viet Nam
IC chips	Thailand, Malaysia, Philippines, Indonesia, Singapore, Viet Nam, Chinese Taipei, China, Korea, USA, Japan, EU
Capacitors	Thailand, Malaysia, Philippines, Indonesia, Singapore
Resistors	Thailand, Malaysia, Philippines, Indonesia, Singapore
Connectors	Thailand, Malaysia, Philippines, Viet Nam
Inductors	Malaysia, Philippines, Viet Nam
Relays	Philippines
Frame, accessories, and electromechanical parts	China, Chinese Taipei, India, Indonesia, Japan, Korea, Malaysia, Thailand, Mexico, Brazil
Intermediate components (liquid crystal modules, Image processing units, tuner units)	China, Chinese Taipei, India, Indonesia, Japan, Korea, Malaysia, Singapore, Thailand
Final product assembly	China, Chinese Taipei, India, Indonesia, Japan, Korea, Malaysia, Thailand, Mexico, Brazil, Viet Nam

(Source: JEITA (2009); taken from Wood & Tetlow (2013))

2.2.2 Desktop and notebook computers

The supply chain for desktop and notebook computers is very complex with 100–1,000 suppliers from the raw materials to the final product. Supply chain actors are present both inside and outside the EU on all levels.

A few general characteristics for the supply chain have been described by Turnbull (2008) and Jepsen et al. (2009). Supply chain patterns seem to be similar for many producers: integrated circuits and other components for desktop computers are produced mainly in South East Asia. For laptops and displays (LCD), the entire production is located in South East Asia, while desktop computers often are assembled from parts produced in South East Asia at sites closer to the market in Europe, due to the more modular design (Jepsen et al. 2009).

The number of international producers of desktop computers is limited. Worldwide leaders in PC shipments in 2012 were Hewlett Packard, Dell, Acer, Lenovo, Apple, and ASUS (Wood & Tetlow, 2013).[9]

Dell (2007) states to have approximately 75 direct suppliers of sub-parts or sub-assemblies located in 153 different sites in the 2007 Sustainability Report. Dell suppliers worldwide (expressed in supplier spend) were 71% from Asia (China, Japan, Korea, Malaysia, Philippines, Singapore, Taiwan, Thailand); 27% from U.S. & South America (U.S., Mexico, Costa Rica and Brazil) and 2% from Europe (Germany, Italy, Ireland and Spain) in 2006.

Hewlett Packard has over 400 contracted suppliers with with own production facilities and a published list of 98 top tier suppliers (Hewlett Packard 2007).

Thus, the supply chain involves several tiers of suppliers who each place articles on the market for assembly into more complicated articles by the next producer in the supply chain.

A graphical overview of the main characteristics for the electronics industry supply chain is given by Turnbull (2008): the production of a power supply unit by a contract producer located inside the EU as shown in Figure 2. It starts with the manufacturing of a circuit board based on epoxy resin (a preparation) and copper foil. The resulting circuit board (an article) is supplied to a circuit board assembler. The circuit board assembler purchases commodity components (articles) from importers. He produces the populated circuit board, PCB (an article), which he supplies to a contract manufacturer. The contract manufacturer then assembles the PCB into the housing (another article) together with cables (more articles) to form the final power supply unit (another article).

[9] The list of computer manufacturers is not exhaustive.

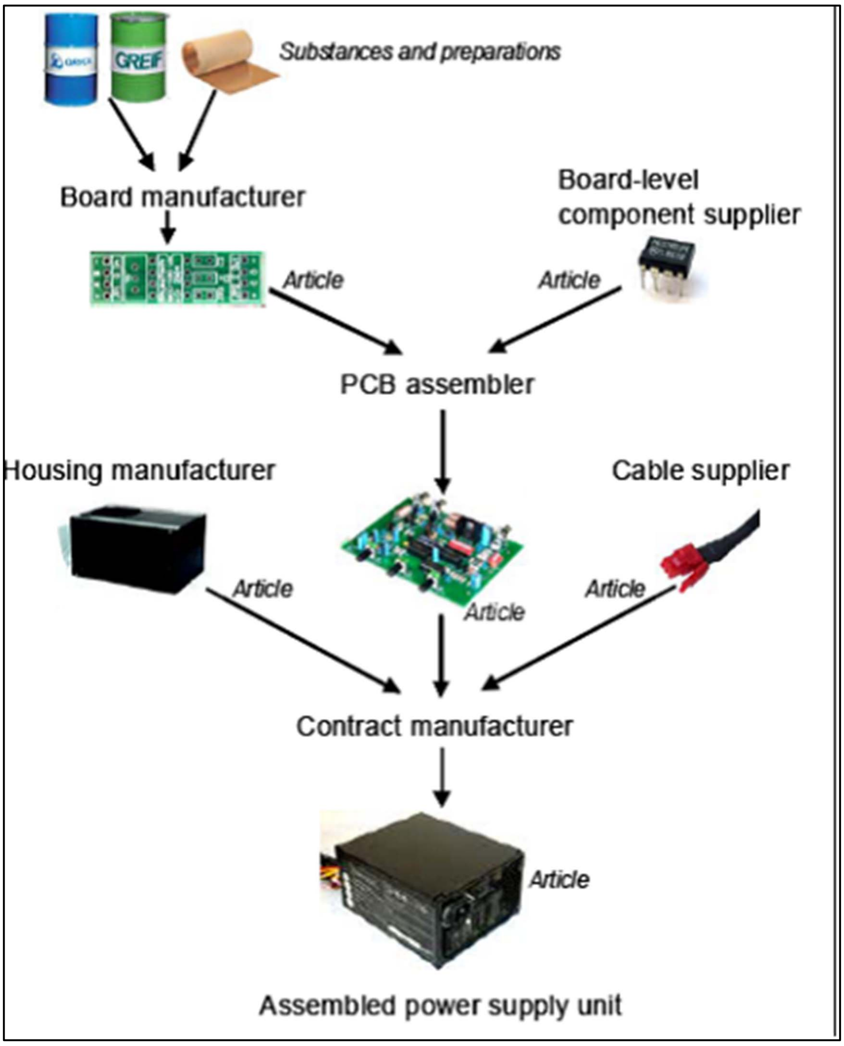

Figure 2: Production of a power supply unit (Turnbull 2008)

The complexity of the supply chain and its geographical core area in Asia is also illustrated in Ciroth and Franze (2011) by showing the number and geographical site of companies involved in the upstream supply chain of a notebook (Table 5).

Table 5: Companies in the upstream supply chain of a notebook (here: ASUS UL50Ag)

Component	Company	Site
Mainboard	confidential	Shanghai, China
HDD	Seagate	Suzhou, China
Processor*#	Intel	unknown
RAM	Hynix	Icheon, South Korea
Display		
LCD panel	AU Optronics	Produced in Taiwan, assembled in China
Bezel*	confidential	China
Case*	unknown	unknown
Keyboard*	confidential	China
Touchpad*	ELan Microelectronics	China
Battery pack		
Assembly	Simplo Technology Inc.	Changshu, China
Plastics*	unknown	unknown
Circuit board*	unknown	unknown
Cells	unknown	Made in Korea
Drive	SEPHIL	Calamba City, Philippines
Fan	Delta Electronics Inc.	Wujiang, China
Speakers*#	unknown	unknown
Camera*#	unknown	unknown
Graphic card*	Intel	unknown
W-Lan card*	AzureWave	Shanghai, China
Power supply	Lite-On Technology Corp	Dongguang, China

*not considered in the S-LCA #not considered in the E-LCA

(Source: Ciroth and Franze 2011)

2.2.3 Knowledge flow along electronics supply chains

Jepsen et al. (2009) conclude that the transfer of knowledge on hazardous substances within the supply chain is hindered by to the complexity of the supply chain and its worldwide distribution.

Information on hazardous substances in materials is often only available if collected for RoHS and REACH compliance, as evidenced by the content of declarations available from manufacturers such as HP [10] , and/or compliance with company specific substance restrictions (e.g. restriction lists; see sections 3.2.2 and 3.3).

The producers' influence on the design, performance and chemistry of (components of) computers and televisions depends on the article in question. For standard commodity articles like wires, screws and printed circuit boards the producers often have low or no influence on design or chemical composition.

Most producers have developed material questionnaires (also known as green procurement surveys) that require suppliers to disclose information about their products. These questionnaires usually take the form of a list of banned or restricted materials and substances that the supplier must certify are not present in the product or subpart. In addition, they often include a separate list of materials and substances that need to be reported when present. The lists are communicated along the supply chain (see section 3.3.3 on verification practices along the supply chain).

Due to the complexity of the electronics supply chain an OEM may therefore face a range of challenges in seeking to verify compliance to Ecolabel criteria that go beyond legal requirements.

2.3 Proposed approach to hazard screening for complex electrical products

At the June 2013 EU Ecolabel Board meeting proposals on how to develop criteria for complex articles such as computers and televisions were tabled for discussion. The proposals were formulated based on input received from the Austrian CB as well as reference to the practices of manufacturers such as Dell and Hewlett Packard.

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[10] Hewlett Packard, *REACH Article 33 declarations*, http://www.hp.com/hpinfo/globalcitizenship/environment/productdata/reachall-products.html#.UgfmFRyGg2V

The proposal has been adapted further and will be tabled for discussion at the October AHWG's for the computer and television product groups. The main elements of the proposal are outlined in Info-Box 5.

Subject to discussion with stakeholders it is proposed to apply this approach to the computer and television product groups. The screening would be applied to the bill of components/materials (see section 2.4) followed by identification of substance groups by their function (see section 2.5). Assessment and verification would then be developed based on a knowledge of the supply chain and the practices of front runner manufacturers (see 3.3.3).

In order to make the approach more workable for these product groups the proposal includes specific reference to Article 23 of Regulation (EC) No 1272/2008 and Annex I point 1.3.4 which derogates alloys, polymers and elastomers from classification if they do not present a hazard in the form they are placed on the market.

Info-Box 5: Proposed approach to the screening of complex articles

- The identification of the main homogenous materials within the bill of materials i.e. metals, alloys, polymers, glass, ceramics
- Separate screening of hazards associated with the chemistry of batteries.
- The identification of functional additives, coatings and treatments as they apply to components of the complex article. These should then be screened for hazards and/or risk of potential release.
- Alloys and polymers to which no potentially hazardous additives, coatings or treatments have been applied can be exempted, reflecting the CLP exemptions for these materials
- Check that the alloys and/or polymers to which hazardous additives or treatments have been applied would pass design for recycling/dismantling requirements *(see also the proposed end-of-waste criteria for polymers; section 1.3.2)*
- Benchmarking of the supplier management systems used by major manufacturers/OEM's, particularly in terms of Tier 1 supplier qualification and the forms of verification used (including the role of analytical testing)

2.4 Assembly of components and bill of materials for computers and televisions

2.4.1 Televisions and displays

Whereas in recent decades almost all television devices were based on cathode ray tube (CRT) technology, a transition to flat screen technology has taken place during the last couple of years. Currently, this market is dominated by two technologies: liquid crystal displays (LCDs) and plasma display panels (PDPs).

2.4.1.1 Thin Film Transistor Liquid Crystal Display Modules (TFT-LCD Module)

This type of modules are used in LCD TVs. In principle, TFT-LCD consists of a lower glass plate (TFT formation), an upper glass pate (Colour filter) and an injected liquid crystal between both glass plates (see Figure 3; EPD LG 2004; KCSWD 2008).

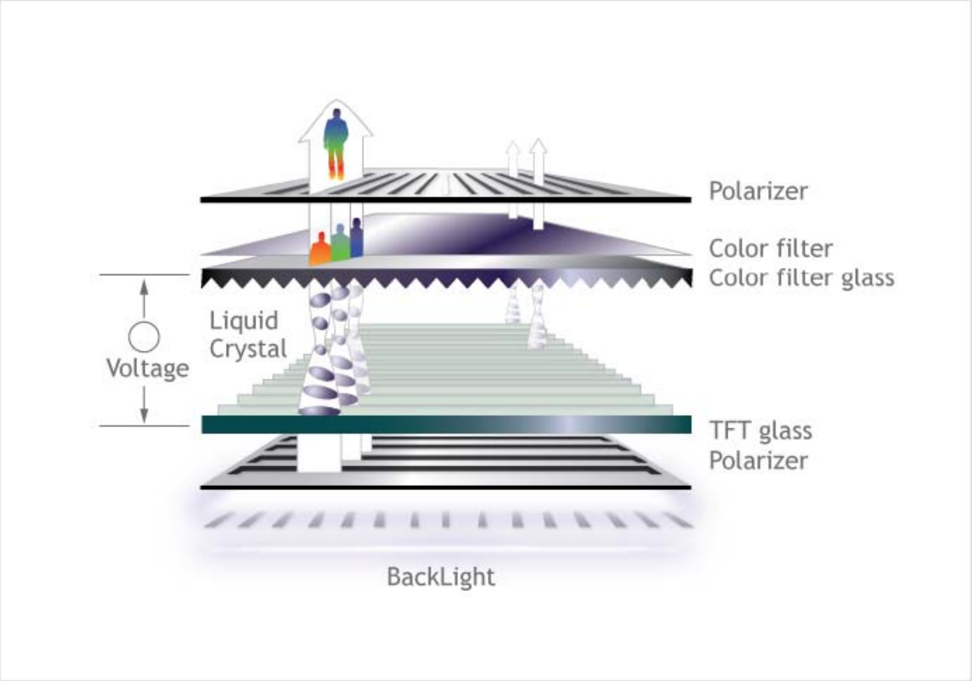


Figure 3: Cross-section of a TFT-LCD Display

(Source: KCSWD 2008)

The main product components are:

- TFT board
- Colour filter board
- BLU (Back light unit)
- Polarizer
- PCB (Printed Circuit Board)
- Cases

The assembly of components is shown in Figure 4.

