EUROPEAN COMMISSION
JOINT RESEARCH CENTRE
**Directorate B, Growth and Innovation (Sevilla)**
Unit 5, Circular Economy and Industrial Leadership

# Assessment of the reparability and upgradability of TVs

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|---|---|
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**Summary:**

Improving the material efficiency of products can be important to reduce their environmental impacts. In particular, an improvement of the reparability and upgradability of products can have the potential of bringing added value to the environment and to the economy by limiting the early replacement of products and thus saving resources. However, the design of products needs to be assisted by appropriate assessment methods.

In this context, the Joint Research Centre Directorate B, Circular Economy & Industrial Leadership unit, has compiled a multi-level approach for assessing the reparability and upgradability of products. This report describes the application of such approach to TVs, with the aim of improving the knowledge about the assessment of the reparability and upgradability of ErP.

The draft report is structured in the following chapters:

1. Product group definition and characterisation (including: scoping, legislation and testing methods of interest for repair and upgrade, relevant information on market, user behaviour and product)
2. Identification of critical aspects and priority parts for the product group and Level 1 assessment (development of a checklist of positive attributes influencing reparability and upgradability of the product group)
3. Annex: further methodological guidance notes about Level 2 (scoring of attributes influencing reparability and upgradability of the product group) and Level 3 assessment (discussion on quantitative parameters)
4. Additional questions.

Two written consultations are planned, the first one taking place from 20 April until 14 May 2018. Please note that at this stage it has been possible to prepare only a draft and incomplete report. The goal of the first consultation is to revise and integrate the background information gathered so far and set the basis for the development of the other steps of the study. Depending on your interest in and familiarity with the subjects covered in the report, you may provide input either to all or some parts and questions of the report, by using the provided commenting form.

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# INTRODUCTION

The Communications from the Commission COM(2015) 614 'Closing the loop - An EU action plan for the Circular Economy' and COM(2016) 773 'Ecodesign Working Plan 2016-2019' point out the increased importance of improving the resource efficiency of products in order to promote a transition towards a more circular economy in the EU. This can be for instance supported through a series of measures aiming to make products more durable, easier to repair, reuse or recycle.

Improving the material efficiency of products can be important to reduce their environmental impacts. In particular, an improvement of the reparability and upgradability of products[1] can have the potential of bringing added value to the environment and to the economy by limiting the early replacement of products and thus saving resources[2]. However, the design of products needs to be assisted by appropriate assessment methods. The importance of assessment and verification procedures is also confirmed by the recent creation of the CEN-CENELEC JTC10 'Energy-related products – Material Efficiency Aspects for ecodesign', which is working on the development of general standards on material efficiency aspects for Energy-related Products (ErP).

In this context, the Joint Research Centre Directorate B, Circular Economy & Industrial Leadership unit, has compiled a multi-level approach for assessing the reparability and upgradability of products[3]. This report describes the application of such approach to TVs, with the aim of improving the knowledge about the assessment of the reparability and upgradability of ErP. The work, entrusted by DG ENV, has a research orientation which does not mean to interfere with ongoing policy processes. Results could however feed into work on actions contained in the Circular Economy Action Plan related to product policy[4] and the Ecodesign task force for ICT products[5].

The draft report is structured in the following chapters:

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2. Identification of critical aspects and priority parts for the product group and Level 1 assessment (development of a checklist of positive attributes influencing reparability and upgradability of the product group)
3. Annex: further methodological guidance notes about Level 2 (scoring of attributes influencing reparability and upgradability of the product group) and Level 3 assessment (discussion on quantitative parameters)

[1] Reparability and upgradability are here defined, respectively, as the ability to restore the functionality of a product after the occurrence of a fault, and the ability to enhance the functionality of a product, independently on the occurrence of a fault. Both can refer to one or more parts of a product. Since similar processes apply to repair and upgrade, the same service conditions and design strategies can influence both reparability and upgradability of a product.

[2] Deloitte, Study on Socioeconomic impacts of increased reparability – Final Report. Prepared for the European Commission, DG ENV, 2016

[3] Cordella, M.; Sanfelix, J.; Alfieri, F. (2018) Development of an Approach for Assessing the Reparability and Upgradability of Energy-related Products, 69, 888-892. https://doi.org/10.1016/j.procir.2017.11.080

[4] http://eur-lex.europa.eu/resource.html?uri=cellar:8a8ef5e8-99a0-11e5-b3b7-01aa75ed71a1.0012.02/DOC_1&format=PDF

[5] https://ec.europa.eu/energy/sites/ener/files/documents/com_2016_773.en_.pdf

4. Additional questions.

Two written consultations are planned in order to get technical input and feedback from the Technical Working Group (TWG) of experts, consisting of manufacturers, retailers, repairers, academia, environmental and consumer NGOs, as well as Member States:

- The first written consultation will mainly cover the first two chapters, and other questions raised along the document (see the Table of Content), and will take place from 23 April until 14 May 2018.
- The second (and last) consultation will cover the entire document, and is preliminarily planned to take place in Summer 2018 (tbc).

In order to facilitate your task, a series of question boxes have been inserted along the document. The JRC team would much appreciate if you could send feedback and comments to JRC-B5-E4C@ec.europa.eu by using the provided commenting sheet.

The final assessment is currently planned to be published by the end of the year. Information and reports will be made available on a dedicate website (http://susproc.jrc.ec.europa.eu/E4C/index.html).

# 1 PG DEFINITION AND CHARACTERIZATION

## 1.1 Scoping

### 1.1.1 Product definitions

Television is defined in the Ecodesign regulation 642/2009[6] as follows:

1. 'television' means a television set or a television monitor;

2. 'television set' means a product designed primarily for the display and reception of audiovisual signals which is placed on the market under one model or system designation, and which consists of:

a) a display;
b) one or more tuner(s)/receiver(s) and optional additional functions for data storage and/or display such as digital versatile disc (DVD), hard disk drive (HDD) or videocassette recorder (VCR), either in a single unit combined with the display, or in one or more separate units;

3. 'television monitor' means a product designed to display on an integrated screen a video signal from a variety of sources, including television broadcast signals, which optionally controls and reproduces audio signals from an external source device, which is linked through standardised video signal paths including cinch (component, composite), SCART[7], HDMI (High Definition Multimedia Interface), and future wireless standards (but excluding non-standardised video signal paths like DVI and SDI), but cannot receive and process broadcast signals.

In the draft version of the revised Ecodesign regulation (unpublished at March 2018), television is defined as: 'an electronic display designed primarily to display broadcast television images; a television integrates one or more tuners to decode broadcast signal and may integrate software and/or hardware solutions for hospitality offering management and maintenance of the guest room'. The scope of the regulation has been extended to electronic displays, including computer displays and signage displays, among others[8]. However, the scope of the present study only covers the assessment of televisions.

The two definitions presented for TVs do not seem to differ significantly one from the other, as both have the same primary function (i.e. to display audio-visual signals) and consider the possibility to have other features/components. The most recent definition, which will be included in the revised Ecodesign regulation for displays, is used to define the scope of this study, which will focus on the most representative technologies on the market.

Given the similarities of TVs with other products under the scope of the revised Ecodesign regulation (e.g. computer monitors), the present study will briefly analyse to what extent the conclusions drawn for TVs could apply to other products of the same family.

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

[7] SCART is a 21-pin socket used to connect video equipment

[8] A signage display is an electronic display designed primarily to be viewed by multiple people in non-desktop based environments

An important aspect to classify TVs is their image quality, which depending on the number of pixels can be standard definition, high-definition (HD), full HD, ultra HD (4k and 8k), true 4k or true 8k (see Table 1).

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Table 1 Classification of TVs according to image quality

| Name | Resolution (pixels) |
|---|---|
| Standard definition | 704x480 |
| HD | 1280x720 |
| Full HD | 1920x1080 |
| Ultra HD (4k) | 3840x2160 |
| True 4k | 4096x2160 |
| Ultra HD (8k) | 7680x2160 |
| True 8k | 8192x4320 |

### 1.1.2 Questions for stakeholders

1) Are the definitions and classifications provided for TVs and related functionalities comprehensive and clear, or would you propose any modifications?

## 1.2 Legislation and testing methods

### 1.2.1 Mandatory legislation

This section describes mandatory legislation which can influence repair and/or upgrade of TVs. Legislation of other aspects (like REACH, CLP, F-gases, RoHS) has not been considered in this study.

#### 1.2.1.1 Ecodesign and Energy Label

Currently TVs are covered by Ecodesign regulation 642/2009[9], amended by regulation 801/2013[10], which is under revision. The revised regulation is planned to be adopted by the end of 2018.

The revised regulation should cover both televisions and monitors for energy requirements but also other monitors for resource efficiency aspects and provision of information. Requirements under discussion for material efficiency aspects are related to the end of life treatment of the displays such as the marking of plastics, in particular if containing flame retardants, and possible presence of mercury and cadmium. Requirements for dismantling, recycling and recovery could be potentially used also to improve the design for disassembly of TVs for repair and upgrade purposes.

TVs are further covered by Energy labelling regulation 1062/2010[11], which is also under revision. The revised label will indicate if the purchased TV uses an external power supply or not. In terms of reparability assessment, this aspect will ease the replacement of that part when failure occurs, especially if standardised models are used like USB type C for example.

#### 1.2.1.2 Reparability

To promote circular economy and boost the repair sector, a few EU member states have implemented VAT reductions on repair services of bicycles, clothing, textiles and leather goods. The list of countries includes Ireland, Luxemburg, Malta, Netherlands, Poland, Slovenia, Finland and Sweden. Other actions taken by governments to incentivise repair are listed in Table 2. Moreover, the European Parliament has asked the EC in July 2017 to consider a 'voluntary European label' covering, in particular, the product's durability, eco-design features, upgradeability in line with technical progress and reparability[12].

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

[10] COMMISSION REGULATION (EU) No 801/2013 of 22 August 2013 amending Regulation (EC) No 1275/2008 with regard to ecodesign requirements for standby, off mode electric power consumption of electrical and electronic household and office equipment, and amending Regulation (EC) No 642/2009 with regard to ecodesign requirements for televisions

[11] COMMISSION DELEGATED REGULATION (EU) No 1062/2010 of 28 September 2010 supplementing Directive 2010/30/EU of the European Parliament and of the Council with regard to energy labelling of televisions

[12] http://www.europarl.europa.eu/news/en/press-room/20170629IPR78633/making-consumer-products-more-durable-and-easier-to-repair (accessed 19/03/18)

Table 2 Strategies with tax reduction to incentivise repair[13]

| | |
|---|---|
| Sweden | 50% labour costs for repairs of large household appliances are tax deductible up to a maximum of 25000 Kr / year or 50000 Kr for persons over the age of 65. This is for repairs performed by professionals at the owner's home. |
| Austria | Proposal put forward by the Federal Chancellor Christian Kern in January 2017 to make repair cheaper by reimbursement of 50% of the labour costs of repair. The maximum amount would be 600 EUR per year per private person and year. Applicable for bikes, shoes, clothes, leather goods, electric household appliances. The city of Graz already introduced this system in November 2016 with maximum support of 100 EUR per household and year. |
| Spain | In Spain there is the Patronage law that allows tax reductions to companies and individuals who donate money from assets to charities. It also includes the donation of used goods, without differentiating them from new ones. |

Another relevant piece of legislation is the French decree 2014-1482 published in December 2014[14], which puts new requirements on retailers to inform consumers about the durability of their products and the availability of spare parts, under the threat of fine of 15'000 EUR. Manufacturers, in turn, are required to deliver the parts needed for repairs within two months. The French decree also extends the burden of proof on the seller in the case of a fault to 24 months. Planned obsolescence is also legal offence punishable by 300,000 €. Planned obsolescence is defined as 'all techniques by which a producer seeks to deliberately limit product life in order to increase the replacement rate'[15].