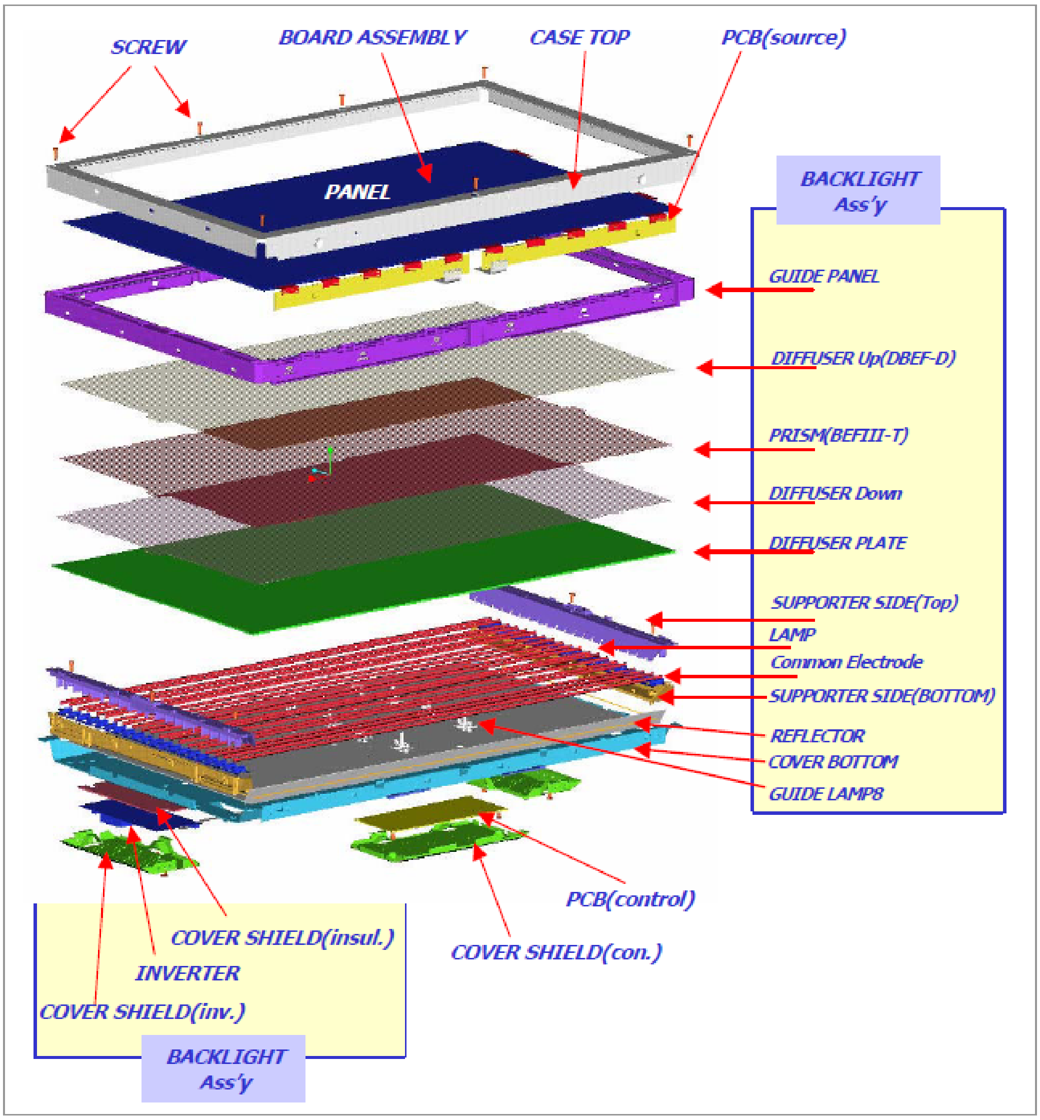


Figure 4: Assembly of a TFT-LCD Module

(Source: EPD LG 2004)

The different component parts of TFT-LCD Modules consist of the following materials (EPD LG 2004):

Part	**Material**
Case Top	Steel
Cover shield	Steel

Part	Material
Screw	Steel
Supporter side	PC
Diffuser plate	PMMA
Reflector	PET
Diffuser	PET
Pris	PET
Cover bottom	Steel
Guide panel	PC
Common electrode	Cu
Guide lamp	PC
PCB	

Flat panel display devices such as LCDs consist primarily of the following types of material (KCSWD 2008):

- Ferrous metal (25% to 44%);
- Plastic (28% to 31%);
- Glass (10% to 23%);
- Printed wire board (6% to 10%);
- Nonferrous metal (3% to 9%);
- Wires (4%); and
- Other materials, including cold cathode fluorescent lamps (CCFLs) or tubes and liquid crystals (<1%),

As can be seen above, plastics are a widely material used in flat panels, with polyvinyl chloride (PVC) being one of the major plastic polymers (FWI, 2001). The main use of PVC plastic in flat panels is in the monitor housing and cables. Many PVC formulations contain additional chemicals: organotin; lead and cadmium-based stabilizers, and plasticizing (softening) additives in flexible PVC, including phthalates. In addition, flame retardants have historically been incorporated into various plastic electronic equipment components. Those receiving the most attention are brominated flame retardants (KCSWD 2008).

Potentially hazardous components and materials are contained both in the display unit itself and in the electronic device containing the display unit (e.g., computer monitor, television); these include substances common to electronics in general, for example lead, cadmium, chromium, antimony, beryllium, and brominated flame retardants. Several substances are unique to flat panels or are present in greater quantities in devices that contain flat panels; these include mercury and liquid crystals[11]. Mercury is used to manufacture the cold cathode fluorescent lamps (CCFLs) that are used to backlight LCD panels (KCSWD 2008). Table 6 presents a list of individual materials and the associated components and parts of LCDs. Computer displays using CRT technology contain many of the same components with the primary exception of liquid crystals. Info-Box 6 describes the bill of material of printed circuit boards (PCB).

Table 6: List of Materials Used in the Manufacture of LCDs

Material	Component	Part
Aluminized mylar	Backlight assembly	Corner tape
Aluminum	LCD assembly; power supply assembly	Glass panel assembly (thin film transistor); heat sink
Beryllium copper	LCD assembly; rear cover	Metal clip, beryllium-copper fingers

[11] Liquid crystals are organic compounds with optical and structural properties of crystals but with the mechanical features of fluids. There are hundreds of liquid crystal compounds used in LCDs, and a typical LCD contains as many as 25 different liquid crystal substances (KCSWD 2008).

Material	Component	Part
	assembly	
Boroslicate	LCD assembly	Glass panel assembly
Brass	Backlight assembly	Brass threaded stand off
Cellulose triacetate-acrylic	LCD assembly	Glass panel assembly (polarizers)
Chromium	LCD assembly	Glass panel assembly (thin film transistor)
Copper	LCD assembly; backlight assembly; power supply assembly; controller	Glass panel assembly (row/column drivers, connection flex, wires/connectors); light assembly (cables); backlight; printed wiring board; power cord receptacle
Foam rubber	Backlight assembly	Gasket
Glass	Backlight assembly	Light assembly (cold cathode tube)
Hi-mu ferric	Backlight assembly	Flat cable toroid
Indium-tin oxide (ITO)	LCD assembly	Glass panel assembly (electrode)
Iodine	LCD assembly	Glass panel assembly (polarizers)
Lead	LCD assembly	Solder
Liquid crystals	LCD assembly	Glass panel assembly
Mercury	Backlight assembly	Light assembly (cold cathode fluorescent lamp)
Molybdenum	LCD assembly	Glass panel assembly (thin film transistor)
Nylon	Backlight assembly; base/stand assembly	Nylon clamp; strain relief bushing
Phospors	Backlight assembly	Light assembly (cold cathode tube)
Plastics and plasticizers (phthalates)	Power supply assembly; rear cover assembly; base/stand assembly	Power cord receptacle; rear cover; covers
Plexiglass	Backlight assembly	Clear protector
Polycarbonate	Backlight assembly	Light pipe, rear plate assembly; plastic tube

Material	Component	Part
Polycarbonate, glass-filled	LCD assembly	Plastic frame
Polyester	LCD assembly; power supply assembly; backlight assembly; rear cover assembly	Brightness enhancer; insulator; power switch; opaque diffuser; white reflector; clothmesh; insulator
Polyester, glass-filled	Base/stand assembly	Upright
Polymide	LCD assembly	Glass panel assembly (orientation film)
Polyoxymethylene (acetal)	Base/stand assembly	Swivel bearing
Resins	LCD assembly	Glass panel assembly (color filters)
Silicon	Controller; power supply assembly; LCD assembly; backlight assembly	Glass panel assembly (thin film transistor, row/column driver tabs and printed wiring boards)
Silicone rubber	LCD assembly; backlight assembly; base/stand assembly	Gaskets; light assembly (shock cushion); rubber feet
Soda lime	LCD assembly	Glass panel assembly (glass)
Stainless steel	Base/stand assembly	Swivel bearing
Steel (iron)	Power supply assembly; backlight assembly; LCD assembly; rear cover assembly; base/stand assembly	Housing; screws; metal plate; rear plate; hold-down plate; meal plate brackets; washers; axle and spring; base weight; C-clip

(Source: KCSWD 2008)

Info-Box 6: Bill of material: Printed Circuit Board (PCB) (Source: Swedish EPA 2011)

PCBs are made of woven glass fibre sheets hardened with a flame retarded epoxy resin. Most commonly, brominated flame retardants (BFR), such as tetrabromobisphenol-A (TBBPA) and polybrominated diphenyl ethers (PBDE), are incorporated into the resin, but chlorinated and inorganic compounds also occur.

The glass in the glass fibre sheets mainly contains oxides of common base elements, such as silicon oxide, calcium oxide and aluminium oxide.

The PCB is layered with copper traces facilitating the conductivity.

The components soldered to the PCBs vary a lot and may contain many different substances.

Relay and switches often contain mercury. Switches may also contain small amounts of cadmium, which also is the case for plated contacts. Light emitting diodes (LEDs) contain gallium arsenide (GaAs), and resistors, capacitors and microchips may contain various metals, although copper and aluminium is most common.

2.4.1.2 Plasma displays

A plasma display is an emissive flat panel display where light is created by phosphors excited by a plasma discharge between two flat panels of glass.

Plasma displays contain xenon and neon gas in hundreds of thousands of tiny cells positioned between two plates of glass. Two types of long electrodes are also sandwiched between the glass plates, on both sides of the cells. The display electrodes are surrounded by an insulating dielectric material and covered by a magnesium oxide protective layer (KCSWD 2008).

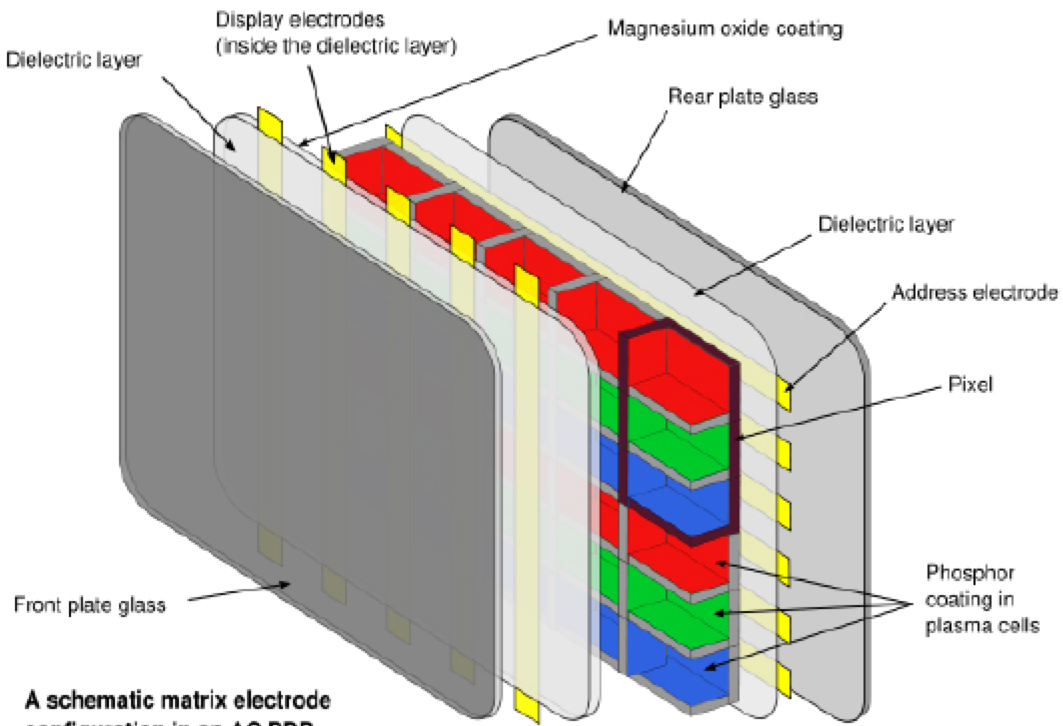


Figure 5: Simple Composition of the Alternating Current Plasma Display Panel with Matrix Electrode Design

(Source: Jari Laamanen March 2007; taken from KCSWD 2008; http://commons.wikimedia.org/wiki/Image:Plasma-display-composition.svg)

Hischier & Baudin (2010) established a detailed composition of a plasma television device:

Table 7: Main components of a (dismantled) plasma television device

Component	Percentage	Main materials
Housing	48,3	Metals, plastics, glass
Internal protection material	0,2	Silicon, plastics
Plasma panel	26	Glass with various coatings
Electronics	17,3	Printed wiring boards

Cables	0,8	Copper, plastics
Packaging	7,4	Carton board, EPS
Total	100	

Stakeholders are kindly asked for further input on the bill of material of TVs in order to identify where within the components/materials coatings, treatments and additives are usually found and/or are required (see also section 2.5).

2.4.2 Desktop and notebook computers

2.4.2.1 Desktop computers

A desktop computer is an article of high complexity consisting of various parts containing multiple components which are composed of high number of different materials. The typical break down of a desktop computer into parts, components and materials is shown in Table 8.

Table 8: Typical composition of parts, components and materials in a desktop computer

Parts	Components	Materials
Optical Drive	Cable Screw Casing PWB Switch Plastic arm Disc tray	Cu-wire Steel tube Steel sheet PBW/Solder Steel Sheet ABS ABS
Hard disk drive (HDD)	PWB Screws Magnet arm Plate Motor Body	PWB, slots, solder Steel tube Steel tube Cu winding wire, steel tube Cast iron
Power supply unit (PSU)	Casing Screws	Steel sheet Steel tube

Parts	Components	Materials
	Power supply Transformer Cables Fan	PET Cast iron/Cu winding wire Cu wire PET/solder
Motherboard	Rubber pins CPU heatpipe Screws Lens Battery Plugs	PVC PC Steel tube PC PET, steel tube
Housing	Metal Bezel HDD trays Screws Chassis	Steel sheet ABS PC/ABS Steel tube Steel sheet, ABS
Cable	-	Cu wire
Mouse	Cables Plastic part Ball steel	PVC, Cu wire ABS Cast iron
Keyboard	Cables PWB Housing	PVC, Cu wire ABS Steel sheet, HIPS, PS, ABS

(Source: Jepsen et al. 2009)

The weight share of the different materials of a desktop computer is presented in Table 9. A more detailed description of materials and weight shares of a desk top computer for office use is given in Table 10.

Table 9: Typical share of materials of a desktop computer

Materials	Desktop computer	Keyboard	Mouse
Metals (ferrous and non-ferrous)	ca. 75%	ca. 63%	ca. 57%
Plastic	ca. 10%	ca. 36%	ca. 43%
Others (e.g. electronics)	ca. 15%	ca. 0.5%	-

(Source: Jepsen et al. 2009)

Table 10: Bill of materials for desktop PCs

EuP Lot 3 prep study: Office desktop PC — MZ

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !
1	LDPE	246	1-BlkPlastics	1-LDPE
2	ABS	381	1-BlkPlastics	10-ABS
3	PA 6	138	2-TecPlastics	11-PA 6
4	PC	264	2-TecPlastics	12-PC
5	Epoxy	98	2-TecPlastics	14-Epoxy
6	Flex PUR	2	2-TecPlastics	16-Flex PUR
7	Steel sheet galvanized	6312	3-Ferro	21-St sheet galv.
8	Steel tube/ profile	107	3-Ferro	22-St tube/profile
9	Cast iron	483	3-Ferro	23-Cast iron
10	Ferrite	0	3-Ferro	24-Ferrite
11	Stainless 18/8 coil	10	3-Ferro	25-Stainless 18/8 coil
12	Al sheet/ extrusion	315	4-Non-ferro	26-Al sheet/extrusion
13	Al diecast	15	4-Non-ferro	27-Al diecast
14	Cu winding wire	257	4-Non-ferro	28-Cu winding wire
15	Cu wire	334	4-Non-ferro	29-Cu wire
16	Cu tube/sheet	67	4-Non-ferro	30-Cu tube/sheet
17	Powder coating	2	5-Coating	39-powder coating
18	Big caps & coils	483	6-Electronics	44-big caps & coils
19	Slots /ext. Ports	310	6-Electronics	45-slots / ext. ports
20	Integrated Circuits, 5% Silicon, Au	69	6-Electronics	46-IC's avg., 5% Si, Au
21	Integrated Circuits, 1% Silicon	96	6-Electronics	47-IC's avg., 1% Si
22	SMD & LEDs avg	194	6-Electronics	48-SMD/ LED's avg.
23	PWB ½ lay 3.75 kg/m2	78	6-Electronics	49-PWB 1/2 lay 3.75kg/m2
24	PWB 6 lay 4.5 kg/m2	163	6-Electronics	50-PWB 6 lay 4.5 kg/m2
25	Solder SnAg4Cu0.5	48	6-Electronics	52-Solder SnAg4Cu0.5
26	Cardboard	2287	7-Misc.	56-Cardboard

(Source: EC DG TREN (2007)

2.4.2.2 Notebook computers

The typical composition of a notebook computer is given in Table 11. The bill of materials of the notebook parts and components is very much comparable to the BOM of desktop computers (see Table 8 and Table 10). The composition of the display is reflected by the bill of components / BOM for LCD displays (see section 2.4.1.1).

Table 11: Typical composition of parts and components of a notebook computer

Part	Component
Case & keyboard	Thermoplastics
	Metal inlays (mostly copper and/or aluminium)
Display	Thermoplastics (case)

Part	Component
	Printed circuit boards (with various parts & components)
	Glass
	Transparent plastic foils & sheets
	Liqued cristals
	Cables
Motherboard & cards	Printed circuit boards (with various parts & components)
	Heat sinks (mostly aluminium & copper)
	Fan (with motor)
	Contacts
Hard Disk Drive	Case (mostly aluminium & stainless steel)
	Disks (glass or aluminium)
	Spindle motor
	Voice coil accelerator (steel, copper, rare earth magnets)
	Reading-writing arm (mostly aluminium)
	Printed circuit board (with various parts & components)
Optical drive	Case (mostly steel & plastics)
	Steel parts
	Spindle Motor
	Printed circuit board (with various parts & components)
Power supply	Plug
	Cables
	Thermoplastics (case)
	Printed circuit board (with various parts & components)
Battery pack	Thermoplastics (case)
	Printed circuit board (with various parts & components)

Part	Component
	Battery cells (mostly Li-Ion)
Others	speakers (plastics, steel, magnets)
	Internal cables
	Structural components (steel, plastics)
	Plugs, connectors, switches
	Camera
	Touchpad

Stakeholders are kindly asked for further input on the bill of material of desktop and notebook computers in order to identify where within the components/materials coatings, treatments and additives are usually found and/or are required (see also section 2.5).

2.5 Functional substances / functional substance groups

According to the proposed approach to the screening of complex articles (see Info-Box 5), functional substances such as additives, coatings and treatments etc. should be identified and grouped and in a next step they should be screened for hazards and/or risk of potential release.

2.5.1 Identification of substance groups by function

The exact compositions of a material within a product is in general of lower relevance as the focus is on functionality and the performance properties of the materials used together with functionality of the final assemblies and sub-assemblies of the product. Consideration of hazards and their substitution potential at a functional level also enables comparisons to be made between different substances within the same grouping.

For example, integrative assessment approaches such as GreenScreen™ screen the intrinsic hazards of substances, then allow a comparison between substances of the same functional group (e.g. flame retardants) on basis of their hazards, and finally enable the selection of those substances with the lowest negative impact on human health and environment as expressed by their hazard profile (see section 3.5.3).

As a starting point for an investigation on the functional level the following Table 12 presents a preliminary identification of substance groups by function that may be relevant in television, desktop computers and notebooks, and gives example substances for each of them. *Feedback is required from stakeholders in order to complete identification of where in the product they may arise.*

Table 12: Substance groups with relevance for television, desktop computers and notebooks

Substance groups	**Where in product?** *To be completed by means of stakeholder input*	**Substances (examples)**
Flame retardants	PWB, plastic casing, housing, connectors	• TBBP-A • Hexabromocyklododekan (HBCDD), • tris(2-chloroethyl)phosphate (TCEP) • Short and medium chain chlorinated paraffins (SCCP and MCCP)
Colorants / dye / pigments	Plastic casing	• Antimony and its compounds; • Lead/lead compounds • Azo dyes • Lead chromate molybdate sulfate red (C.I. Pigment Red 104) • Lead sulfochromate yellow (C.I. Pigment Yellow 34)
Solder		• Antimony or bismuth and its compounds • Cadmium/cadmium compounds
Catalysts : a) flame retardant catalyst b) curing catalyst for silicone		a) • Antimony or beryllium and its compounds b)

Substance groups	**Where in product?** *To be completed by means of stakeholder input*	**Substances (examples)**
resin and urethane resin		• Dibutyltin (DBT) • Dioctyltin (DOT)
Plastizicer		• Phthalates (including DEHP, BBP, DINP, DIDP, DNOP, DHNUP, DIHP) • Short Chain Chlorinated Paraffins (SCCPs)
Additives (e.g. in metal, glass and plastics)		• Phthalates (plastizicers in plastics) • Arsenic compounds (in glass)
Adhesives		• Phthalates
Anti-corrosion surface treatments		• Cadmium/cadmium compounds
Lubricants / Surfactant		• Phthalates • Nonylphenol • Nonylphenolethoxylates
Anti-microbial agents/coatings		• Selenium and its compounds, • Triclosan • Organotins Tributyl tin oxide (TBTO) Dibutyltin dichloride (DBTC) Dibutyltin (DBT) Dioctyltin (DOT)
Ceramics		• Beryllium oxide (BeO)
Electrolytes (in batteries)		• Bis(2-methoxyethyl) ether
Stabilizer	PVC cables	• Cadmium/cadmium compounds • Lead/lead compounds • Dibutyltin (DBT) for PVC • Dioctyltin (DOT) for PVC
Surface finish/treatment: Ink, paint, plating[12]; anti-corrosion layer		• Cadmium/cadmium compounds
Fluorescence		• Cadmium/cadmium compounds

[12] Surface covering in which a metal is deposited on a conductive surface

2.5.2 Evidence on emissions of hazardous substances during the use phase for the products

As mentioned above, functional substances or functional substance groups such as additives, coatings and treatments etc. should not only be screened for their hazards but also for their potential relevance and their release during the product life cycle. This could relate to both the workforce during manufacturing and the consumer during use of the product.

Methods for the determination of chemical emission rates from electronic equipment during intended operation are specified in the Standard ECMA-328[13]. It is proposed that more detailed evidence is gathered once an improved picture of the substance groups and potential hazards has been developed.

As an example, the potential exposure to flame-retardant chemicals throughout their life cycle in PCBs has been investigated during the Flame Retardants (FRs) in Printed Circuit Boards (PCBs) Partnership (see section 3.1.1 and Table 15).

[13] http://www.ecma-international.org/publications/files/ECMA-ST/ECMA-328.pdf

3. HAZARDOUS SUBSTANCE APPROACH STEP 2: SECTORAL ECO-INNOVATION AND GREEN CHEMISTRY

Here we present a scoping of eco-innovation and green chemistry initiatives relating to the computer and television manufacturing sector. This informs step 2 of JRC-IPTS's approach to hazardous substance criteria development.

The aim of Step 2 is to inform the ambition level and framework for the criteria. The intention is that these are defined by the product design, substitution potential and supply chain management systems evidenced by the leading products on the market. In order to ensure a balanced approach evidence is collated from Government, Industry, Ecolabel and NGO initiatives.

Further examples of initiatives relevant to computer and television products are requested from stakeholders.

3.1 Government-led initiatives

3.1.1 Evaluation of flame retardants in Printed Circuit Boards, USA EPA

A broad-based stakeholder group joined with the Design for the Environment (DfE) Program in the U.S. Environmental Protection Agency's (EPA's) Office of Pollution Prevention and Toxics (OPPT) to form the Flame Retardants (FRs) in Printed Circuit Boards (PCBs) Partnership[14]. The partnership includes members of the electronics manufacturers, component and board manufacturers, chemical companies, trade associations, environmental groups, universities, and governments.