#### 1.2.1.1 General Product Safety Directive 2001/95/EC

The General Product Safety Directive (GPSD) 2001/95/EC aim is to ensure that only safe products are made available on the market.

The GPSD applies in the absence of other EU legislation, national standards, Commission recommendations or codes of practice relating to safety of products. It also complements sector specific legislation. Specific rules exist already for the safety of toys, electrical and electronic goods, cosmetics, chemicals and other specific product groups[16]. The GPSD does not cover pharmaceuticals, medical devices or food, which fall under separate legislation.

The GPSD establishes obligations to both businesses and Member States' authorities:

Businesses should place only products which are safe on the market, inform consumers of any risks associated with the products they supply. They also have to make sure any dangerous products present on the market can be traced so they can be removed to avoid any risks to consumers.

[13] http://www.rreuse.org/position-paper-on-reduced-taxation-to-support-re-use-and-repair/ (accessed on 10/03/18)

[14] Decree No. 2014-1482 of 9 December 2014 concerning Disclosure Requirements and Supply of Spare Parts

[15] http://transform-together.weebly.com/news-3---launch-of-ss-wg.html (accessed on 1 March 2018)

[16] https://ec.europa.eu/info/business-economy-euro/product-safety-and-requirements/consumer-product-safety/standards-and-risks-specific-products_en (accessed on 21 March 2018)

Member States, through their appointed national authorities, are responsible for market surveillance. They check whether products available on the market are safe, ensure product safety legislation and rules are applied by manufacturers and business chains and apply sanctions when necessary. Member States should also send information about dangerous products found on the market to the Rapid Alert System for non-food dangerous products (RAPEX). This is a cooperation tool enabling rapid communication between EU, EEA authorities about dangerous products to be able to trace them everywhere on the European market. Third countries like China and international institutions are also involved.

Market surveillance authorities cooperate closely with customs, which play a major role in protecting consumers from any imported unsafe products coming from outside the EU.

#### 1.2.1.2 Guarantees for consumers

The Consumer Sales Directive 1999/44/EC regulates aspects of the sale of consumer goods and associated legal guarantees. According to the 1999/44/EC Directive the term guarantee shall mean any undertaking by a seller or producer to the consumer, given without extra charge, to reimburse the price paid or to replace, repair or handle consumer goods in any way if they do not meet the specifications set out in the guarantee statement or in the relevant advertising.

The duration of the guarantee for new products must be at least 2 years. The minimum duration is applied in the majority of EU-countries. Longer durations are applied in some countries (e.g. Sweden, Ireland, the Netherlands and Finland) depending on the expected lifespan of the item sold. The duration of the guarantee for second hand goods can be lower (minimum 1 year).

The seller must deliver goods to the consumer, which are in conformity with the contract of sale, and then further specifies presumption of conformity of a number of conditions. The Directive introduced a 'reversal of burden of proof' of at least 6-months. This is the period within which the lack of conformity is presumed to have existed at the time of delivery and the seller is thus liable to the consumer, i.e. the seller must prove that the item was not defective. After six months the burden of proof shifts to the consumer, i.e. the consumer must prove that the product was defective. The Directive is currently revised. In the Commission proposal for a revised Directive, the burden of proof shifts to the consumer only after 2 years.

Article 3 of the Consumer Sales Directive indicates a list of remedies that should be provided to the consumer in the case of a defect (i.e. repair, replacement, reduction in price and rescission of contract). In the first place, the consumer may require the seller to repair the goods or he may require the seller to replace them.

In addition, Directive 2011/83/EU on consumer rights defines the concept of 'commercial guarantee' (also known as 'warranty'), which can be offered by sellers or producers in addition to the legal guarantee obligation. This can either be included in the price of the product or at an extra cost.

### 1.2.2 Standards and testing procedures

Although several standards are available for testing the energy performance of TVs[17], few standards (either published or under development) address aspects of relevance for the

[17] Energy Conservation Program: Test Procedures for Television Sets - Uniform Test Method for Measuring the Energy Consumption of Television Sets; EN 50301:2001 - Methods of measurement for the power consumption of audio, video and related equipment; IEC 62087:2011 - Methods of measurement for the power consumption of audio, video and related equipment; IEC 62301 -

assessment of the reparability and upgradability of TVs. Table 3 includes the most relevant ones.

**Table 3 Standards of relevance for assessing the reparability and upgradability of TVs**

| Standard | Title / Scope | Publication date |
|---|---|---|
| IEEE 1680.3-2012 | IEEE Standard for Environmental Assessment of Televisions | 2012-09-19 |
| ONR 192102 | Sustainability label for electric and electronic appliances designed for easy repair (white and brown goods) | 2006-09-01 |
| prEN 45554 | General methods for the assessment of the ability to repair, reuse and upgrade energy related products | Expected in 2019 |

The IEE 1680.3-2012 standard includes a specific chapter on product longevity (life cycle extension), where it requires to the manufacturers to provide: a) upgradeable firmware; b) information about how and where the TV can be serviced, and c) a resolution process for products that fail within one year. These three criteria are also included in the EPEAT ecolabel scheme, as described in Table 6 of the following section.

The ONR 192102 includes a list of criteria to facilitate the repair of products. The criteria are separated into product design criteria (25 requirements of which 9 are mandatory) and service documentation criteria (14 requirements of which 7 are mandatory). For each list of criteria the non-mandatory requirements give points to the assessed product when fulfilled (5 or 10 points). At the end of the assessment the product is rated according to the final score obtained as it appears in Table 4.

**Table 4 Assessment scores and quality levels of the ONR 192102**

| Number of points achieved | Quality level | Assessment |
|---|---|---|
| 45 – 69 | 5 | Good |
| 70 – 94 | 6 | |
| 95 – 119 | 7 | Very good |
| 160 – 144 | 8 | |
| 145 – 174 | 9 | Excellent |
| 175 – 205 | 10 | |

The prEN 45554 standard about repair, reuse and upgrade of ErP is part of CEN/CENELEC JTC10, currently working on the preparation of generic standards for the assessment of material efficiency aspects of ErP. In the case of prEN 45554, the standard includes a series of parameters influencing the ability of an ErP to be repaired, reused or upgraded, as well as methods to assess such parameters individually. It is expected that the final standard will be published in 2019.

Household electrical appliances - Measurement of standby power; JEITA Test Standard - Measurement method for energy consumption efficiency of television receivers

### 1.2.3 Environmental labelling

Several environmental labelling schemes exist worldwide for TVs. These schemes include pass/fail criteria over the entire life cycle of the product with the aim of targeting environmentally superior products and setting the reference for improving the overall environmental performance of the product group. An overview of environmental labelling schemes for TVs is provided in Table 5.

**Table 5 Environmental labels for TVs**

| Scheme | Title | Version | Effective | Valid until |
|---|---|---|---|---|
| EU Ecolabel | EU Ecolabel for TVs[18] | - | November 2009 | 31 December 2019 |
| Blue Angel | Television sets[19] | - | July 2012 | 31 December 2017 |
| Nordic Swan | Nordic Ecolabelling of TV and Projector[20] | 5.5 | 20 June 2013 | 30 June 2020 |
| TCO Development | TCO Certified Displays[21] | 7 | November 2015 | Not specified |
| | TCO Certified Edge Display | 2.0 | April 2014 | Not specified |
| EPEAT | Televisions[22] | - | Not specified | Not specified |
| US Energy star | Television specification | 7.0 | October 2015 | Not specified |
| Green Mark (Taiwan) | Televisions | Second revision | November 2013 | Not specified |

Ecolabel schemes have been analysed to identify any criteria addressing repair and upgrade aspects. Table 6 includes the results of the analysis. As apparent, reparability and/or upgradeability aspects are not covered systematically in all schemes. The majority of them request the availability of spare parts for a certain period of time after ceasing the production of the TV. In the Blue Angel criteria for TVs, for example, spare parts are defined as the parts

[18] COMMISSION DECISION of 12 March 2009 establishing the revised ecological criteria for the award of the Community Eco-label to televisions

[19] https://www.blauer-engel.de/en/products/electric-devices/fernsehgeraete (accessed 19/03/18)

[20] http://www.nordic-ecolabel.org/product-groups/group/?productGroupCode=071 (accessed 19/03/18)

[21] http://tcocertified.com/files/2015/11/TCO-Certified-Displays-7.0.pdf (accessed 19/03/18)

[22] https://www.epeat.net/resources/criteria-2/#tabs-1=televisions (accessed 19/03/18)

of the TVs that may break down within the scope of the ordinary use of the product. However, no scheme provides a specific list of these components.

The criteria of EPEAT is based on the standard IEE 1680.3 described in the previous section and the manufacturers interested in obtaining the EPEAT certificate of their product may order a copy of the standard.

**Table 6 Reparability and upgradability aspects covered in environmental labels for TVs**

| Label \ Aspect | Instructions | Durability / life time extension |
|---|---|---|
| **EU Ecolabel 2009** | Information for professionals about easy dismantle for the purpose of repair and replacement of worn parts and upgrading older or obsolete parts | Availability of compatible electronic replacement parts should be guaranteed for 7 years from that time the production ceases |
| **Blue Angel 2012** | - | Availability of replacement parts shall be guaranteed for 5 years from that time the production ceases |
| **Nordic Swan 2013** | Information for professionals about easy dismantle for the purpose of repair and replacement of worn parts | Availability of compatible replacement parts shall be guaranteed for 7 years from that time the production ceases |
| **TCO 2012 / TCO Certified Edge 2012** | Instructions for professionals available upon request | Availability of replacement parts shall be guaranteed for at least 3 years from that time the production ceases |
| **EPEAT** | - | Upgradeable firmware; Service information readily available; Early failure process |

*Note: Environmental labels not addressing reparability and reparability aspects are not reported in the table above.*

### 1.2.4 Questions for stakeholders

| |
|---|
| 1) Are there any other relevant legislation, testing methods, standard references or eco-labelling schemes worth to mention with respect to reparability and upgradeability of TVs? |
| 2) How could legislation and standards influence reparability and upgradability of TVs, in your opinion?<br>For example, the General Product Safety Directive 2001/95/EC specifies specific rules for electrical and electronic goods, which could hinder reparability. |
| 3) Is legislation and testing for TVs applicable also to other products of the same family (e.g. computer displays), or there are other specific elements to take into account? |

## 1.3 Market information

This section intends to provide a summary description of the market of TVs, as well as indications about costs, which can be used to understand the economic impact of critical aspects associated to the repair and upgrade of products.