This initiative was formed in order to develop an improved understanding of the environmental and human health impacts of new and current materials that can be used to meet the fire safety requirements for circuit boards. The partnership evaluated eight commercially available flame retardants for FR-4 laminate materials

[14] http://www.epa.gov/dfe/pubs/projects/pcb/index.htm

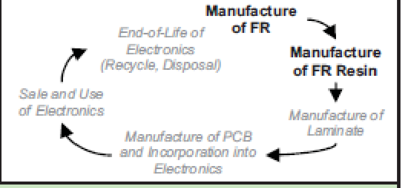
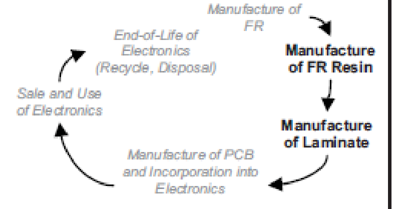
for PCBs[15]: TBBPA, DOPO, Fyrol PMP, aluminum hydroxide, Exolit OP 930, Melapur 200, silicon dioxide, and magnesium hydroxide. In addition, the reaction products of epoxy resin with TBBPA, DOPO, and Fyrol PMP were evaluated, because both TBBPA and DOPO undergo chemical reactions during manufacturing. Results of the programme are presented in US EPA (2008) and summarised in Table 13 and Table 14. The report does not recommend a single best flame retardant for PCB applications or rank the evaluated flame retardants, but sets up flame retardants chemical profiles presenting information on environmental and human health impacts. It has to be noted that flame-retardant evaluations in this programme are hazard assessments with considerations for exposure, but are not full risk assessments. The partnership recognised that the human health and environmental impacts are important factors in selecting a flame retarding chemical or formulation to provide fire safety in a PCB. However, the partnership also identified other factors as being important, such as flame-retardant effectiveness, electrical and mechanical performance, reliability, cost, and impacts on end-of-life emissions. They also note that many of the flame-retardant chemicals evaluated must be used together in different combinations to meet requirements for the intended end-use of the PCB (US EPA 2008).

Besides the hazard summary the US EPA (2008) also identifies the highest priority routes of exposure to flame retardant chemicals used in PCBs. The report provides general background regarding potential exposure pathways that can occur during different life-cycle stages, discusses factors that affect exposure potential in an industrial setting, provides process descriptions for the industrial operations involved in the PCB manufacturing supply chain (identifying the potential primary release points and exposure pathways) and discusses potential consumer and environmental exposures. Table 15 summarises the potential exposure to flame-retardant chemicals throughout their life cycle in PCBs.

[15] Printed circuit boards that meet the V0 requirements of the UL 94 fire safety standard are referred to as FR-4 boards.

Table 13: Screening Level Toxicology Hazard Summary of reactive flame retardants in Printed Circuit Boards

L = Low hazard M[1] = Moderate hazard H = High hazard — Endpoints in colored text (L, M, and H) were assigned based on experimental data.
Endpoints in black italics (*L*, *M*, and *H*) were assigned using estimated values and professional judgment (Structure Activity Relationships).
◊ Hazard designations, which are based on the presence of epoxy groups, arise from the analysis of low molecular weight oligomers (molecular weight <1,000) that may be present in varying amounts. The estimated human health hazards for higher molecular weight (>1,000) components, which contain epoxy groups, are low for these endpoints.
‡ Concern based on potential inhalation of small particles less than 10 microns in diameter that may be present in varying amounts.
§ Concern linked to direct lung effects associated with the inhalation of poorly soluble particles less than 10 microns in diameter.
∇ Persistent degradation products expected (none found in this report).
R Recalcitrant: substance is or contains inorganics, such as metal ions or elemental oxides, that are expected to be found in the environment >60 days after release.

Chemical	CASRN	Human Health Effects									Aquatic Toxicity		Environmental		Exposure Considerations
		Acute Toxicity	Skin Sensitizer	Cancer Hazard	Immunotoxicity	Reproductive	Developmental	Neurological	Systemic	Genotoxicity	Acute	Chronic	Persistence	Bioaccumulation	Availability of FRs throughout the lifecycle for reactive and additive FR chemicals and resins[2]
Reactive Flame-Retardant Chemicals[2]															
Tetrabromobisphenol A (TBBPA) (Albemarle, Chemtura, and others)[3]															
TBBPA	79-94-7	L	L	*L*	L	L	M	L	L	L	H	*H*	M	L	
DOPO (6H-Dibenz[c,e][1,2] oxaphosphorin, 6-oxide) (Sanko Co., Ltd. and others)															
DOPO	35948-25-5	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	L	*M*	*M*	*L*	*L*	
Fyrol PMP (Aryl alkylphosphonate) (Supresta)															
Fyrol PMP	Proprietary	*L*	L	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*H*	*L*	
Reactive Flame-Retardant Resins[2]															
Reaction product of TBBPA - D.E.R. 538 (Phenol, 4,4'-(1-methylethylidene)bis[2,6-dibromo-, polymer with (chloromethyl)oxirane and 4,4'-(1-methylethylidene)bis[phenol]) (Dow Chemical)															
D.E.R. 538	26265-08-7	*L*	M	*M*◊	*L*	*M*◊	*M*◊	*L*	*L*	M	*L*	*L*	*M*	*L*	
Reaction Product of DOPO – Dow XZ-92547 (reaction product of an epoxy phenyl novolak with DOPO) (Dow Chemical)															
Dow XZ-92547	Proprietary	*L*	M	*M*◊	*L*	*M*◊	*M*◊	*L*	*L*	*M*◊	*L*	*L*	*H*	*L*	
Reaction product of Fyrol PMP with bisphenol A, polymer with epichlorohydrin (Representative Resin)															
Representative Fyrol PCB Resin	Unknown	*L*	*L*	*M*◊	*L*	*M*◊	*M*◊	*L*	*L*	*M*◊	*L*	*L*	*H*	*L*	

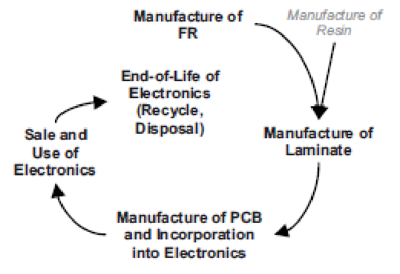
[1] The moderate designation captures a broad range of concerns for hazard, further described in Table 4-3.
[2] Reactive FR chemicals and resins may not completely react, and small amounts may be available during other parts of the lifecycle.
[3] The EU has published a comprehensive risk assessment for TBBPA in reactive applications. This risk assessment is a valuable source of information when choosing flame retardants for printed circuit board applications.

(Source: US EPA 2008)

Table 14: Screening Level Toxicology Hazard Summary of additive flame retardants in Printed Circuit Boards

L = Low hazard M[1] = Moderate hazard H = High hazard — Endpoints in colored text (L, M, and H) were assigned based on experimental data.
Endpoints in black italics (*L, M, or H*) were assigned using estimated values and professional judgment (Structure Activity Relationships).
◊ Hazard designations, which are based on the presence of epoxy groups, arise from the analysis of low molecular weight oligomers (molecular weight <1,000) that may be present in varying amounts. The estimated human health hazards for higher molecular weight (>1,000) components, which contain epoxy groups, are low for these endpoints.
‡ Concern based on potential inhalation of small particles less than 10 microns in diameter that may be present in varying amounts.
§ Concern linked to direct lung effects associated with the inhalation of poorly soluble particles less than 10 microns in diameter.
∇ Persistent degradation products expected (none found in this report).
R Recalcitrant: substance is or contains inorganics, such as metal ions or elemental oxides, that are expected to be found in the environment >60 days after release.

Chemical	CASRN	Human Health Effects									Aquatic Toxicity		Environ-mental		Exposure Considerations
		Acute Toxicity	Skin Sensitizer	Cancer Hazard	Immunotoxicity	Reproductive	Developmental	Neurological	Systemic	Genotoxicity	Acute	Chronic	Persistence	Bioaccumulation	Availability of FRs throughout the lifecycle for reactive and additive FR chemicals and resins
Additive Flame Retardants[3]															
Aluminum hydroxide															
Aluminum hydroxide	21645-51-2	*L*	*L*	*L*	*M*	*L*	L	*M*	L	*L*	H	M	*H*[R]	*L*	
Exolit OP 930 (phosphoric acid, diethyl-, aluminum salt) (Clariant)															
Exolit OP 930	225789-38-8	L	L	*L*	*M*	*L*	*M*	*M*	L	L	M	*M*	*H*[R]	*L*	
Melapur 200 (Melamine polyphosphate) (Ciba)[4]															
Melapur 200	218768-84-4	L	*L*	*L*	*L*	*L*	*L*	*L*	*M*	*M*	*L*	*L*	*M*	*L*	
Polyphosphoric acid	8017-16-1	L	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	L	*L*	
Melamine	108-78-1	L	L	L	*L*	*L*	L	*L*	M	M	L	L	M	*L*	
Silicon dioxide amorphous[5]															
Silicon dioxide amorphous	7631-86-9	L	L	L	*L*	L	L	*L*	H[§]	L	*L*	*L*	*H*[R]	*L*	
Silicon dioxide crystalline[5]															
Silicon dioxide crystalline	1317-95-9	L	L	H[‡]	H[§]	L	L	*L*	H[§]	H[§]	*L*	*L*	*H*[R]	*L*	
Magnesium hydroxide															
Magnesium hydroxide	1309-42-8	L	*L*	L	*L*	*L*	*L*	*L*	L	*L*	*L*	*L*	*H*[R]	*L*	



[1] The moderate designation captures a broad range of concerns for hazard, further described in Table 4-3.
[3] Although additive flame retardants are present throughout the lifecycle of the PCB, they are locked into the polymer matrix of the epoxy laminate material.
[4] Melapur 200 dissociates in water to form polyphosphoric acid and melamine ions. For this reason, Table 4-1 includes both dissociation ions.
[5] Representative CAS numbers are included in this summary table. Section 4.2.9 includes a full list of CAS numbers.

(Source: US EPA 2008)

Table 15: Potential exposure to flame-retardant chemicals throughout their life cycle in PCBs

Reactive FRs	
Manufacture: Chemical manufacture, resin formulation	Manufacture emissions will vary based on manufacturing practices and physical/ chemical properties; direct exposure is possible because the neat chemical is handled.
Prepreg and laminate production	Cutting of material can release minor amounts of dust that contains epoxy resin. Reactive FRs are part of the polymer (chemically bound), and only trace amounts of unreacted FR are anticipated to remain in the polymer matrix. Trace quantities are currently unknown* and/or will vary based on manufacturing methods and processes.
PCB manufacturing and assembly	Remaining, unreacted flame retardant may offgas; PCB manufacturing processes, such as drilling, edging, and routing, cut into the base material. In electronic assembly, some soldering processes could induce thermal stress on resins, which could yield degradation products. Testing is needed to determine the potential for formation of these products.
Use	Only residual unreacted flame retardant is available to offgas during use. In order for exposure to occur, offgassing from residual unreacted flame retardant would have to escape product casing. Testing is needed to determine exposure potential.
End of Life	*Disassembly / Recycling:* Disassembling electronics and shredding PCBs can release dust that contains epoxy resin. Reactive FRs are chemically bound to the polymer; however, levels of exposure and any subsequent effects of exposure to the reacted flame retardant products during the disposal phase of the life cycle, in which FRs may become mobilized through direct intervention processes, such as shredding, are unknown. *Landfill*: Testing needs to be conducted to determine exposure potential from leaching from PCBs. *Incineration*: Combustion byproducts need to be considered (see combustion experiments). *Smelting*: Combustion byproducts need to be considered (see combustion experiments). *Open Burning*: Combustion byproducts need to be considered (see combustion experiments).
Additive FRs	
Manufacture: Chemical manufacture, resin formulation	Manufacture emissions will vary based on manufacturing practices and physical/ chemical properties; direct exposure is possible because the neat chemical is handled.
Prepreg and laminate production	Cutting of material can release minor amounts of dust that contains epoxy resin. Additive FRs are not chemically bound to the polymer, and their potential to offgas or leach out of the product is not known. Physical/chemical properties, such as vapor pressure and water solubility, may contribute to the potential for exposure to these chemicals.
PCB manufacturing and assembly	Additive flame retardant may offgas; PCB processes, such as drilling, edging, and routing, cut into the base material. In electronic assembly, reflow or wave soldering processes could induce thermal stress on resins, which could yield offgas products. Physical/chemical properties, such as vapor pressure and water solubility, may contribute to the potential for exposure to these chemicals.
Use	Although flame retardants are embedded in the polymer matrix, testing needs to be conducted to better understand the offgassing potential of additive flame retardants. Dermal exposure is not anticipated since the FRs are embedded in the polymer matrix.
End of Life	*Disassembly/Recycling:* Disassembling electronics and shredding PCBs can release dust that contains epoxy resin. Additive FRs are not chemically bound to the polymer and can be released through the dust. Physical/chemical properties, such as vapor pressure, may contribute to the potential for exposure to these chemicals. *Landfill*: Testing needs to be conducted to determine exposure potential from leaching from PCBs. *Incineration*: Combustion byproducts need to be considered (see combustion experiments). *Smelting*: Combustion byproducts need to be considered (see combustion experiments). *Open Burning*: Combustion byproducts need to be considered (see combustion experiments).

(Source: US EPA 2008)

3.2 Industry-led initiatives

3.2.1 International Electronics Manufacturing Initiative (iNEMI): HFR-Free Electronics and PVC-Free Cabling for Notebook and Desktop Products

The International Electronics Manufacturing Initiative (iNEMI) is a consortium of 100 leading electronics manufacturers, suppliers, associations, government agencies and universities. OEM members include Dell, HP, Lenovo and Samsung. The organisation has several collaborative research and development projects underway to evaluate the electrical, mechanical, and volume readiness of environmentally friendly HFR-free and PVC-free alternatives.

iNEMI's OEM members[16] already produce specific product configurations in which the major system components (or even the whole complex article) are BFR/CFR/PVC-free (Table 16). Nevertheless, there are still significant technical issues with higher complexity products and these are being evaluated by iNEMI project teams (iNEMI 2010).

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[16] iNEMI Members include inter alia Dell, Inc.; Hewlett-Packard; Lenovo; Samsung; http://www.nemi.org/members?page=1

Table 16: Status of activities on BFR/CFR/PVC free components

Table 1. Summary of Computer Product Advancements Made to Date		
Key System Elements	**Notebook Status 2H 2010 New Products**	**Desktop Status 2H 2010 New Products**
CPU heat sink	HFR –free	HFR-free
CPU socket	HFR-free	HFR-free
CPU fan	HFR-free not available	HFR-free not available
CPU	HFR-free	HFR-free
Memory modules	HFR-free	HFR-free
Power supply	HFR-free and PVC-free not available	HFR-free and PVC-free not available
Hard drive & DVD burner	HFR-free	HFR-free
Video/graphics card or module	HFR-free	HFR-free
Mother board (excluding high-end circuits required for workstations & servers)	Low volume, specific SKUs only	Not HFR-free (iNEMI teams addressing)
System enclosure	PVC-free	PVC-free

(Source: iNEMI 2010)

3.2.2 Joint Industry Guide (JIG): Material Composition Declaration for Electro-technical Products

The Joint Industry Guide (No. JIG-101 Ed. 4.1) is an initiative of the Consumer Electronics Association. It is a material composition declaration guide, which is designed to promote consistent and standardized material declaration requests across the global (electrotechnical) supply chain (JIG 2012). It is understood to be a point of reference for manufacturers and the wider industry. It is currently in its final edition as it will be taken over by the IEC 62474 material declaration standard.

The JIG establishes three criteria that determine whether substances shall be declared:

- Criteria 1 – R (Regulated)

  Substances that are subject to enacted legislation that (a) prohibits their use; or (b) restricts their use; or (c) requires reporting or results in other regulatory effects (e.g. labeling) and where the substance-specific effective date is currently in effect or scheduled to go into effect at a specific date in the future.

- Criteria 2 – A (For Assessment Only)

  Substances that are likely to be subject to enacted legislation where the substance specific effective dates of the regulatory requirements are uncertain.

- Criteria 3 – I (For Information Only)

  Substances that are not regulated but where there is a recognised market requirement for reporting their content in electro-technical products. Reporting is used to facilitate company assessment regarding widely adopted industry environmental agreements or standards.

The resulting declarable substance list is based on these criteria which CE/industry has used to determine which justify disclosure when these material/substances are present in electrotechnical products in amounts that exceed their specified threshold levels.

Within the JIG list of declarable substances the group of **regulated substances (R)** includes in total 54 different substances/substances groups such as:

- RoHS compounds (Cd, Pb, Ld, Cr (VI), PBDEs, PBBs)
- HBCDD
- Shortchain chlorinated paraffins (SCCP)
- Azocolourants and azodyes which form certain aromatic amines
- Phthalates
- Asbestos
- Boric acid
- Arsenic compounds
- Organotin compounds

- Ozone depleting substances
- PFOS
- PCBs
- PCTs
- Polychlorinated naphtalenes
- Radioactive substances

The group of **substances for assessment only (A)** includes only one substance:

- 4-[4,4'-bis(dimethylamino) benzhydrylidene] cyclohexa- 2,5-dien-1-ylidene] dimethylammonium chloride (C.I. Basic Violet 3)

The group of **substances for information only (I)** includes in total 4 different substances/substance groups:

- Beryllium oxide (BeO)
- Brominated flame retardants (other than PBBs, PBDEs or HBCDD) both in plastic materials and printed wiring board laminates
- Chlorinated flame retardants both in plastic materials and printed wiring board laminates
- PVC (in plastic materials except printed wiring board laminates)

3.3 Original Equipment Manufacturer (OEM) initiatives

3.3.1 Market leading television and display manufacturers

The five major brands by revenue share in the flat panel TV market are Samsung, LG Electronics, Sony, Panasonic and Sharp (see section 2.2.1). Their voluntary activities on the phase-out of hazardous substances in TVs go beyond legal requirements such as RoHS and REACH and are summarised in Table 17.

It is worth noting that the focus of these activities is largely substance or substance group specific. Manufacturers with products certified with ecolabels may have had to screen their products for certain hazard classifications, as identified in section 3.4.

Both LG Electronics and Samsung classify hazardous substances into four levels of concern:

- Level A-I / Class I substances: Substances are regulated by EU RoHS Directive 2002/95/EC.
- Level A-II / Class II substances: Substances are managed by regulation or convention other than EU RoHS Directive.
- Level B-I / Class III substances: Substances which are voluntary phase-out due to the potentially negative effects to the environment or the health.
- Level B-II / Others: Substances need to be monitored

(Table 17 lists only Level B-I / Class III substances: Substances which are voluntary phased-out.)

LG Electronics has voluntarily phased out PVC, brominated and chlorinated flame retardants, phthalates, antimony and its compounds, beryllium and its compounds and musk xylene in all parts of new TV models (produced after 01.01.2013).

Samsung has voluntarily phased out TBBP-A from all products (January 2008); BFR from the housing of Samsung TV models which are certified with the Nordic Ecolabel as well as PVC and phthalates in internal wires with the exemption of LCD/LED panels and PDP modules. Antimony trioxide and beryllium compounds are also named as (potential) phase-out substances, however, they state that for the following applications there are currently no suitable alternatives:

1) Beryllium alloy used in connectors and certain electronic components;

2) Antimony trioxide (Sb_2O_3)

- added in ceramics for certain electronic components;

- used as a catalyst in polymeric materials for certain electronic components.

Table 17 Voluntary phase-out of substances by TV manufacturers (beyond legal requirements such as RoHS and REACH)

Manufacturer	Samsung	LG Electronics	Sony	Panasonic	Sharp
Voluntary phase-out substances (beyond legal requirements such as RoHS and REACH)	- TBBP-A (all products; Jan 2008) - BFR (housing of Samsung TV models, certified with Nordic Ecolabel) - PVC in internal wires; exemption: LCD/LED panel and PDP module) (Jan 2011) - Phthalates in internal wires; exemption: LCD/LED panel and PDP module) (Jan 2013) - Antimony trioxide in internal wires; exemption: LCD/LED panel and PDP module) (Jan 2013) - Beryllium and its compounds [a)]	- PVC - BFR (other than PBDE and PBB) - Chlorinated flame retardants - Phthalates - Antimony and its compounds - Beryllium and its compounds - Musk xylene	Sony works on the Reduction and Replacement of Chemical Substances of Very High Concern such as PVC, BFR, Hg, Phthalates, Beryllium compounds and arsenic compounds.[b)] From the information provided it does not become clear whether these restriction already apply to TVs.	No public information on voluntary phase-out of hazardous substances in TV could be found.[c)]	Sharp TVs comply with the new EU Eco-label criteria, as of Nov. 1, 2009.[d)] However, it was not possible to find any public information on voluntary phase-out of hazardous substances.
Phase-out date	See above for each substance	01/01/2013	-	-	-
Verification data for the material information by supplier	Certification process involving supplier documentation, audits and in-house testing (verification).	- Test report - Simplified analysis result (Desk-type XRF, Portable XRF etc.),	-	-	-

Manufacturer	Samsung	LG Electronics	Sony	Panasonic	Sharp
		- Non-use certification report / Warranty, - MSDS - Samples (more than 5, raw material condition when necessary)			
References	Samsung Standards for Control of Substances concerning Product Environment (2011)[17]	LG Electronics manual of the hazardous substance management in the parts and models; The Sixth edition (2011)	Management regulations for the environment-related substances to be controlled which are included in parts and materials [18]	-	-

[a]) The phase-out plans for voluntary substances are by necessity subject to the successful identification and availability of technically suitable alternatives.

The following applications of the substances targeted for phase-out currently have no suitable alternatives:

1) Beryllium and compounds

Beryllium alloy used in connectors and certain electronic components

2) Antimony Trioxide (Sb2O3)

- added in ceramics for certain electronic components
- used as a catalyst in polymeric materials for certain electronic components

[b]) http://www.sony.net/SonyInfo/csr_report/environment/chemical/products/index3.html#block2

[c]) http://panasonic.net/sustainability/en/eco/chemical/

[d]) http://www.sharp.eu/cps/rde/xchg/eu/hs.xsl/-/html/eu_eco_label.htm

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[17] http://www.samsung.com/us/aboutsamsung/corpcitizenship/environmentsocialreport/downloads/SEC%20Standard0QA-204.pdf

[18] http://www.sony.net/SonyInfo/procurementinfo/ss00259/ss_00259ec_General_use_12EC.pdf

3.3.2 Market leading computer manufacturers

The major brands in the computer market are HP, Asus, Acer, Dell, Lenovo, Apple Samsung and Toshiba (see section 2.2.2). Their voluntary activities on the phase-out of hazardous substances in computers go beyond legal requirements such as RoHS and REACH are summarised in Table 18.

It is worth noting that the focus of these activities is largely substance or substance group specific. Manufacturers with products certified with ecolabels may have had to screen their products for certain hazard classifications, as identified in section 3.4.

HP is working to phase out brominated flame retardants (BFRs) in new products that currently contain BFRs. To evaluate whether the commercially available alternatives to BFRs have a lower adverse impact to human health and the environment, an integrated assessment approach was developed for analysing potential replacements. This integrated approach incorporates a comparative chemical hazard screening step based on a tool called the GreenScreen™ for Safer Chemicals (see section 3.5.3).

As shown in Figure 6, the GreenScreen™ is used early in the material selection process in order to eliminate unsuitable alternatives before investing the significant time and resources needed to conduct performance, exposure, and life-cycle assessments. Importantly, the GreenScreen™ evaluates constituents and breakdown products of substances, enabling a thorough and balanced evaluation of exposure and life cycle in subsequent analyses.

Dell has replaced the phthalates DEHP, BBP, and DBP with Trioctyl Trimellitate (TOM or TOTM) or Dioctyl Terephthalate (DOCP) in all products. TOM and DOCP offer the same functionality, however they are neither classified nor labelled and are not CMR substances. Dell has also started to request that its suppliers disclose the use of additional phthalates (DIDP, DNOP, DIBP, DHNUP, DIHP) to enable swift phase out of these as well (see SUBSPORT Case Study[19]). Furthermore, Dell has been adopting the use of mercury free LED in notebooks and flat panel displays since 2008. Mercury has been used in Liquid Crystal Display (LCD) backlights for notebook and flat panel displays (monitors). Light Emitting Diode (LED) was introduced as a substitute to LCD backlights a few years ago. This technology avoids the use of mercury while using energy more efficiently than LCD (see SUBSPORT Case Study[20]).