### 1.3.1 Market sales and trade

Figure 1 includes the number of TVs produced in the EU-28 member states for the period 2010 to 2016. Within the EU-28 member states, Poland is the main producer with about 65% of the total units in 2016, followed by Slovakia (28%) and Czech Republic (5%)23.

Figure 2 shows the imports and exports of TVs for the EU28 during the period of time 2010 to 2016. Net size of imports is of the same order of magnitude of internal production in the EU. The number of imported units has had a gradual increase from 2013 to 2016, up to reach the levels of 2012. On the other hand, the number of exports shows a gradual decrease from 2012 to 2016.

Figure 1 Production of TVs in EU-28[24]

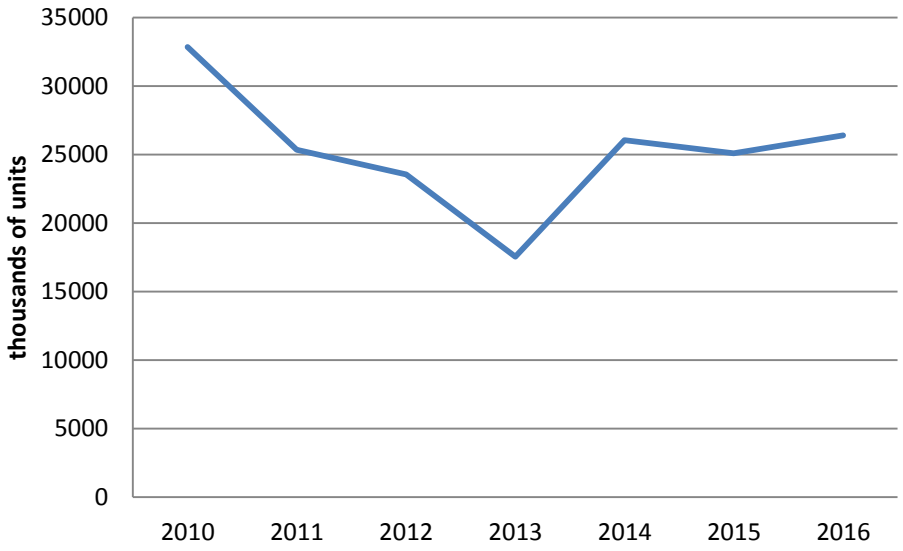
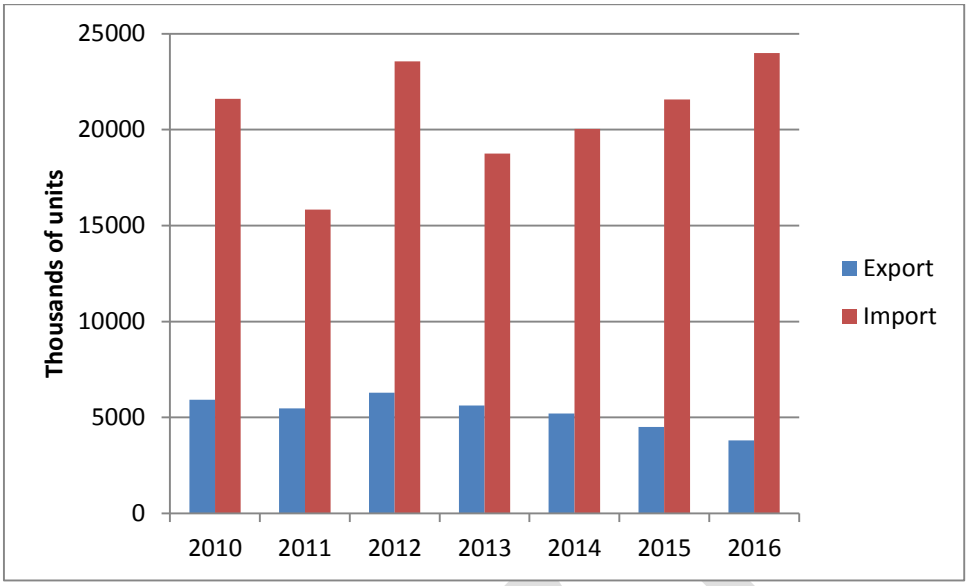



Figure 2 EU28 imports and exports of TVs[25]

[23] http://ec.europa.eu/eurostat/web/prodcom/data/database (The prodcom code used for TVs is 26.40.20.90 Other television receivers, whether or not combined with radio-broadcast receivers or sound or video recording or reproduction apparatus n.e.c.) (accessed 20/03/18)

[24] http://ec.europa.eu/eurostat/web/prodcom/data/database (The prodcom code used for TVs is 26.40.20.90 Other television receivers, whether or not combined with radio-broadcast receivers or sound or video recording or reproduction apparatus n.e.c.) (accessed 20/03/18)

[25] http://ec.europa.eu/eurostat/web/prodcom/data/database (The prodcom code used for TVs is 26.40.20.90 Other television receivers, whether or not combined with radio-broadcast receivers or sound or video recording or reproduction apparatus n.e.c.) (accessed 20/03/18)




### 1.3.2 Market share of technologies

Several types of TVs can be found in the market, the dominant technology is LCD (liquid crystal display), as CRT (cathode ray tube) technology has been gradually replaced by flat TVs. Table 7 includes a description of TV technologies that can be found on the market.

**Table 7 Description of the different technologies for TVs[26]**

| | |
|---|---|
| **CRT** | With CRT TV the image is generated by shooting electrons through a tube onto a screen, exciting the particles on it. CRT TV formats have been on the fall since the early 2000's with the introduction of far thinner LCD screens. |
| **LCD** | A liquid crystal display is a special flat panel that can block light, or allow it to pass. The panel is formed by segments with a block filled with liquid crystals. By increasing or reducing the electrical current, the colour and transparency of the blocks can be modified. In order to generate the image an external light source is needed, e.g. a fluorescent light. |
| **LED** | LED TVs are an updated version of the LCD generation, indeed the technology is similar but instead of using a backlight fluorescent bulb they use an array of LEDs. This makes them more efficient and allows smaller sizes, meaning the TV can be narrower. LED have two further major categories Direct (Back-lit) LED and Edge-lit LED:<br>*Direct LED:* These displays are backlit by an array of LEDs directly behind the screen. This enables focused lighting areas – meaning specific cells of brightness and darkness can be displayed more effectively.<br>*Edge-lit LED:* Lights are set around the television frame. Edge-lit models reflect light into the centre of the monitor, and are the thinnest, lightest models available. Since they have fewer lights in the centre of the screen. |

[26] https://www.ebuyer.com/blog/2014/03/tv-types-explained-plasma-lcd-led-oled/ (accessed 22/03/18)

| | |
|---|---|
| **PLASMA** | Plasma screens are composed of two sheets of glass with a mixture of gases in between the layers. In the manufacturing process these gases are injected and sealed in plasma form. The gases react and cause illumination in the pixels across the screen when charged with electricity. Plasma is superior to LCD & LED in terms of contrast and colour accuracy. It is used in the super-sized 80-inch+ screens as the plasma screens are easier, and more cost effective, to produce in larger formats. |
| **OLED** | OLED uses 'organic' materials like carbon to create light when supplied directly by an electric current, and do not require a backlight to illuminate the set area. OLED screens can be very thin and flexible thanks to that. Since the individual areas are lit up directly, the colours and contrasts are of better quality. |

Data from 2013 about the shipment of TV technologies suggested an increased penetration of LCD at the expenses of CRT and plasma TVs, which are gradually disappearing from the market (see Figure 3). In the long term, the TV replacement cycle seems shifting from the flat panel replacement of CRTs to flat panel upgrades, especially as new features become more affordable.[27]

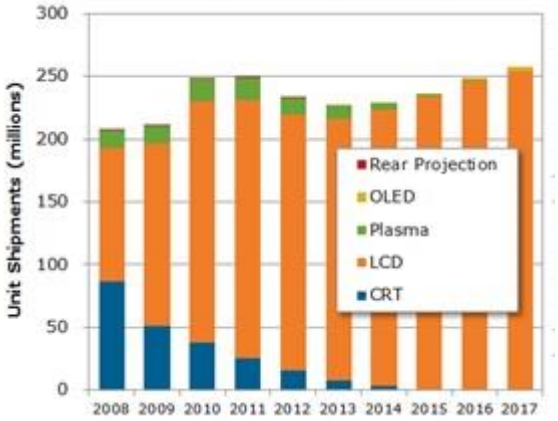



**Figure 3 Worldwide TV shipments by technology, forecast performed in 2013[28-29]**

In the coming years, 4k OLED TVs could replace 4k LCD for the high-end market, although the new generation of 8k LCD could also take part of the share. Figure 4 shows the predictions for TVs abover 1000 USD.

[27] Development of European Ecolabel and Green Public Procurement Criteria for Televisions – Technical Report - Task 2 (2013) Osmani D. et al.

[28] http://www.displaysearch.com/cps/rde/xchg/displaysearch/hs.xsl/121023_global_tv_demand_expected_to_be_flat_in_2013.asp (accessed in 2013)

[29] Development of European Ecolabel and Green Public Procurement Criteria for Televisions – Technical Report - Task 2 (2013) Osmani D. et al.

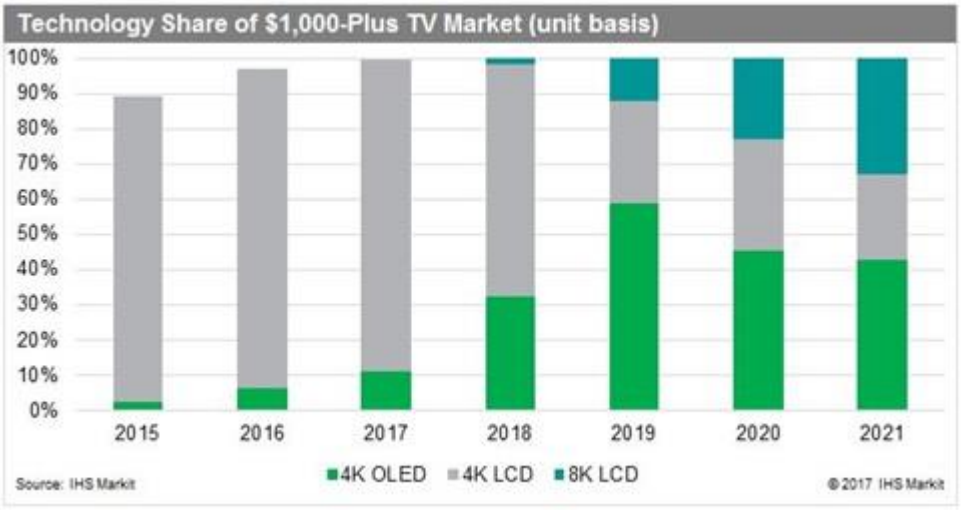



Figure 4 Technology share of $1.000-Plus TV Market (unit basis)[30]

Figure 5 shows the share of shipments worldwide by main brands. It has to be noted that it includes only LCD TVs, which represent the majority of the market. Plasma has never had a significant share and OLED has a low share at the moment, although it is growing and predicted to be significant[31].