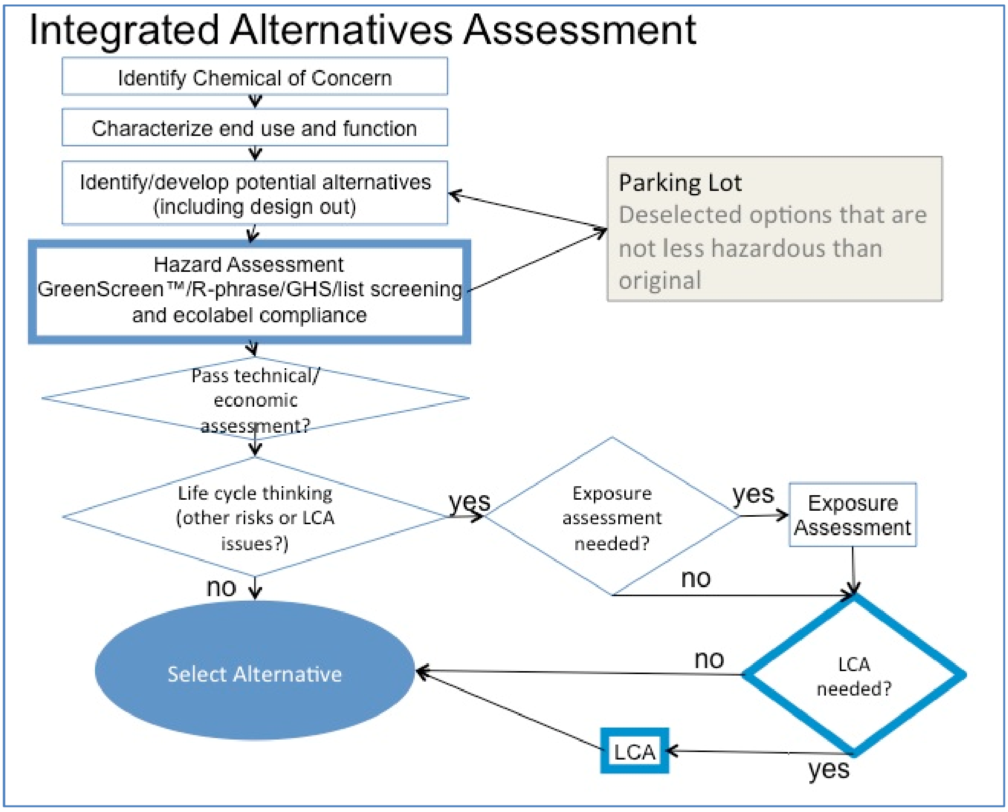

Figure 6: Integrated Alternatives Assessment by HP

(Source: SUBSPORT Case Study Database[21])

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[19] http://www.subsport.eu/case-stories/304-en?lang=

[20] http://www.subsport.eu/case-stories/115-en?lang=

[21] http://www.subsport.eu/case-stories-database

Table 18 Voluntary phase-out of substances by computer manufacturers (beyond legal requirements such as RoHS and REACH)

Manufacturer	HP	Acer	Asus	Dell	Lenovo	Apple	Samsung	Toshiba
Voluntary phase-out substances (beyond legal requirements such as RoHS and REACH)	Restriction of certain ortho-phthalates; Phase out of halogens including BFRs and PVC, where technically feasible in new products (e.g. 96% of HP Compaq business PCs and HP notebooks launched since 2011 are low-halogen as defined by the iNEMI [a)]; Arsenic-free display glass;	BFRs (all products; 2009); PVC (all products; 2009); Certain phthalates [b)] in all products by 2009 and finally all phthalates by 2012; Beryllium and its compounds (all products; 2012); Antimony and its compounds (all products; 2012)	Restriction of halogenated compounds such as BFRs and CFRs as well as antimony and beryllium and their compounds by the end of 2012	Arsenic-free display glass in laptops (2009); BFR and PVC in external case plastics (2004),	PVC/BFR in all mechanical plastic parts	Restriction of brominated and chlorinated compounds at the elemental level in all homogeneous materials; Arsenic-free display glass; Mercury-free LED-backlit display	TBBP-A (all products, 2008); BFRs, PVC, Phthalates, Antimony trioxide and Beryllium in different applications[22]	No information on voluntary phase-out substances
Further activities	Integrated assessment approach to analysing potential materials replacement based on the GreenScreen for Safer Chemicals; Member of iNEMI (see section 3.2.1) Joint statement to ban the use of BFR and PVC (see section 3.3.4)	Joint statement to ban the use of BFR and PVC (see section 3.3.4)		Phase out of further phthalates. Member of iNEMI (see section 3.2.1) Joint statement to ban the use of BFR and PVC (see section 3.3.4)	Member of iNEMI (see section 3.2.1)		Member of iNEMI (see section 3.2.1)	

[22] For more detailed information visit http://www.samsung.com/us/aboutsamsung/sustainability/environment/chemicalmanagement/managementoftargetsubstances.html

Manufacturer	HP	Acer	Asus	Dell	Lenovo	Apple	Samsung	Toshiba
Verification data for the material information by supplier		Each supplier must submit an appropriate product test report. Audits to ensure that production complies with Acer's environmental protection standards.		Supplier Declaration of Conformity (SDoC); Supplier RoHS audit; Third-party analytical testing (see also section 3.3.3.2)		Full material declaration by suppliers. In-house testing; Third-party analytical testing for RoHS and REACH compliance (see also section 3.3.3.1)		
References	HP Standard 011 General Specification for the Environment[23]	Acer Restricted Chemical Substances Management[24] Guidance of Restricted Substances in Products (2006)	ASUSTek Corporate Sustainability Report 2012[25]	Dell's Chemical Use Policy[26]			Samsung Policy on Target Substances[27]	

a) In accordance with the "iNEMI Position Statement on the Definition of 'Low-Halogen' Electronics." Plastic parts contain < 1,000 ppm (0.1%) of bromine [if the Br source is from BFRs] and < 1,000 ppm (0.1%) of chlorine [if the Cl source is from CFRs or PVC or PVC copolymers]. All printed circuit board (PCB) and substrate laminates contain bromine/chlorine total < 1,500 ppm (0.15%) with a maximum chlorine of 900 ppm (0.09%) and maximum bromine being 900 ppm (0.09%). Service parts after purchase may not be low-halogen. Power supply and power cords are not low-halogen.

b) Including DEHP, DBP, BBP, DINP, DIDP and DNOP

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[23] http://www.hp.com/hpinfo/globalcitizenship/environment/pdf/gse.pdf

[24] http://www.acer.co.in/ac/en/AU/content/management

[25] http://csr.asus.com/english/file/ASUS_CSR_2012_EN.pdf

[26] http://www.dell.com/downloads/global/corporate/environ/Chemical_Use_Policy.pdf

[27] http://www.samsung.com/us/aboutsamsung/sustainability/environment/chemicalmanagement/policyontargetsubstances.html

3.3.3 Verification along the supply chain

A major concern of EEE manufacturers in relation to EU Ecolabel hazardous substance criteria is the ability to verify the presence of hazards in sub-components. In the following section selected company specific case studies are presented to illustrate different verification strategies and aprocedures along the supply chain.

3.3.3.1 Case study Apple: Restriction of bromine- and chlorine-based compounds in all homogeneous materials of Apple products

Apple's suppliers were required to establish strict compliance management programs, which included using certified laboratory testing to demonstrate that they were complying with the new requirements. Throughout the transition to bromine- and chlorine-free materials, Apple monitored its suppliers' compliance via internal audits. A transparent compliance program, which allows for quick and inexpensive material testing (here: analysis of Br and Cl on elemental level), enabled Apple to identify problems early on and take corrective action. According to the experience of Apple, an extensive auditing program in a supply chain is critical to increasing compliance and ensuring full implementation of new material specifications, particularly during the early stages of the transition. (Nimpuno et al. 2009)

3.3.3.2 Case study Dell: Supplier Declaration of Conformity

Dell requires suppliers to sign a Supplier Declaration of Conformity (SDoC) to ensure that all product materials comply with Dell's environmental policy (Dell 2013). To sign the SDoC, the supplier must ensure that the product meets the Dell Materials Restricted for Use specification and record any applicable exemptions. At Dell's request, the supplier must also be able to provide technical documentation in the form of internal design controls, a supplier declaration or analytical test data. Dell's goal is to collect supplier declarations for each part of a product's bill of materials. This will ensure that each product meets the legislated materials requirements.

A second tier in Dell's compliance verification strategy is the supplier RoHS audit program. This program can be divided into two parts: a traditional audit and an in-depth supplier survey.

A traditional audit, in which Dell parts are selected at random and submitted for third-party analytical testing, is conducted on a quarterly basis. Samples are tested for the presence of restricted materials, including those prohibited by the RoHS Directive. The audit is used to further validate SDoCs and to ensure that Dell's entire supply chain complies with the directive. Dell also actively screens samples in-house by using X-Ray Fluorescence (XRF) equipment.

3.3.3.3 Case study Seagate: bromine- and chlorine-free hard disk drives

Seagate is a manufacturer of bromine- and chlorine-free hard disk drives.

Seagate compliance incorporates supplier full disclosure, with third party data review and audit. Software automation is used to gather and manage data (Martin, n.y).

Seagate implemented an automated Compliance Assurance System for tracking the use of all materials in hard-drive components. The system was based on an industry-standard reporting form developed by IPC (originally the Institute for Printed Circuits). Seagate used it to launch a full material reporting and disclosure requirement across its supply chain. The system requires component suppliers to report on all substances present, regardless of whether or not the substance is restricted. To do so, the vendors provide the CAS numbers for each compound they use. Seagate also specified that suppliers provide independent lab analyses to prove conformance to RoHS and low-halogen restrictions, as well as an official statement confirming that the materials conform to Seagate's list of several hundred banned substances. (Nimpuno et al. 2009)

3.3.3.4 *Case Study Philips: BOMcheck*

BOMcheck[28] provides easy-to-use declaration tools to generate and maintain their substance declarations in the database. The declaration tool covers a list of restricted and declarable substances which are relevant to hardware articles and electrical and electronic equipment (EEE). The list is aligned with the IEC 62474 screening of REACH Candidate List Substances. The IEC 62474 database of restricted and declarable substances will replace the Joint Industry Guide (JIG) later in 2013 (BOMcheck 2013).

BOMcheck offers either a Full Materials Declaration (FMD) or a Regulatory Compliance Declaration (RCD).

A FMD provides the % weight of each individual material in the part and the % weight of each substance which is intentionally added to each material. For example, a FMD for a PVC coated copper wire will contain two materials – the PVC coating and the copper wire. The PVC coating will include all intentionally added substances (e.g. stabilisers, plasticisers, flame retardants etc).

A Regulatory Compliance Declaration (RCD) includes only those substances which are restricted or declarable for hardware products by regulations in North America, Europe and Asia Pacific. BOMcheck provides detailed practical guidance on where these substances can be found in materials or parts of hardware products, and any exemptions that apply. Knowledge on where to look for restricted and declarable substances saves sample testing costs. However, the RCD needs to be updated every 6 months when more substances are added to the REACH Candidate List and other regulatory requirements. Therefore, OEMs encourage their suppliers to make a Full Materials Declaration (FMD) because BOMcheck automatically uses the FMD to re-calculate an RCD for the suppliers' parts when the list of regulated and declarable substances changes.

[28] https://www.bomcheck.net/en/

For example, Philips has asked its suppliers to declare compliance with REACH, RoHS and other requirements by making BOMcheck declarations, with a preference for Full Materials Declaration (FMD).

3.3.4 Joint Statement of leading electronics companies and environmental organisations

In 2010, an alliance consisting of Acer, Dell, Hewlett-Packard and Sony Ericsson, together with public interest organisation ChemSec, Clean Production Action and the European Environmental Bureau, called on EU legislators to ban the use of all brominated flame retardants (BFR) and polyvinyl chloride (PVC) in electronics put on the market from end of 2015 onwards.[29] According to the alliance the supply chain can provide safer substitutes for these hazardous substances. The alternatives are available, cost effective and suppliers are ready to scale up their production of these alternative materials.

A research report released by ChemSec demonstrates that most applications of PVC and BFRs have been removed from over 500 product models on the market today, including mobile phones, computers, washing machines, coffee machines and TVs (Nimpuno et al. 2009). Products from 28 companies, among them Acer, Apple, Dell, HP, Nokia, Philips, Samsung and Sony Ericsson, are listed in the report.

The joint statement also stressed the ability of these substances to generate highly hazardous dioxins and other substances of concern when these substances are incinerated at the end of life or more importantly, burned in substandard treatment sites outside the EU. The export of e-waste is banned under EU law but evidence shows that much e-waste makes its way to Asia, Africa and Latin America where it may not be recycled.

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[29] http://www.eeb.org/?LinkServID=AC143499-00BA-5F1E-B1F6C8FD3BAC76F3&showMeta=0

3.4 Ecolabel requirements

Various voluntary (eco)labels and certifications exist beyond the legal binding requirements of the RoHS Directive and REACH regulation which ban or at least restrict the use of further hazardous substances in EEE.

Table 19 provides an overview of hazardous substances and hazard classifications which must be avoided or reduced in order to meet ecolabel criteria and verification requirements. Some of the main points worthy of note include:

- Nordic Swan, TCO and EPEAT contain certain restrictions on halogenated flame retardants beyond the legal requirements of RoHS and explicitly restrict PVC in plastic parts (> 25 g or in large plastic parts, respectively). EU Ecolabel requests that plastic parts shall not contain a chlorine content greater than 50 % by weight.
- TCO does also restrict certain non-halogenated flame retardants in plastic parts weighing more than 25 grams
- Both EU Ecolabel and Nordic Swan restrict certain phthalate plascticizers.
- All labels set requirements or even forbid the use on mercury or its compounds in backlights of (computer) displays.
- EU Ecolabel, Nordic Swan and TCO restrict substances or mixtures meeting the criteria for classification with given hazard classifications or categories in accordance with Regulation (EC) No 1272/2008.
- The verification requirements of the four labels are quite different:
    - EU Ecolabel requests that the applicant shall provide a declaration of compliance with each criterion, together with related documentation, such as declarations of compliance signed by the suppliers of substances and copies of relevant safety data sheets.
    - Nordic Swan demands a declaration from the manufacturer showing that the requirements are fulfilled.

- Under TCO all certified product models are tested in an independent test facility and all environmental and CSR documentation are independently verified by a third party.
- EPEAT uses a self-declaration and verification system:
  1) Manufacturers must possess and produce evidence to support all declarations;
  2) EPEAT employs rigorous and transparent post-declaration verification procedures by regularly selecting products and criteria from the registry at random and hiring independent experts to verify that the chosen products meet the selected criteria as declared. The process includes unannounced, in-depth investigations and public exposure in all cases of nonconformance. All incidents are published in verification reports that include both manufacturer and product names. The system is designed to make non-conformance publicly embarrassing and to maintain the constant likelihood of investigation at any time.

  All Subscribers can expect to have multiple products investigated each year. The verification process may require a manufacturer to provide production reports, lab analysis or other data, or EPEAT may independently obtain products and subject them to detailed laboratory analysis or destructive disassembly[30].

[30] http://www.epeat.net/learn-more/verification/

Table 19: Hazardous substances criteria of different (eco) labels for TV, desktop and notebook computers

EU Ecolabel	Nordic Swan	TCO	EPEAT
PBB and PBDE shall not be used (according to RoHS)	**Flame retardants in plastic and rubber parts** • The flame retardants HBCDD, TCEP and SCCP/MCCP must not be added. • The flame retardant TBBP-A must not be added except in PWB • Other **organic halogenated flame retardants** and **other flame retardants** assigned one or more of the following risk phrases, or combinations, must not be added [b)]: – H350, H350i, H340, H360F, H360D, H360Fd, H360Df	**Halogenated substances** • **Plastic parts** weighing more than 25 grams shall not contain **flame retardants or plasticizers that contain organically bound bromine or chlorine.** The requirement applies to plastic parts in all assemblies and sub-assemblies. Exempted are printed wiring board laminates, electronic components and all kinds of cable insulation. The product shall not contain **PBB, PBDE and HBCDD.** The requirements apply to components, parts and raw materials in all assemblies and sub-assemblies of the product e.g. batteries, paint, surface treatment, plastics and electronic components.	**Flame retardants and plasticizers** - Elimination of intentionally added SCCP flame retardants and plasticizers in certain applications - Large plastic parts free of certain flame retardants classified under European Council Directive 67/548/EEC
Plastic parts shall not contain a chlorine content greater than 50 % by weight. Only biocidal products containing biocidal active substances included in Annex IA to Directive 98/8/EC of the European Parliament and of the Council (1), and authorised for use in computers, shall be allowed for use.	**Plastic parts** >25g must not contain chlorinated polymers such as PVC	• **Plastic parts** in the product weighing more than 25 grams shall not contain **chlorine or bromine as a part of the polymer (e.g. PVC).** • Printed wiring board laminates, and all kinds of internal and external cable insulation are not considered to be part of plastic parts and are therefore not included in the mandate.	Large plastic parts free of PVC
Plasticizers If any plasticiser substance in the manufacturing process is applied, it must comply with the requirements on	**Plasticizers/phthalates** • The **external power cable** delivered with the audiovisual equipment should be free from the phthalates listed below: DEHP; DBP/DnBP; BBP; DCHP; DIBP;	-	-

EU Ecolabel	Nordic Swan	TCO	EPEAT
hazardous substances set out above. Additionally DNOP (di-n-octyl phthalate), DINP (di-isononyl phthalate), DIDP (di-isodecyl phthalate) shall not intentionally be added to the product.	DINP; DIDP; DNOP; DHP; DEP; DIHP; Bis(2-methoxyethyl) phthalate; Diisopentyl phthalate; N-pentyl-isopentyl phthalate		
Mercury or its compounds shall not intentionally be added to the backlights of the computer display.	• The **background light** in the TV-screen must not have any mercury (Hg) content. • The lamp for projectors cannot contain mercury (Hg)	• Notebooks/Tablets: The product shall not contain mercury. [C)] • Displays: The maximum level of mercury in **background lighting** systems allowed is 3,5 mg Hg/lamp.	Reporting/low threshold/elimination of intentionally added Hg in light sources
RoHS substances (i.e. Cd, Pb, Hg, Cr (VI), PBB, PBDE) shall not be used.	See [d)]	The product shall not contain Cd, Pb and Cr VI. This applies to components, parts, and raw materials in all assemblies and subassemblies of the product e.g. paint, surface treatment, plastics and electronic components.	RoHS compliance; Elimination of intentionally added Cd, Pb (in certain applications) and Cr VI
Product or any part of it shall not contain substances referred to in Article 57 of Regulation (EC) No 1907/2006 of the European Parliament and of the Council (1) nor substances or mixtures meeting the criteria for classification in given hazard classes or categories in accordance with Regulation (EC) No 1272/2008	-	**Non-halogenated substances** Substances that have been assigned one of the following hazardous statement and where there are less hazardous commercially available alternatives are restricted: • H340, H341, H350, H350i,H351, H360F, H360D, H361d, H361f, H362, H372, H373, H400 and H410, H411 The following **non halogenated flame retardants** shall not be used in **plastic parts** weighing more than 25 grams: • - Antimony(III) oxide (Sb2O3), CAS: 1309-64-4 • - Tri-o-cresyl phosphate, CAS: 78-30-8	-

EU Ecolabel	Nordic Swan	TCO	EPEAT
		Exempted are printed wiring board laminates, electronic components and all kinds of cable insulation • Triethyl phosphate (CAS: 78-40-0) • Magnesium hydroxide (CAS: 1309-42-8) Likely banned substances in the next version TCO Certified (due to hazard classification) • Zinc borates (CAS: 138265-88-0) • Triphenyl phosphate (CAS: 115-86-6) • Sodium toluene-4-sulphonate (CAS: 657-84-1) • Bis phenolA bis (biphenyl) phosphate (CAS: 181028-79-5) • (1-methylethylidene)di-4,1-phenylenetetraphenyl diphosphate (CAS: 5945-33-5) • Tri-cresyl phosphate (CAS: 1330-78-5) • Cresyl diphenyl phosphate (CAS: 26444-49-5) • Resorcinol bis (diphenyl diphosphate) (CAS: 57583-54-7)	

EU Ecolabel	Nordic Swan	TCO	EPEAT
Assessment and verification The applicant shall provide a declaration of compliance with each criterion, together with related documentation, such as declarations of compliance signed by the suppliers of substances and copies of relevant safety data sheets in accordance with Annex II to Regulation (EC) No 1907/2006 for substances or mixtures. Concentration limits shall be specified in the safety data sheets in accordance with Article 31 of Regulation (EC) No 1907/2006 for substances and mixtures.	**Verification** Declaration from the manufacturer showing that the requirements are fulfilled.	**Verification** • All certified product models are tested in an independent test facility that is accredited according to ISO/IEC 17025 and approved by TCO Development • All environmental and SR documentation independently verified by a third party	**Verification** • Self-declaration: manufacturers must possess and produce evidence to support all declarations • Verification system: Regular selection of products and criteria from the registry at random and independent analysis to verify that the chosen products meet the selected criteria as declared. The process includes unannounced, in-depth investigations and public exposure in all cases of non-con-formance.

a) The listed Nordic Swan criteria apply to TV and Projector since these are the most recent criteria.

b) Exceptions are made for printed circuit boards.

c) Exceptions are made for flame retardants in cases where there is demand for safety reason with reference to low voltage directive 73/23/EG or standard EN 60335-1; printed circuit board, PCB; and/or plastic and rubber parts that weight less than 25 gram and are parts of electric components.

d) Mercury is regulated in RoHS 2 directive (2011/65/EU), however exempting the use of mercury in the backlighting of FPDs. TCO argues that today the LED backlight technology for FPDs makes it possible to go beyond the RoHS Directive and ban the use of mercury altogether. The maximum concentration value tolerated for the product, including the FPD lamps is 0.1 % by weight in homogeneous materials.

e) The requirement on heavy metals was removed with the motivation that the directive RoHS (2002/95/EC) captures the problem with use of heavy metals in electrical and electronic equipment. The RoHS-directive poses both absolute requirements, points out limit values and exceptions of use in certain areas. As such legislation works effectively, making producers generally to comply with its requirement, the motivation for Nordic Ecolabelling having own requirements in this area is not supported by relevance.

3.5 NGO Initiatives

3.5.1 SUBSPORT case stories

The goal of the SUBSPORT[31] project is to develop an internet portal that constitutes a state-of-the-art resource on safer alternatives to the use of hazardous chemicals. The portal is intended to support companies in fulfilling substitution requirements of EU legislation, such as those specified under the REACH authorisation procedure, the Water Framework Directive or the Chemical Agents Directive.

The SUBSPORT Case Story Database[32] provides substitution examples as well as information on alternative substances and technologies from enterprises, published reports and other sources. Relevant substitution examples taken from SUBSPORT Case Story Database are summarised in Table 20.

Table 20: SUBSPORT Specific Substances Alternatives Assessment

Hazardous substance	Function	Application (relevant for EEE)	Alternatives[33]	Substitution established by
• Hexabromocyclododecane (HBCDD) • DecaBDE • Tetrabromobisphenol A (TBBPA)	Flame retardants	High Impact PolyStyrene (HIPS) used in electronics housings; PWB	• Aluminium hydroxide • Melamine polyphosphate • Diethylphosphinic acid aluminium salt • Resorcinol bis (biphenyl phosphate) • Bisphenol A bis (biphenyl phosphate) • Diphenyl cresyl phosphate	HP Apple

[31] http://www.subsport.eu/

[32] http://www.subsport.eu/case-stories-database

[33] Alternatives include only substances that do not fulfil SUBSPORT Screening Criteria (SDSC) for SVHC (i.e. carcinogenic, mutagenic or toxic to reproduction (CMR); very persistent and very bioaccumulative (vPvB); endocrine disruption; neurotoxicity and sensitization).

Hazardous substance	**Function**	**Application (relevant for EEE)**	**Alternatives**[33]	**Substitution established by**
			• Alloys of PPE/HIPS treated with halogen-free flame retardant alternatives Boehmite	
• Di(2-ethylhexyl) phthalate (DEHP)[34] • Dibutyl phthalate (DBP) • Benzyl butyl phthalate (BBP) • Diisobutyl phthalate (DIBP)	Plasticizer	Cables	• Trioctyl Trimellitate (TOM or TOTM) • Dioctyl Terephthalate (DOCP)	Dell
Mercury[35]		Liquid Crystal Display (LCD) backlights for notebook and flat panel displays (monitors).	Change of technology to Light Emitting Diode (LED)	Dell Apple
Arsenic[36]	Used in glass production to eliminate air bubbles that may lower quality in applications like electronics (TVs, cell phones, computers etc.)		Change of technology: thermal desorption of gas bubbles in glass	Apple
PVC[37]		Power cord; wires; cables	Commercially Available PVC-Free Materials such as Thermoplastic elastomers (TPEs)[38]; (see also Table 21)	

[34] http://www.subsport.eu/case-stories/304-en?lang=

[35] http://www.subsport.eu/case-stories/229-en?lang=

[36] http://www.subsport.eu/case-stories/195-en?lang=

[37] http://www.subsport.eu/case-stories/114-en?lang=

[38] To ensure that the replacements for PVC have a lower adverse impact to human health and the environment, potential replacement materials were evaluated using an integrated approach that incorporates a comparative chemical hazard screening step based on the GreenScreen for Safer Chemicals.

Table 21: Examples of Commercially Available PVC-Free Materials

Supplier	Trade Name	Resin
Kraton Polymers	Kraton™	Styrene-Ethylene/Butylene-Styrene (SEBS) Polymer (CAS#66070-58-4) and Olefinic Polymers
PolyOne GLS	OnFlex HFFR 320-01, OnFlex HFFR 360-0185	Thermoplastic Elastomer
SABIC Innovative Plastics	Noryl	Polyphenylene Ether (PPE CAS#25134-01-4), Styrene-(ethylenebutylene)-styrene (SEBS), High Impact Polystyrene (HIPS CAS#9003-55-8) and Polystyrene (CAS#9003-53-6)
Showa Kasei Kogyo	Maxiron	Polyethylene and Polystyrene
DSM	Arnitel® XG	Thermoplastic co-polyester; polymer with 1,4-butanediol and .alpha.-hydro-.omega.-hydroxypoly(oxy-1,4-butanediyl) CAS No. 9078-71-1

(Source: SUBSPORT Case Study on Polyvinyl chloride (PVC) Power Cord Alternatives)

3.5.2 ChemSec and Clean Production Action: Alternatives to bromine and chlorine chemistry

The two non-profit environmental organizations, ChemSec and Clean Production Action, report case studies on how seven electronics companies (two major consumer electronics companies, and five component suppliers) have addressed the industry-wide technical performance challenges associated with a material change to bromine- and chlorine-free chemistry, while upholding quality, reliability, and product performance at an acceptable cost (Nimpuno et al. 2009).

3.5.2.1 Case Study Apple: Bromine- and chlorine-free computers

Apple restricts the use of brominated and chlorinated compounds, at the elemental level, from its products meaning that bromine- and chlorine-based compounds are eliminated in all homogeneous materials[39] used in Apple products. Consequently, Apple’s iMac and Macbook products are free of all BFR s and PVC (internal cables and AC power cords). Apple had to work with suppliers to change the composition of hundreds of parts, including printed circuit boards (PCBs), connectors, fan impellers, cable insulators, adhesives, films, inks, dyes, flexible printed circuits, and enclosures (Nimpuno et al. 2009). Furthermore, Apple products have arsenic-free display glass and mercury-free LED-backlit displays[40].