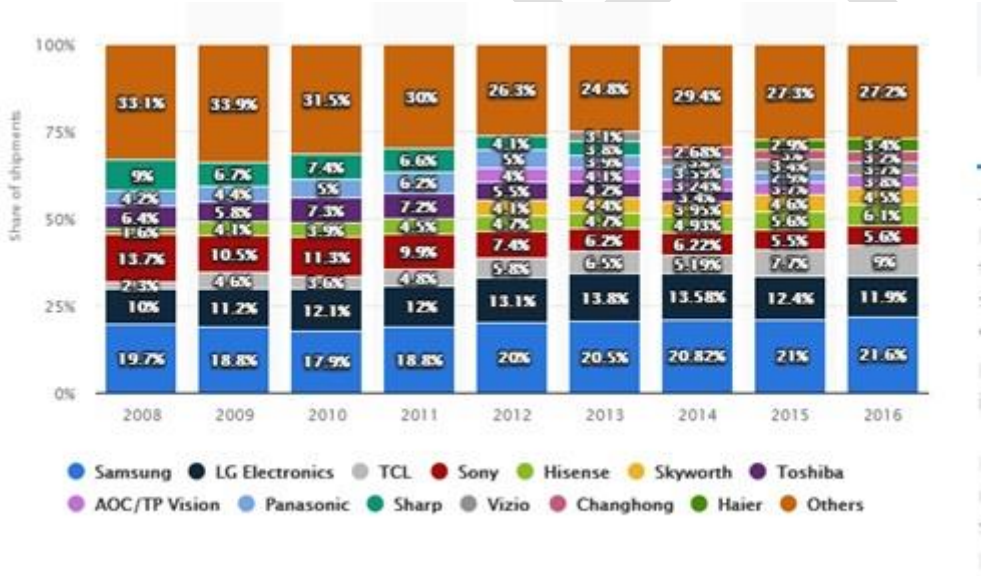



Figure 5 Share of shipments LCD TVs worldwide by main brands[32]

[30] http://news.ihsmarkit.com/press-release/oled-tv-expected-grow-more-50-percent-1000-plus-market-2019 (accessed 20/03/18)

[31] https://www.flatpanelshd.com/flatforums/viewtopic.php?f=2&t=8453 (accessed 21/03/18)

[32] https://www.statista.com/statistics/267095/global-market-share-of-lcd-tv-manufacturers/ (accessed 01/03/18)

### 1.3.3 Key actors in the repair market

The TV repair market is mainly covered by professional repairers, normally certified by the brand manufacturers and located at the point of sale, but not necessarily. The do-it-yourself repair seems to be rather low as the repair normally requires electronic knowledge by the user. The availability of disassembly information seems to be as well limited to professionals and in some cases it requires a fee to access it, this aspect influences in the cost of the repair operation making it more expensive.

Websites like iFixit.com[33] provide guides and solutions to repair household electronics. In the case of TVs, the website compiles questions from the users regarding different failure modes and descriptions on how to fix them, as an illustrative example Figure 6 shows a screenshot of the information than can be found. When available, the website provides information about where to purchase the components needed for replacement and/or tools required. For some TV models the website includes a trouble shooting for general, audio and video problems, one example is for the model LG 32CS560, as it showed in the right side of Figure 6 where the list of problems included in the troubleshooting appear.

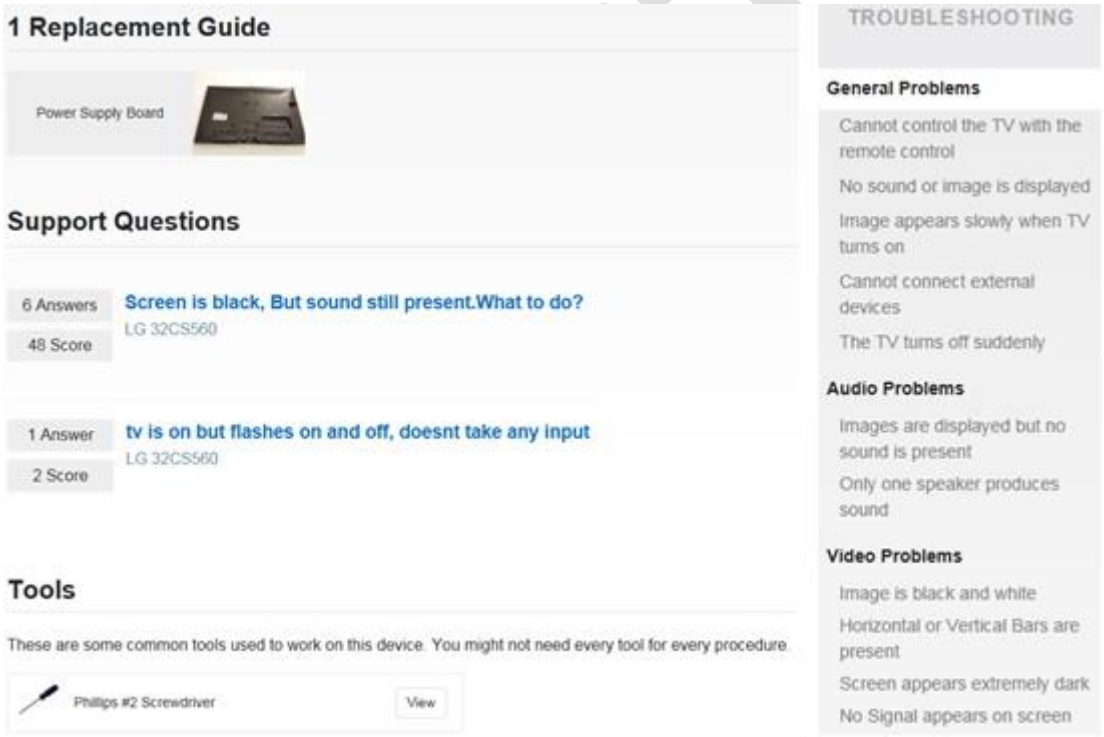



**Figure 6 Example of information available in iFixit[34]**

[33] https://www.ifixit.com/ (accessed 20/03/18)

[34] https://www.ifixit.com/Device/LG_32CS560 (accessed 20/03/18)

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### 1.3.4 Questions for stakeholders

1) Does the basic information reported provide a satisfactory overview of the market of TVs? Could you otherwise share any information to amend or integrate in the following aspects?

- Sales and penetration of TV technologies, for different market segments/technologies
- Key actors, main market channels, market structure and major players

2) Which is the current ownership of new and 2nd hand TVs in the EU? Which are the trends for the future?

3) Do you agree that LCD is the main technology used for TV? If not, which other technologies are relevant, and for which market segments (e.g. OLED TVs, quantum dots, micro-LED)?

4) Which technologies may become relevant in the future, and for which market segments (e.g. LCD, OLED TVs, quantum dots, micro-LED)?

5) Which are the main circular business models and market trends for TVs?

6) Could you please share any relevant data or source of information to quantify average costs related to the life cycle of TVs?

| **Category** | **Average value** (1) (2) | | |
|---|---|---|---|
| | **Low-end** | **Medium** | **High-end** |
| Representative technology | | | |
| Manufacturing cost **(EUR/product)** | | | |
| Purchase price **(EUR/product)** | | | |
| Variation of the value of the product over time | | | |
| Installation costs **(EUR/product)** | | | |
| Maintenance costs **(EUR/product)** | | | |
| Repair costs **(EUR/product)** (3) | | | |
| Refurbishment costs **(EUR/product)** (3) | | | |
| Margin for resale (% of residual value) | | | |
| Disposal costs **(EUR/product)** | | | |

Note:
(1) VAT included
(2) Costs representative for 2018
(3) Where relevant

7) Which could be the relative contribution of key parts of a TVs to the overall cost of the product? How the cost would change for spare parts?

8) How does the quality of TVs influence its reparability? What could be the impact on the final cost of a more reparable product?

9) Compared to TVs, which are the main differences for other products of the same family (e.g. computer displays)?

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## 1.4 User behaviour

This section intends to provide a summary description about the experience of users with TVs, in particular with respect to repair and upgrade considerations.

### 1.4.1 Product's lifetime and replacement

The TV replacement cycle has decreased on a global scale from 8.4 to 6.9 years, compared to the previous 10-15 year average, when the main replacement was from CRT-to-CRT technology[35]. Reasons for this trend could have been the declining of prices, a wider variety of sizes, and the desire for the latest technologies.

Regarding the replacement of TVs, the most critical driver in nearly all countries seems to be a desire to trade up in size, followed by wanting to own a flat panel TV with improved picture quality[36]. Price related factors are also important in TV replacement decisions. The existing TV being outdated or broken seems also a strong driver for TV replacement, but not one of the top reasons. New advanced features such as LED backlights, 3D and internet connectivity, seem however only to a minor extent be important to buy a new TV just because these features become available. Regarding internet connectivity, most consumers view it as a nice feature to have, but not as a principle reason to upgrade a TV. For 3D, the lack of broadly available content is making this feature not a main reason to upgrade the TV in the first place.

### 1.4.2 Questions for stakeholders

| |
|---|
| 1) How long do users keep their TVs and which are the main reasons of replacement? |
| 2) Which is the users experience with repair of TVs? How frequently and how this is done? Which are the main reasons and how they could be encouraged to repair their devices? |
| 3) How users typically upgrade their TVs? How much frequently is this done? Which are the main reasons and how they could be encouraged to upgrade their devices? |
| 4) Could you please share any other information about conditions of use and user behaviour that you consider relevant for the analysis? |
| 5) Compared to TVs, which are the main differences for other products of the same family (e.g. computer displays)? |

[35] Development of European Ecolabel and Green Public Procurement Criteria for Televisions – Technical Report - Task 2 (2013) Osmani D. et al.

[36] Development of European Ecolabel and Green Public Procurement Criteria for Televisions – Technical Report - Task 2 (2013) Osmani D. et al.

## 1.5 Product and system aspects

This section intends to provide a technical description of TVs, with the aim of supporting the further analysis of reparability and upgradability aspects.

### 1.5.1 Functions

As described in section 1.1, the main purpose of a TV is to display broadcast television images (i.e. to receive audio-visual signals). The television functions as a graphical interface between the received signal and the user.

Secondary functions of TV can include:

- data storage with a HDD,
- display of DVD, VCR, video-consoles, or
- internet browsing (for smart TVs).

### 1.5.2 Parts

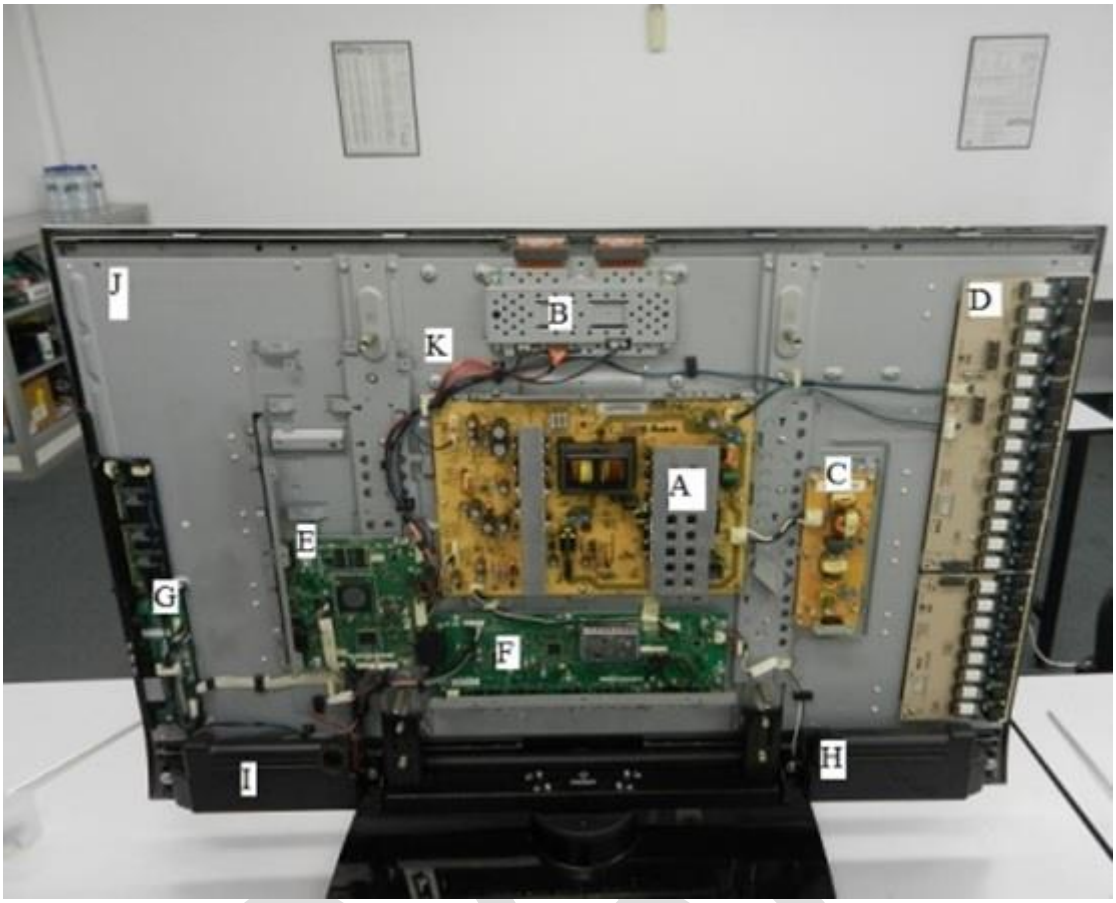
Table 8 provides the list of typical components included in an LCD computer display, which can be considered similar to those of an LCD TV[37]. Figure 7 provides a graphical representation of how the key parts of an LCD TV are arranged, while Figure 8 shows the parts of an OLED TV. As it can be appreciated, the circuits are different for LCD and OLED TVs, although they have similar parts (main board, T-con board, speakers, etc.). Components like WIFI board and MOIP are characteristics of a smart TV.

Table 8 Typical part of an LCD TV[38]

| Function | Part |
|---|---|
| Image display | Lliquid crystals |
| | Thin-film transistors |
| | Electrodes |
| | Colour filters |
| | Polarizers |
| | Orientation film |
| | Backlight |
| Glass structure | Front panel |
| | Back panel |
| Electronics | LCD controller PWB |
| | Backlight PWB |
| | Column and row driver PWBs |
| | Other PWBS (e.g. power supply) |
| Casing | Plastic casing and base |
| | Plastic frame and base |

[37] Socolof et al. Environmental life cycle impacts of CRT and LCD desktop computer displays. Journal of Cleaner Production (2005).

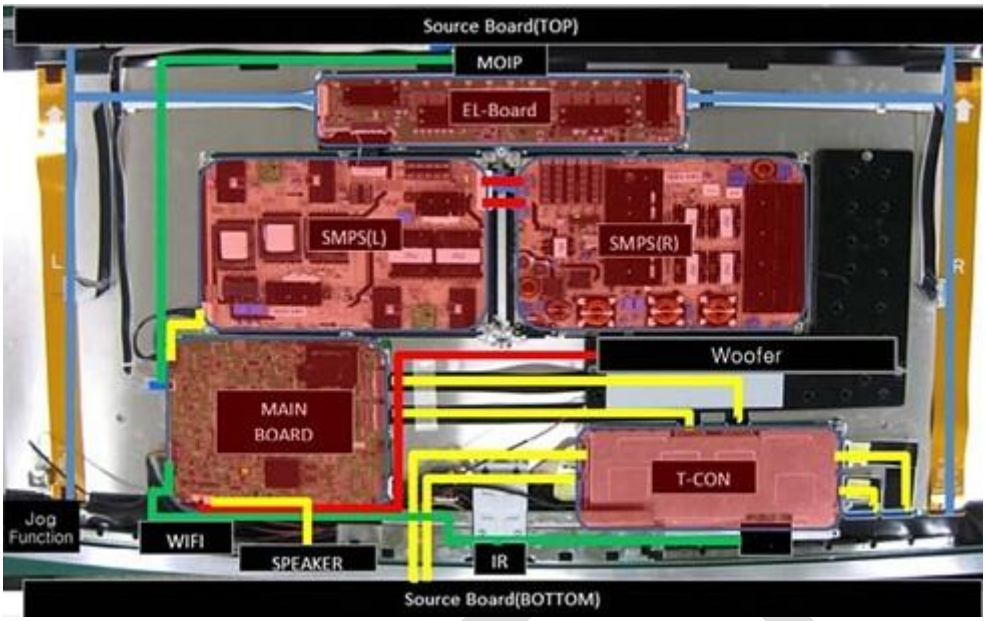
[38] Socolof et al. Environmental life cycle impacts of CRT and LCD desktop computer displays. Journal of Cleaner Production (2005).




A: Power Board
B: T-con Board
C: EMI Filter board (sometimes is built into the Power Board)
D: Inverter Board (sometimes is built into the Power board and called as I/P board)
E: Main Board
F: Jackpack
G: Side Key Panel/Power Control/Remote Receiver Unit (IR/LED control)
H: Left Speaker
I: Right Speaker
J: LCD panel
K: Low-voltage differential signaling (LVDS) cable

**Figure 7 Components of an LCD TV**[39]

[39] http://www.electronicrepairguide.com/lcd-tv-repair-basic.html (accessed 21/03/18)




MOIP: Multimedia over Internet Protocol

SMPS: Switch mode power supply, left (L) and right (R)

IR: Infra-red receiver

**Figure 8 Components of an OLED TV[40]**

Another important component that is not listed in the above descriptions is the remote control.

A BOM has been found for a LCD-TV of 20.1" with an integral cold cathode fluorescent lamp as backlight system[41].

**Table 9 BOM of an LCD-TV[42]**

[40] https://electronicshelponline.blogspot.com.es/2016/02/samsung-oled-tv-smps-troubleshooting.html (accessed 21/03/18)

[41] JRC Technical Report (2012) Integration of resource efficiency and waste management criteria in European product policies – second phase

[42] JRC Technical Report (2012) Integration of resource efficiency and waste management criteria in European product policies – second phase

| Component | Materials | Mass [g] |
|---|---|---|
| **Components: Frames / covers** | | |
| Back cover | ABS | 920 |
| Main front cover | ABS | 340 |
| Support | ABS | 250 |
| Secondary front covers | PC | 15 |
| | plastic (unspecified) | 98 |
| Main metal frame | Iron/steel | 1580 |
| Metal frames (n°2) | Iron/steel | 261 |
| PCB support | Iron/steel | 48 |
| Support for cable plugging | Iron/steel | 34 |
| | plastic (unspecified) | 38 |
| Internal support | Aluminium | 353 |
| Lamps support | Aluminium | 30 |
| **Components: PCBs and connectors** | | |
| Main PCB | Various (rich in precious metal) | 245 |
| PCB (secondary) | | 61 |
| PCB (secondary) * | | 1 |
| PCB | Various (very rich in precious metal) | 55 |
| film connectors: n° 4 | | 4 |
| PCB (secondary) | Various (poor in precious metal) | 300 |
| PCB (secondary) | | 8 |
| **Component: LCD screen** | | |
| LCD (larger than 100 $cm^2$) | Glass, plastics, others (indium: 48.2 mg) | 473 |
| Plastic light guide | PMMA | 1565 |
| Plastic foils | Plastics | 100 |
| Fluorescent lamps (n° 2) | Glass + various (Hg: 8mg; rare earths: 5.8mg) | 8 |
| **Other components** | | |
| Capacitors (n°2, diameter larger than 2.5cm) | Various | 9 |
| Fan | plastic; steel | 19 |
| External cables | Copper; plastic | 120 |
| Internal cables | | 25 |
| Speakers | Steel; plastics | 196 |
| Screws | Iron/steel | 30 |

* PCB smaller than 10 $cm^2$

### 1.5.3 Software

The operating system installed in normal TVs (i.e. not a smart TV) is normally not subject of updates, as this type of TV runs with the same software during its entire life. This software is used to control volume, brightness, subtitles, image format, tune channels, etc.

With the introduction of smart TVs, manufacturers seem to be upgrading the software/firmware for a better use experience and efficiency of the system. Normally the updates can be downloaded from the manufacturer's website and it can be downloaded directly from the TV with an internet connection or by pairing a device (computer or tablet) to the TV (directly or via an intermediate storage device such as a USB stick).