Apple defined bromine- and chlorine-free by using the same limit established in relevant standards such as the IEC 61249-2-21[41], namely that of 900 ppm (0.09 %) of bromine and chlorine, and 1500 ppm (0.15 %) of the combined total of the two elements. This threshold essentially restricts all intentionally added BFR compounds and PVC applications, because chlorine and bromine in BFR and PVC applications are not effective at such low concentrations. Bromine is typically used in concentrations above 50,000 ppm to make plastics flame retardant and the chlorine content in PVC is even higher (Nimpuno et al. 2009).

3.5.2.2 Case Study DSM: Bromine- and chlorine-free plastic components

DSM Engineering Plastics offers a range of halogen-free products such as bromine- and chlorine-free high-temperature plastics that can be used in electronics. These new products can be used as PVC replacements for electronic wires and cables as well as internal and external electronic connectors (Nimpuno et al. 2009).

Two key bromine- and chlorine-free DSM EP products with desirable qualities for electronic connectors and cables are:

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[39] Apple’s specification requires that its established thresholds be met for all homogeneous materials. This ensures that every material used in the company’s products can be tested and verified with readily available and inexpensive test methods and procedures.

[40] http://www.apple.com/lae/environment/reports/

[41] IEC 61249-2-21 (2003) Standard for low-bromine and low-chlorine printed circuit board laminates

- Arnitel XG (www.arnitel.com) is a high-performing thermoplastic co-polyester that contains no BFR s, PVC, halogens, or plasticizers. The product has been approved for use with electronic wires and cables by the Underwriters Laboratories (UL).
- Stanyl ForTii (PA4T, www.fortii.com) is a bromine-, chlorine-, and halogen-free polyamide resin that can be used for internal and external electronic connectors.

DSM EP is able to produce its halogen-free plastic resins in high volume to meet increasing demand.

3.5.2.3 Case Study Nan Ya CCL and Indium Corporation: Bromine- and Chlorine-Free Printed Circuit Boards (PCBs)

Nan Ya and Indium produce bromine- and chlorine-free materials for use in printed circuit boards (PCBs). Nan Ya is a supplier of rigid laminates used to connect PCBs' insulating layers, and produces halogen-free laminates complying to FR- 4 industry standard. Indium developed a new halogen-free solder paste that negates the need for intentionally added bromine and chlorine.

3.5.2.4 Case Study Seagate Technology: Bromine- and Chlorine-free Hard Disk Drives

Seagate is a manufacturer of hard disk drives, and approximately 50 % of the disk drives Seagate ships meet halogen-free specifications (Status: 2009). Hard disk drives comprise several hundred individual components that Seagate sources from between 250 to 300 suppliers, and bromine and chlorine had to be eliminated from the hard drives' printed circuit boards, circuit cabling, adhesives, and plastic housings. (Nimpuno et al. 2009)

3.5.3 GreenScreen for Safer Chemicals (GreenScreen™)

GreenScreen™ is a method for comparative Chemical Hazard Assessment (CHA) developed by Clean Production Action that can be used for identifying chemicals of high concern and safer alternatives.[42] There are some similarities between its hazard-based approach and that of the EU Ecolabel.

Green Screen evaluates a chemical - along with its known and predicted breakdown products - based upon 18 hazard endpoints (see Table 22). Each hazard is divided into three levels of concern: high, moderate, and low. Two hazards, persistence and bioaccumulation, have an additional level of concern of very high, which reflects the growing international consensus in defining very persistent and very bioaccumulative (vPvB) chemicals. Each level of concern (for each hazard) is defined by threshold values that are quantitative, qualitative, or based on expert references.

Table 22: GreenScreen™ Hazard Criteria

ENVIRONMENTAL FATE	ENVIRONMENTAL HEALTH*	HUMAN HEALTH GROUP I	HUMAN HEALTH GROUP II	PHYSICAL HAZARDS
Persistence (P)	Acute Aquatic Toxicity (AA)	Carcinogenicity (C)	Acute Mammalian Toxicity (AT)	Reactivity (Rx)
Bioaccumulation (B)	Chronic Aquatic Toxicity(CA)	Mutagenicity & Genotoxicity (M)	Systemic Toxicity & Organ Effects (incl. Immunotoxicity) (ST)	Flammability (F)
		Reproductive Toxicity (R)	Neurotoxicity (N)	
		Developmental Toxicity (incl. Developmental Neurotoxicity) (D)	Sensitization (SnS)	
		Endocrine Activity (E)	Respiratory Sensitization (SnR)	
			Skin Irritation (IrS)	
	*Other Ecotoxicity Studies when available		Eye Irritation (IrE)	

42 http://www.cleanproduction.org/Greenscreen.php

The GreenScreen defines four benchmarks whereby each benchmark consists of a set of hazard criteria which encompass a combination of hazards and threshold values (Figure 7). Thus, substance can be allocated to one of these four benchmarks depending on their intrinsic properties. It has to be noted that GreenScreen™ is a hazard based approach, not a risk based approach since exposure data are not considered for the substance evaluation.

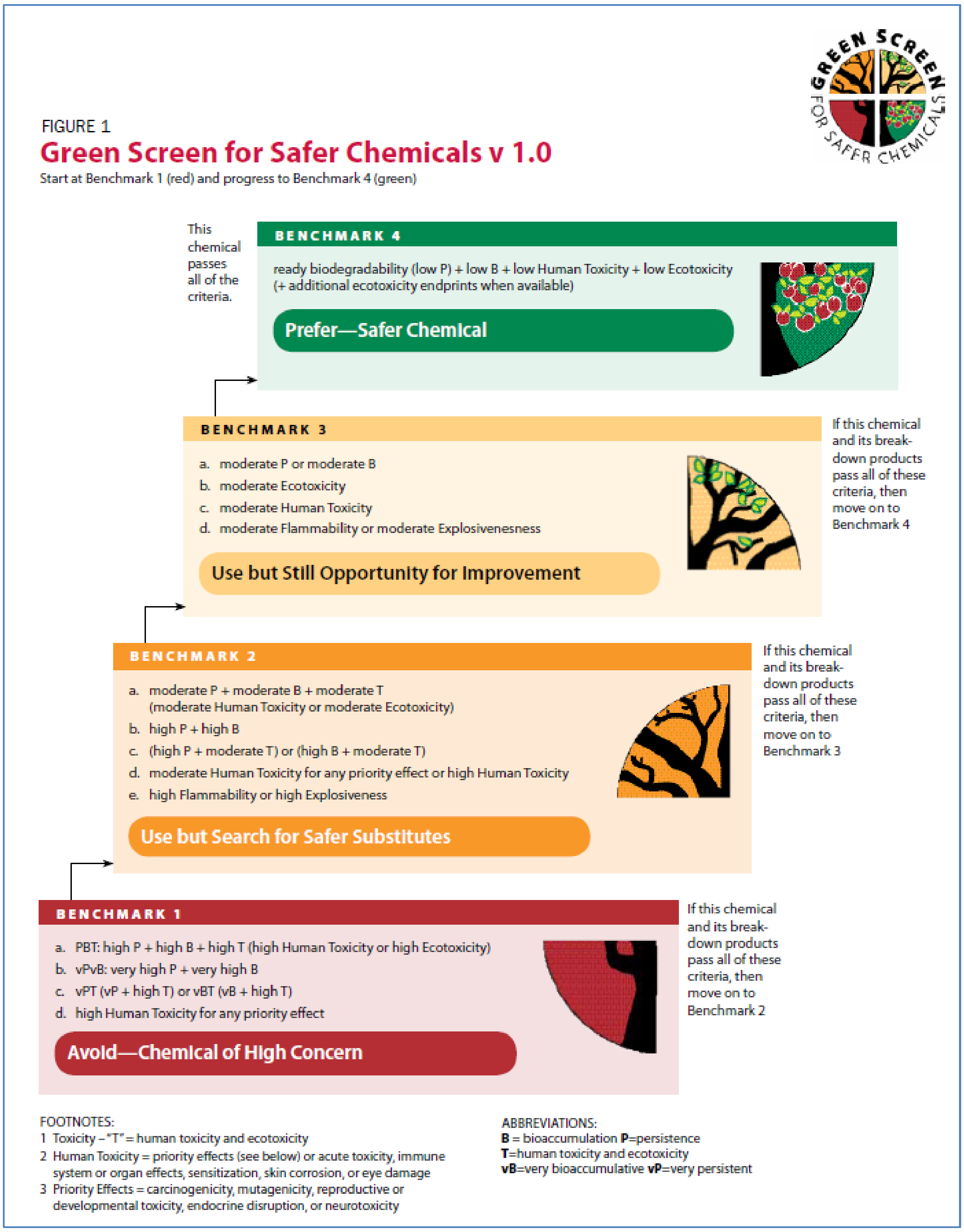

Figure 7: Benchmark of GreenScreen™ for Safer Chemicals

(Source: CPA 2009)

The allocation of different chemical substances having a similar function (e.g. different flame retardants) to the four GreenScreen™ benchmarks then allows a comparison between the substances and the selection of those substances with the lowest negative impact on environment and human health (see Table 23).

Table 23: Example GreenScreen™ Assessment of Similar Function Chemicals (Source: Hewlett Packard 2013)

Green Screen Assessments of Similar Function Chemical			
Common Name	**CAS #**	**Full Name**	**Benchmark**
Preferred			
Design	none	Design material out, dematerialize	4
Substance 0	#####-##-#	Chemical name	4
Use but still opportunity for improvement			
Substance 1	#####-##-#	Chemical name	3
Substance 2	#####-##-#	Chemical name	3
Use but search for alternatives			
Substance 3	#####-##-#	Chemical name	2
Substance 4	#####-##-#	Chemical name	2
Substance 5	#####-##-#	Chemical name	2
Substance 6	#####-##-#	Chemical name	2
DO NOT USE			
Substance 7	#####-##-#	Chemical name	1
Substance 8	#####-##-#	Chemical name	1
Substance 9	#####-##-#	Chemical name	1
Substance 10	#####-##-#	Chemical name	1
Substance 11	#####-##-#	Chemical name	1
Substance 12	#####-##-#	Chemical name	1

The computer manufacturer Hewlett Packard (HP) uses the GreenScreen™ as a core part of their analysis of replacement substances. Using the GreenScreen™, HP has already assessed about 140 chemical substances, amongst these 69 flame retardants (both halogenated and non-halogenated FR; Hewlett Packard 2013; see Table 24) as well as 20 phthalates and their replacements. The GreenScreen™ Assessment of the flame retardants (FR) showed that none of them fulfilled the highest benchmark (i.e. “prefer”) and only 6 FR fulfilled benchmark 3 requirements (i.e. ”Use but still opportunity for improvements). Most FR were allocated to benchmark 2 (i.e. use, but search for better alternatives), and 16 chemical should be avoided to the GreenScreen™ Assessment, amongst these also 13 non-halogenated

FR. It should also be highlighted that for 14 non-halogenated substances no or very little data are available impeding an assessment of environmental and human health impacts.

Table 24: Results of an HP GreenScreen™ Assessment of 69 flame retardants (Source: Hewlett Packard 2013)

GS rating		Br	Cl	P	Other	Total
4	Prefer	-	-	-	-	0
3	Use, still opportunity for improvements	1	-	-	5	6
2	Use, but search for safer alternatives	1	3	6	20	30
1	Avoid	3		6	7	16
	No / very little data	3	-	12	2	17
	Total	8	3	24	34	69

3.5.4 ENFIRO

ENFIRO[43] has carried out a Life Cycle Assessment process to identify safer, environmentally compatible flame retardants. To date, seven PIN flame retardants have been identified as generally safe, that is with few issues of only low concern[44]:

- Aluminium diethylphosphinate (Alpi),
- Aluminium hydroxide (ATH),
- Ammonium polyphosphate (APP),
- Melamine polyphosphate (MPP),
- Dihydrooxaphosphaphenanthrene (DOPO),
- Zinc stannate (ZS),

[43] EU funded project ENFIRO www.enfiro.eu

[44] http://www.pinfa.org/documents/Media/Newsletter/pinfa_newsletter_issue_no30_may-2013.pdf

- Zinc hydroxstannate (ZHS)

The ENFIRO methodology includes prioritisation of areas for substitution, selection of potentially safer flame retardants, evaluation of fire safety and application functionality, risk and impact assessment. Nine different polymer materials have been assessed for fire performance and flame retardant losses (leaching, off-gasing) in applications including electronics and textiles.

The PIN flame retardants show fire safety, processing characteristics and finished product performance comparable to halogenated substances, but better smoke suppression in case of fire. For all materials assessed, a performance PIN FR fire safety solution was successfully identified offering lower risk for health and the environment, lower risks of bioaccumulation, lower pollutant emissions in case of fire, and importantly reduced risks of pollutant emissions during end-of-life waste management. Further development might however be necessary for implementation in some applications. (pinfa 2013)

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