### 1.5.4 Questions to stakeholders

1) Do you agree with the above description of functions and sub-functions of TVs? If not, please explain why and provide the information needed to modify it.

| |
|---|
| 2) Could you share information about design and innovation cycles, manufacturing process and how they can influence the reparability and upgradability of TVs? |
| 3) Is the description of the parts of an LCD and OLED TVs correct and comprehensive? If not, please explain why and provide any necessary information. |
| 4) Are there any other key technologies for TVs which are worthy of consideration apart from LCD and OLED TVs (e.g. Quantum dots and Micro-LED)? Could you please indicate how they differ in terms of functions, parts and other technological aspects? What are your expectations for market share for the different technologies? |
| 5) Do you have information to share about the BOMs of the identified key technologies for TVs? |
| 6) Which is the market share of SMART TVs and which are the key software considerations that can obstacle or facilitate the repair/upgrade of such TVs? |
| 7) Compared to TVs, which are the main differences for other products of the same family (e.g. computer displays)? |

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# 2 ASSESSMENT OF REPARABILITY AND UPGRADABILITY

Three levels of complexity have been conceived for assessing the reparability and upgradability of TVs:

- Level 1: Qualitative assessment, based on a checklist of positive conditions for reparability and upgradability;
- Level 2: Semi-quantitative assessment, based on the characterization of product-specific parameters;
- Level 3: Quantitative assessment, based on technical and environmental indices.

The adoption of one or more levels depends on specific targets, familiarity with tools and methods, and availability of data. Level 1 is the simplest one and aims at finding design requirements with which to improve the reparability and upgradability of products. Level 2 builds on the first and aims at assessing reparability and/or upgradability of alternative design options with respect to the requirements identified at Level 1. Level 3 can complement the assessment and identification of more reparable and/or upgradable solutions by analysing the technical complexity of products and the environmental and economic impacts.

The three levels of the assessment are all based on the preliminary definition of priority parts for the product under study.

## 2.1 Identification of critical aspects and priority parts of the product

The first step of the assessment is to identify critical aspects and priority parts for the product under analysis. Priority parts are here defined as those components, assemblies, or any other hardware or software constituents which are more important for the repair/upgrade of the product. The identification of priority parts is a core part of the assessment.

### 2.1.1 Failure modes and impacted parts

A study conducted by WRAP[43] on three LCD TVs, identified the following most common faults in the products:

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

Their study aims at providing guidance to buyers and manufacturers to procure and produce longer lasting and easier to repair TVs. According to that study, assemblies such as the screen that are fragile and critical to use, are particularly susceptible to damage. Damage occurs through strains on connectors and printed circuit boards that are subject to flexing, causing strain on soldered joints. Electronic components and solder can also become damaged by variations in temperature and humidity for example, that can aggravates poorly soldered joints and corrupts chips.

Continuing with this work, WRAP published a more detailed study in 2014 about durable LCD TVs[44]. Common failures and impacted components of TVs were identified in that report, their findings are summarised in Table 10.

[43] http://www.wrap.org.uk/sites/files/wrap/TV%20case%20study%20AG.pdf (accessed 21/03/18)

459 **Table 10 Common failure in LCD TVs according to WRAP[45]**

| Component | Failure mode |
|---|---|
| Remote control | - Electronic faults on the PCB of the remote control, caused by poor connections, component failures and/or battery leakage/corrosion.<br>- The print on the keypads might get worn.<br>- Damaging the casing.<br>- Insert batteries the wrong way.<br>- Not following the instructions. |
| Power supply | - Fault with the power supply, the remote power button or the TV on-off switch. Caused by a poor switch contact or a fault on the power PCB. |
| Control board and connectors | - Failures can cause screen and picture failures. This can be due to poor connectors or an electronic fault on the control PCB.<br>- Faults on external connectors (SCART, HDMI and Aerial sockets) can be caused by weak mounting onto a PCB or by a user mistake in forcing the plugs into the connector. |
| Speakers and mounts | - Poor sound quality due to case vibrations, speaker damaged physically transit or a fault with the sound PCB resulting in poor or no sound.<br>- Thermal or mechanical faults by excess input power, power outside the speaker bandpass and excessive diaphragm movement through low frequencies. |
| Stand wall, mount and case | - Some are weak in relation to the TV weight.<br>- Cracking and failure, crack propagation. |
| Programming / set-up | - Complex set-ups, tuning procedures and/or poor instructions can lead to consumer dissatisfaction and returns, despite not having a real failure. |

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461 In a study about user behaviour in Europe (not published yet) other problems were identified
462 for flat TVs. In their findings the most common problem would be the remote control
463 followed by screen and connectors. For more recent televisions, the streaming from the
464 smartphone or tablet is also a common problem, and for smart TVs the portal with apps.

465 Another common failure in LCD televisions are faulty capacitors that can lead to: flickering
466 screen, screen image disappears after several seconds, dim screen, slow start, power LED on
467 but no image, shuts down for no apparent reason, no LED no picture or no sound, sound and

[44] https://eproducttechguide.wrap.org.uk/products/lcd-televisions/ (accessed 21/03/18)

[45] https://eproducttechguide.wrap.org.uk/products/lcd-televisions/ (accessed 21/03/18)

no picture and unusual colours. The capacitors can be examined on the televisions and see if they are in bad condition[46].

Other failure modes have been also identified by independent repairers and websites containing repair information for LCD TVs[47]. Some of them are included in the Table 11.

**Table 11 Additional failure modes in LCD TVs according to independent repairers**

| Failure mode | Cause |
|---|---|
| Image disappears immediately | The main cause is due to a failure in the inverter that supplies energy to the lamps. This failure can also be made by other irregularities in the board, as for example the weakening of a lamp and as consequence the inverter identifies the drop of energy consumption, switching off the TV for security measures. |
| The TV does not switch on | It can be generated by a failure in the transformer or in the power supply, generating a failure in the electricity supplied to the circuit boards. |
| Lines in the image | The most common cause is a failure in the transistor column or irregularity in the transference of the low-voltage differential signalling. It could also be related to failure on the T-con board. |
| Image showed with a mosaic effect | It is normally cause by a failure in one of the components in the T-con board, although sometimes it can be caused by a failure in the low-voltage differential signalling. |

Table 12 provides a list of failure modes and their cause based on the information gathered, note that the list contains failures of smart TVs.

**Table 12 Typical failure modes and cause of LCD TVs**

<table>
<tr><th>Failure mode</th><th colspan="2">Cause</th></tr>
<tr><td>Remote control does not work</td><td colspan="2">–Electronic faults on the PCB of the remote control, which could be caused by poor connections, component failures and/or battery leakage/corrosion<br>–The print on the keypads might get worn<br>–Damaging the casing<br>–Insert batteries the wrong way<br>–Not following the instructions</td></tr>
<tr><td rowspan="2">Screen related</td><td>Image disappears immediately</td><td>–Failure in the inverter that supplies energy to the lamps<br>–Weakening of a lamp</td></tr>
<tr><td>Lines in the image</td><td>–Failure in the transistor column<br>–Failure in the transference of the low-voltage differential signalling</td></tr>
</table>

[46] http://apike.ca/content/2012/11/how-find-bad-capacitors-tv.html (accessed 21/03/18)

[47] http://buscotecnicos.com/blog/?p=519 (accessed 23/03/18)

| | | |
|---|---|---|
| | Image showed with a mosaic effect | –Failure in one of the components in the T-con board<br>–Failure in the low-voltage differential signalling |
| Failure when streaming from smartphone/tablet | –Failure when pairing the TV with the devices sometimes due to complex set up or unclear instructions | |
| Connectors | –Weak mounting on the main PCB or by a user mistake in forcing the plugs into the connector | |
| Portal with apps | –Software updates<br>–Various apps running at the same time | |
| Digital synchronizer | –Complex set up or unclear instructions | |
| Poor sound quality or no sound | –Case vibrations<br>–Speaker damaged physically<br>–Fault with the sound PCB | |
| USB ports not working | –Burn out ports<br>–Outdated firmware of the TV<br>–Compatibility issues with the format of the USB (NTFS, FAT32 or exFAT) | |
| No power supply | –Poor contact of the on-off switch<br>–Fault on the power PCB (e.g. failure in the transformer) | |

### 2.1.2 Typical repair operations

Repairing a TV requires electronic knowledge from the repairer and access to the service manual of the product, these two aspects influence in raising the price of the total cost of the repair operation, to the point that the consumer could consider more convenient the purchase of a new TV.

Problems related to the different boards could be easily fixed by facilitating the replacement of the corresponding board and/or the specific component on the board (e.g. fuse, capacitors, diodes). To do so, manufacturers should facilitate the disassembly of the TV by avoiding soldering of the board and use robust connectors or plugs. An example of the required steps to disassemble a flat TV is given in section 2.1.4. Websites like iFixit include detailed manuals about how to replace specific components of a TVs (for example, one of them describes how to replace a faulty diode from the power board of an LG LCD TV)[48].

### 2.1.3 Typical upgrade operations

The upgrade of TVs normally implies the substitution of the product by a new one. The upgrade of specific parts or features appears limited. For example, upgrading from LCD to OLED it is impossible due to difference in circuits and connections of the hardware. On the other hand, upgrading a normal LCD TV to a smart TV can be carried out by connecting a

[48] https://www.ifixit.com/Guide/Repairing+LG+17LX1R+LCD+Television+Power+board/10099 (accessed 21/03/18)

smart TV receptor (like for example the google chromecast or the apple TV). In these cases the TV only needs to have the correct connector to plug the receptor.

Software upgrades are instead possible for smart TVs and they are provided by the manufacturer. Their frequency of update is also influenced by the updates in the applications or platforms that smart TVs offer.

### 2.1.4 Steps for the disassembly of parts

Easy access to critical components is essential to facilitate the repair operation. According to a study from WRAP[49], it is a common practice to use clips as joint technique for the cover of the TV, which increase the risk of damage when opening it for repair. They also encountered difficulties to find fastening points in mid to high-cost models. In favour, all the models assessed in their study used standard screws which allow disassembly and reassembly.

Regarding the circuit boards, the same study from WRAP[50] concludes that power circuit boards were easy to access and they could be easy replaced at board or component level. This was not the case of the video circuit board and the control inverter, which in some cases were located between the cover and the screen, hindering or making impossible the access to them. They also conclude that the majority of electrical joints were designed with clip-fit connectors or spades, which facilitate the replacement of components.

In order to facilitate the disassembly of the components of a TV which are prone to fail, the manufacturer has to provide clear indications on how to disassemble the product, as well as facilitate the access and disassembly of the component by using adequate joining techniques, as indicated in the findings from the WRAP study mentioned about. Table 13 illustrates what has been considered to be a good example of the indications to disassemble an LCD TV, the example is from the model PDI-P23LCD.

The disassembly starts with the removal of the stand and back cover, which are usually attached with screws.

Once the back cover is removed the repairer can have access to all the boards and cables connecting them, although this depends on the specific model. For example, some TVs can indeed have the T-con board in another assembly level (between the screen and the cover) and it could be even soldered.

All the boards need to be removed to have access to the LCD module of the TV. Normally they are attached with connectors and plugs which might require delicate movements as the connectors and/or boards can be fragile. Separating the LCD module might require the removal of several screws as this component is normally attached to different parts of the TV and frame.

Once the LCD module is removed, the remaining component is the front cover of the TV.

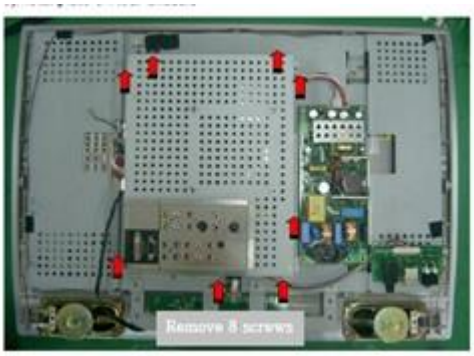
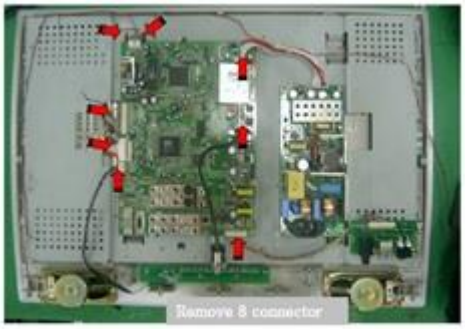
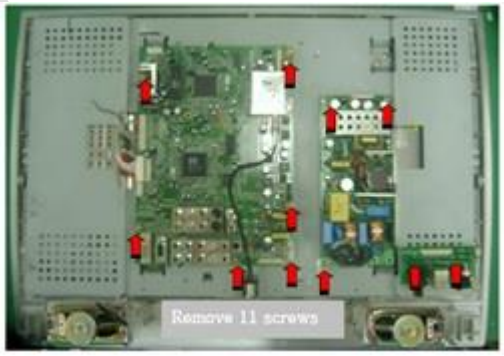
**Table 13 Example of disassembly steps for an LCD TV[51]**

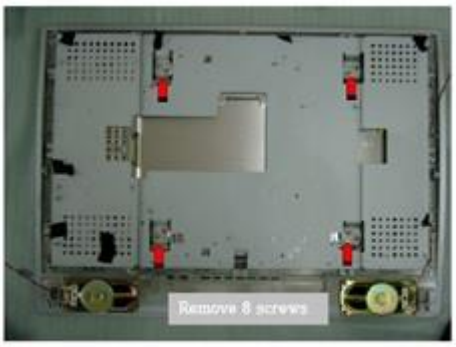
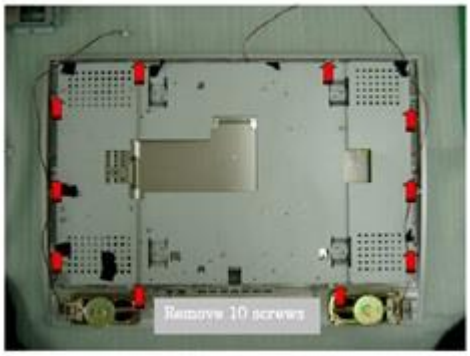
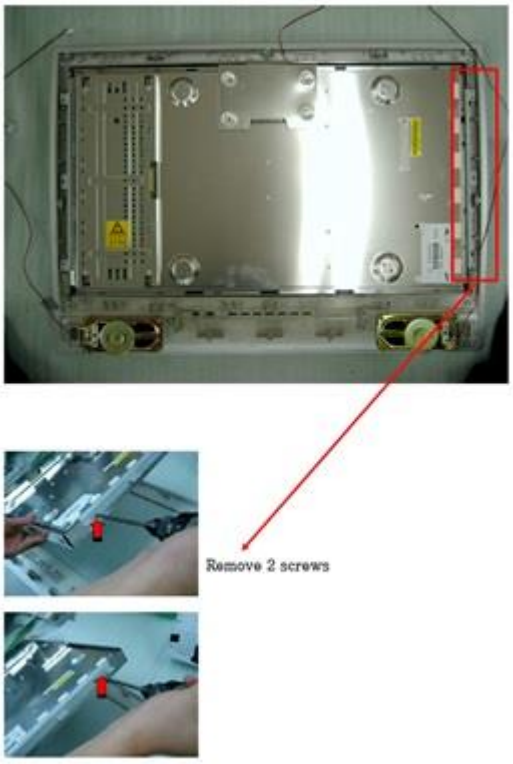
| | |
|---|---|
| Step 1: Removal of stand | Step 2: Removal of back cover |

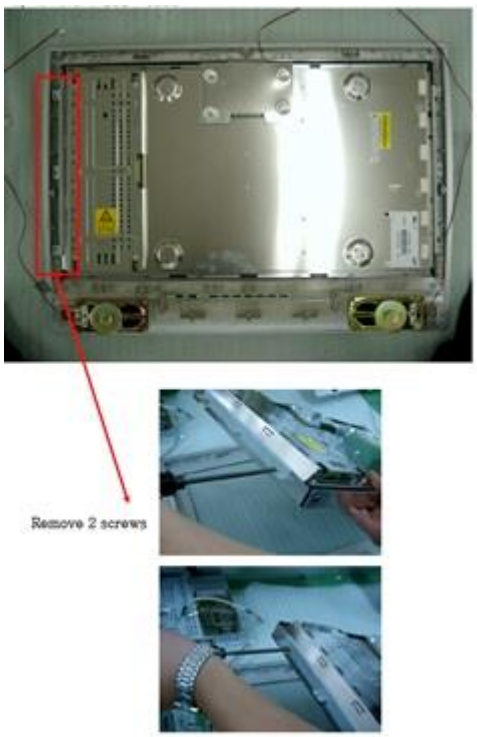
[49] http://www.wrap.org.uk/sites/files/wrap/TV%20case%20study%20AG.pdf (accessed 21/03/18)

[50] http://www.wrap.org.uk/sites/files/wrap/TV%20case%20study%20AG.pdf (accessed 21/03/18)

[51] http://cdn2.hubspot.net/hubfs/2506483/PDiarm_Oct2016/pdf/PD196I93R1.pdf (accesed 21/03/18)

| | |
|---|---|
|  |  |
| Step 3: Metal plate and rear chassis | Step 4: Remove bracket |
|  |  |
| Step 5: Disconnect 8 plugs on Main PCB | Step 6: Remove 11 screws from main PCB and SMPS PCB |
|  |  |
| Step 7.1: Remove LCD module – part 1 | Step 7.2: Remove LCD module – part 2 |

<table>
<tr><td> 
</td><td> 
</td></tr>
<tr><td>Step 7.3: Removal of LCD module – part 3</td><td>Step 7.4: Removal of LCD module – part 4</td></tr>
<tr><td>  </td><td> 
</td></tr>
<tr><td>Step 7.5: Removal of LCD module – part 5</td><td>Step 7.6: Removal of LCD module – part 6</td></tr>
</table>





### 2.1.5 Definition of priority parts

A preliminary list of priority parts, to be considered in the following steps of the assessment, has been defined based on the input gathered. These are:

- TV stand;
- Main board;
- Speakers;
- Remote control;
- T-con board;
- Sound board;
- Power PCB;
- LVDS cable.

Possibilities of ranking parts on the basis of economic, environmental and technical considerations will be explored.

### 2.1.6 Questions for stakeholders

| |
|---|
| 1) Do you agree with the analysis of typical failure modes? If not, please explain why and share any information regarding frequency of failure modes in TVs. |
| 2) Do you have further statistical information to share about frequency of failures or temporal distribution for LCD TVs and other types of key technologies identified (e.g. OLED TV)? |

| |
|---|
| 3) Which are the most relevant parts of a TV for repair, with respect to considerations about cost, environmental impacts and difficulty of disassembly and reassembly? Please provide supporting information. |
| 4) Which are the most relevant parts/features for upgrade, with respect to considerations about cost, environmental impacts and difficulty of disassembly and reassembly? Please provide supporting information. |
| 5) Do you consider the disassembly steps described in Table 13 as representative for the complete disassembly of the product? If not, could you please provide a description of steps that you consider more representative? |
| 6) Do you have information about typical repair/upgrade operations, their difficulty (e.g. steps and tools needed, time for disassembly), and the related costs? |
| 7) Which are the main barriers hindering repair and upgrade of TVs and which technical solutions could be applied to increase the chance of repair and upgrade TVs?<br>For example:<br>- Signage displays and TVs could be replaced because of LCD displays, while electronics are still working. Likelihood of repairing TVs could be increased if LCD displays were easily replaceable.<br>- The use of (standard) external power supplies could facilitate the replacement of the component in case of failure and increase the reparability of TVs.<br>- Modular design concepts for TVs. |
| 8) Compared to TVs, which are the main differences for other products of the same family (e.g. computer displays)? |

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## 2.2 Level 1: Development of a product-specific checklist of positive attributes

The first level of the assessment consists in the development of a product-specific checklist of positive attributes that can positively influence the reparability and upgradability of TVs. A preliminary list of these attributes is presented in this section. This has been developed starting from information available in the literature[52,53,54,55,56,57,58] and tailored to TVs on the basis of the elements gathered in the course of this study.

The list is composed of pass/fail requirements which the product needs to fulfil to be considered as reparable and/or upgradable. This can be considered as an entry level for the assessment but implies that it would not be possible to take into account partial variations of design: a product can be, or not, reparable and/or upgradable.

### 2.2.1 Attributes

#### 2.2.1.1 Identification of the problem

The manufacturer shall provide in the user manual a list of the most frequent failure modes of the TV together with a description of the cause, so that the problem can be easily identified.

Description of error codes, messages indicated on the screen and/or blinking light indicators shall be provided. The list can be provided either in printed or online form (and shall include at least the failure modes identified in Table 12)

#### 2.2.1.2 Availability of maintenance and repair information

The manufacturer shall provide in the user manual information about proper maintenance of the TV and its parts (e.g. remote control).

The manual shall include information on how to proceed in order to repair the TV (at least for the priority failure modes identified in section 2.1) and the contacts of the customer service centre.

#### 2.2.1.3 Safety precautions

The user manual shall indicate all the safety precautions to consider when performing the repair or upgrade of the product.

[52] https://www.ifixit.com/Info/Repairability#Section_Overview

[53] Flipsen et al., 2016. Developing a Reparability Indicator for Electronic Products

[54] www.repairability.org (accessed on 14 March 2018)

[55] COMMISSION DECISION (EU) 2016/1371 of 10 August 2016 establishing the ecological criteria for the award of the EU Ecolabel for personal, notebook and tablet computers (available at: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32016D1371&from=EN)

[56] IEEE 1680.1 Standard for Environmental Assessment of Personal Computer Products

[57] 1680.3-2012 - IEEE Standard for Environmental Assessment of Televisions

[58] 1680.1/Draft_23, March 7, 2017 Draft Std.for Enviromental Assessment of Personal Computers Products Including Notebook Personal Computers, Desktop Personal Computers, Slate/Tablets, Small Scale Servers, Signage Displays and Personal Computer Monitors

It shall be indicated if a specific working environment is necessary to perform the repair operation due to defined safety precautions. Specific working environment can be a professional workshop or manufacturing plant.

#### 2.2.1.4 Technical knowledge needed

The manufacturer shall indicate the level of technical knowledge required to handle the problems identified in attribute 1. To the extent possible, the manufacturer shall facilitate the repair or upgrade operations to be performed by the consumer.

Examples of levels to define the technical knowledge are given below.

1. Layman: An example of a layman is a consumer able to repair or upgrade their own products in a household environment with readily available tools.
2. Generalist: Independent professional services or non-profit repair initiatives where a generalist with knowledge of basic techniques and safety precautions is able to carry out repairs or upgrades in a workshop with specialised tools.
3. Professional: Independent or manufacturer authorised professional services centre where individuals have training and/or experience for the specific product with dedicated tools to do the repairs. An authorised professional is a professional who is recognized by the manufacturer and receives from the manufacturer any tools, information or other support required for the type of repair that he or she is entrusted with by the manufacturer, including tools, information or other support not available to the general public or independent repair professionals.
4. Manufacturer: Professional repairer as in level 3 with full access to all design documentation and maintenance files of products, working in the manufacturer's workshop. In some instances, certain repair operations may be restricted on grounds of safety, quality, performance or data security to a limited group of companies that have a closer relationship to the manufacturer and can be directly trained and audited.

#### 2.2.1.5 Availability of spare parts

Original or backwardly compatible spare parts shall be made available to replace priority parts.

Manufacturers shall ensure availability of spare parts in a fair time interval, and for a minimum period of time following the end of production of the model. The manufacturer shall provide information about how to obtain them.

#### 2.2.1.6 Identification of parts

Priority parts of relevance for repair/upgrade operations shall be easy to identify.

This shall be done by providing clear instructions in the service manual and/or by marking or labelling the parts.

#### 2.2.1.7 Accessibility of priority parts

All priority parts shall be accessible, meaning that no obstacles impede the direct access of the tool for the complete disassembly of the part (e.g. priority parts partially obstructed by other parts of the TV).

#### 2.2.1.8 Visibility of screws and other fasteners

Screws and other fasteners used to disassemble and re-assemble priority parts shall be clearly visible.

#### 2.2.1.9 Removability of fasteners and disassembly reversibility

The assembly of priority parts shall be done by using screws and/or multiple-use snap-fits which facilitate the re-assembly of the television after being repaired or upgraded.

#### 2.2.1.10 Types of tools needed

Only common tools shall be needed to disassemble priority parts. Table 14 includes a list of the common available tools.

**Table 14 List of common tools available and reference standards**

| Tool type | Reference |
|---|---|
| Hammer, steel head | ISO15601 |
| Combination pliers | ISO5746 |
| Half-round nose pliers | ISO5745 |
| Multigrip pliers (multiple slip joint pliers) | ISO8976 |
| Diagonal cutters | ISO5749 |
| Combination pliers for wire stripping & terminal crimping | - |
| Combination wrench | ISO7738 |
| Hexagon socket keys (Allen keys) | ISO2936 |
| Screwdriver for slotted heads | ISO2380 |
| Screwdrivers for cross-recessed (Phillips® and Pozidriv®) heads | ISO8764 |
| Screwdrivers for hexalobular recess (Torx®) heads | ISO10664 (driving feature) |
| Multimeter | - |
| Utility knife (cutter) with snap-off blades | - |

#### 2.2.1.11 Modular Design

The product shall have a modular design facilitating the change of priority parts. Information shall be provided about: modules, visual representation, method and steps for the module change.

An example could be the use of surface mounted technique to attach parts in the PCBs instead of attaching them with the through hole technique.

#### 2.2.1.12 Updatable features (smart TVs only)

The product shall allow users the possibility to update key features with no limitation of time.

The manufacturer shall provide updates to allow the use of the recent versions of apps and platforms provided with the TV, this includes as well software for pairing other devices (e.g. computers, smartphones, tablets).

The update of feature shall be achievable in the product without performing a product exchange, for example by using an external memory device (e.g., USB card or cable connection, SD card, or equivalent) or from a remote source using a network connection. The port, slot, or connector that is used for the firmware upgrade shall be accessible without tools.

Information on upgrading the product firmware shall be provided in the product owner's manual.

#### 2.2.1.13 Data deletion (smart TVs only)

Built-in secure data deletion functionality shall be made available to support the deletion of all data contained in data storage components (i.e. hard drives and solid state drives) in function of the risks faces and in order to grant the security of personal data and to facilitate the reuse of these parts.

### 2.2.2 Questions for stakeholders

| |
|---|
| 1) Do you agree with the list of attributes reported above? Do you consider any of them either not relevant, unfeasible to verify, and/or high expensive? Please indicate how you would modify the list and explain why. |
| 2) Which are the warranty issues associated to the repair of TVs that could be considered in the attribute list? |
| 3) How should spare parts availability be defined (for instance in terms of availability over time, and delivery time)? |
| 4) How the reported attributes could be assessed and verified? Please provide specific indications for individual attributes. |
| 5) Are any of the reported attributes implemented by manufactures? Please indicate which ones and provide some examples. |
| 6) Do you see any major barriers to the implementation of these attributes by industry? Please explain which ones and why. |
| 7) Compared to TVs, which are the main differences for other products of the same family (e.g. computer displays)? |

# 3 ANNEX

This section includes supporting information to the stakeholders regarding the levels 2 and 3 of the assessment which are not covered in this first consultation. The level 2 of the assessment refers to the scoring of attributes influencing reparability and upgradability, and the level 3 covers discussion on quantitative parameters.

## 3.1 Level 2: Semi-quantitative assessment

The attribute presented in chapter 2.2.1, which could also see the integration of quantitative parameters, can set the basis for the semi-quantitative assessment of the reparability and upgradability of TVs. This requires the definition of rating criteria to use for the evaluation of each attribute.

Number of rating criteria and scores are defined in this step. An option could be to define three levels of assessment for each attribute taking inspiration from the approach proposed by Flipsen et al. (2016)[59]: negative (0 points), neutral (0.5 points) and positive characteristics (1 point). The higher the score is the better the reparability/upgradability characteristics are.

Scores can be normalised to a different scale (e.g. 0-to-1, 0-to-5, or 0-to-10) to improve their understanding, and aggregated into overall or thematic indices (e.g. fitness for repair/upgrade, design for repair/upgrade, repair/upgrade services) depending on the scope of the analysis. Weights can also be assigned if some attributes are considered to be more important than others.

If the attributes considered in the assessment have the same weight, the overall score (S) for a specific product on the market or a specific design option can be calculated as average of each individual score as indicated in the following equation:

$$S = \frac{\sum_{i=1}^{n} s_i}{n}$$

Where: $s_i$ is the single score of each individual attribute and $n$ is the total number of attributes.Compared to the first level of the assessment, the characterization and rating of product-specific attributes can allow better differentiation between design options. On the other hand, the assessment becomes more subjective due to the inclusion of elements like evaluation criteria, weighting factors, rating scales.

## 3.2 Level 3: Quantitative assessment

Depending on data availability and cooperation from stakeholders, quantitative parameters could be used to assess the complexity of a product's design. This corresponds to the third level of the assessment, which can complement the previous

[59] Flipsen et al., 2016. Developing a Reparability Indicator for Electronic Products

ones for the assessment and identification of repairable and/or upgradable product options[60].

Several methods can be found in literature to measure the complexity of a product's design[61,62,63,64,65,66,67,68,69]. Disassemblability is a key concept to quantify the ability to disassemble priority parts from a product. From the review of different methods, the following parameters have been preliminarily selected for possible consideration as measure of the disassembly complexity:

1. Disassembly depth indices, either based on the number of steps needed to disassembly a part or on the number of parts to be removed and fasteners of the product[70]
2. Time for disassembly[71], which is an aggregated parameter to assess the overall disassemblability of products taking into account aspects as number of disassembly steps, easiness to access parts or difficulty of the operation itself[72].

[60] The quantification of more complex parameters will require additional effort in terms of data input and calculations, which could be difficult to gather and verify in practice.

[61] Fang HC, Ong SK, Nee AYC. Product Remanufacturability Assessment and Implementation Based on Design Features. Procedia CIRP 26; 2015. 571 – 576

[62] French Technical Centre for the Mechanical industry (CETIM), CAP'ECO methodology. Personal communicaiton

[63] Gershenson JK, Jagannath Prasad G, Allamneni S, Modular Product Design: A Life-cycle View. Journal of Integrated Design and Process Science 1999; 3(4)

[64] Giudice F, Kassem M. End-of-life impact reduction through analysis and redistribution of disassemblydepth: A case study in electronic device redesign. Computers & Industrial Engineering 2009;57:677–690

[65] IFIXIT, Ease of disassembly methodoloy. Personal communication

[66] Kobayashi M, Higashi M. Layout Optimization Method Considering Disassemblability for the Facilitation of Reuse and Recycle. Proceedings of the 10th World Congress on Structural and Multidisciplinary Optimization, May 19 -24, 2013, Orlando, Florida, USA

[67] Olson B, Riess M. Calculation of Recyclability on the Product Level – Challenges for a Smart Phone.Proceeedings of Electronics Goes Green 2012+, 9-12 September 2012, Berlin, Germany

[68] Soh SL, Ong SK, Nee AYC. Application of Design for Disassembly from Remanufacturing Perspective. Procedia CIRP 26 2015; 577 – 582

[69] Vanegas P, Peeters JR, Cattrysse D, Duflou JR, Tecchio P, Mathieux F, Ardente F. Study for a method to assess the ease of disassembly of electrical and electronic equipment - Method development and application in a flat panel display case study. JRC Technical Reports 2016

[70] Giudice F, Kassem M. End-of-life impact reduction through analysis and redistribution of disassemblydepth: A case study in electronic device redesign. Computers & Industrial Engineering 2009;57:677–690

[71] Vanegas P, Peeters JR, Cattrysse D, Duflou JR, Tecchio P, Mathieux F, Ardente F. Study for a method to assess the ease of disassembly of electrical and electronic equipment - Method development and application in a flat panel display case study. JRC Technical Reports 2016

[72] Disassembly time could be measured, but this would be subjective since the overall length depends, among other factors, on the operator skills. Standard time units representing the effort needed to perform an operation could thus be assigned to each task of the disassembly process

These parameters, ranging from simpler and more applicable to more sophisticated and difficult to apply, could be used to set quantitative requirements that TVs must fulfil to facilitate its disassembly and the extraction of key parts.

Additionally, benefits associated to repair/upgrade a product could be assessed through LCA-based indices quantifying environmental and/or economic impacts of repair/upgrade scenarios.

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| |
|---|
| 1) Are there any relevant studies, projects and initiatives about the reparability and upgradability of TVs that you would like to point out? |
| 2) Could you share relevant LCA studies assessing the reparability/upgradability of TVs? |
| 3) Which would be in your opinion the most appropriate rating criteria and weighting factors to evaluate the attributes in the semi-quantitative assessment of Level 2 (scoring system)? |
| 4) Which quantitative parameters and indices described in Level 3 could be worthy to consider for the assessment of TVs? Would you have available data to support us in the assessment? |
| 5) Do you have any other comments to make? |

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