EuP Preparatory Studies “Televisions” (Lot 5)

Final Report on Task 1 “Definition”

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Content

Introduction

This is the final report on Task 1 “definition” for the EuP Preparatory Studies on televisions (lot 5).

The findings presented in this report are results of the research conducted by the IZM consortium and the continuous feedback from a wide range of stakeholders. The statements and recommendations presented in the final report however are not to be perceived as the opinion of the European Commission.

We like to acknowledge the fruitful collaboration and trustful working relationship with various industry partners, non-industry stakeholders, and the European Commission throughout the study. We like to thank all stakeholders for their contributions and critical reviews of our reports.

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1. DEFINITION

1.1. Product Category and Performance Assessment

For the EuP Preparatory Study Lot 5 “Consumer Electronics” the European Commission sets the focus on the product category televisions (TV). The first task of the study is to define the scope of the product category TV based on a spectrum of existing definitions or categorizations deriving from:

- Product categories and classifications used for official European Union trade statistics (e.g. PRODCOM, EU-25 Trade Statistics)
- Product definitions according to standardization (e.g. IEC, EN, ISO)
- Product categories in conjunction with eco-labels and voluntary agreements (e.g. GEEA, Energy Star Program, Eco-label, Codes of Conduct)
- The primary product performance parameter (the “functional unit”), and if needed
- Secondary product performance parameter

The definition of product categories is serving in general different purposes such as marketing, market surveillance and statistics, standardization and labeling. Product categories therefore distinguish specific aspects of a product accordingly. They usually differentiate system related types of equipment, the intended function or functionalities of products, different technologies, or performance criteria. As a matter of fact product categories are changing frequently over time according to technology or market driven development. This situation will become quite clear when looking at existing definitions for TV and their segmentation. The majority of existing definitions is not taking current technology and product system developments into account. They basically reflect the analog TV and CRT only situation of the year 2000.

Our intention is to define the product category TV in light of the ongoing technical changes with a more long-term perspective. Secondly we intend to set the scope for the product category TV and sub-categories in reference to the primary task of this study:

- The assessment of products that have a “significant” environmental impact in EU-25
- The identification and analysis of eco-design improvement potential for TVs

In that respect, the definition of the product category TV and the specific product scope of the study should to be seen in direct conjunction to the market, technical trend, and consumer behavior analysis in the subsequent tasks 2 and 3.

Following the definition of scope we will have to determine relevant criteria or performance parameters describing the "playing field" for eco-design in the product category TV. This means, that we have to define the so called "functional unit" representing product performance parameters which have the strongest influence on the environmental impact of TVs and could be used as indicators for showing improvement. According to VHK methodology report the "functional unit" should be identified on the basis of functional performance characteristics (e.g. screen size to power consumption ratio) and not on the basis of technology.

1.1.1. Existing Definitions and Product Categories

1.1.1.1. General Product Distinction Criteria

The term television (TV) refers to a wide spectrum of products depending on the system boundaries we apply. The term has come to refer to all the aspects of television from the television devices (TV-set), television related equipment (e.g. TV/video combinations), up to the complete television broadcasting and receiving system including:

- An image source - this may be a camera for live pick-up of images or a flying spot scanner for transmission of films.
- A sound source.
- A transmitter, which modulates one or more television signals with both picture and sound information for transmission.
- A receiver (television) which recovers the picture and sound signals from the television broadcast.
- A display device, which turns the electrical signals into visible light and audible sound.

In a more narrow sense the term TV describes just the device for receiving a television broadcast and providing the joined picture and sound. Before we define the product scope for the lot 5 study we outline a set of auxiliary criteria in order to indicate distinctions of existing definitions and product categories. The distinction criteria are the following:

- Distinction of **product types** (e.g. TV-sets, products with TV related functions such as TV/VCR combination units, Set-Top-Boxes, etc.).
- Distinction of **functionality** (e.g. integrated receiver, display, speaker, video)
- Distinction of **technologies** (e.g. display technologies such as CRT, LCD, etc. and analog or digital signal receiving / processing technology, mains operated or battery powered).
- Distinction of **performance** (e.g. screen surface area, resolution, luminance, contrast, etc.)

In the following we will provide an overview on existing definitions and classifications in the context of television products. The existing definitions derive from EU statistics, standardization and eco-labeling schemes. Based on this analysis we will present a definition of the product category television which will set the scope for the lot 5 preparatory study.

1.1.1.2. EU Trade Statistics Classifications

At first we have to introduce the classifications for the product category “television” which is currently used in European Union trade statistics. Eurostat, the statistical office of the European Communities, and their external trade database PRODCOM classifies the product category “television receivers” (Code 32.30.20) into ten subgroups, see Table 1 below. The classifications reflect a differentiation of various types of television equipment e.g. TV receivers, video monitors, TV/video projectors, as well as different types of television components e.g. cable or satellite receiver decoder units, other tuner blocks. PRODCOM also differentiates display technologies like CRT, LCD and Plasma as well as performance related aspects e.g. colour TV or black & white TV. In conclusion we observe a wide spectrum of criteria, which build the base for the PRODCOM classification. A particular structure (e.g. which reflect typical market segments) is not obvious.

Table 1: PRODCOM classification applicable to televisions

32.30.20	**Television receivers**
32.30.20.20	Colour television projection equipment and video projectors
32.30.20.30	Colour televisions with a video recorder or player
32.30.20.45	Colour *video monitors* with cathode-ray tube
32.30.20.49	Flat panel *video monitor*, LCD or plasma, etc., without tuner (colour video monitors) (excluding with cathode-ray tube)
32.30.20.50	Colour television receivers with integral tube (excluding television projection equipment, apparatus with a video recorder or player, video monitors)
32.30.20.60	Flat panel colour TV receivers, lcd/plasma, etc. excluding television projection equipment, apparatus with video recorder/player, video monitors, television receivers with integral tube
32.30.20.75	Tuner blocks for CTV/VCR and cable TV *receiver units* (colour video tuners) (excluding those which isolate high-frequency television signals)
32.30.20.79	Satellite TV *Receiver/Decoder* (colour television receivers) (excluding with a screen, video tuners, video monitors, television projection equipment, with integral tube)
32.30.20.83	Black and white or other monochrome *video monitors*
32.30.20.85	Black and white or other monochrome television receivers (excluding video monitors)

Since 1995 in addition to PRODCOM Eurostat provides another EU-25 trade statistic, whose classification is based on the Combined Nomenclature (CN). Table 2 shows the nomenclatures corresponding to PRODCOM.

The EU-25 Trade Statistic shows a diverse classification. As in the case of the PRODCOM classification we observe various product types e.g. television receiver, video/television combos, as well as a differentiation of various display technologies and performance parameters.

Table 2: EU-25 Trade Statistic classification and corresponding CN-Codes applicable to televisions

CN-Code	Description of CN-Codes	Corresponding Prodcom description
8528.12.20	Apparatus incorporating a video recorder or reproducer (reported since 2000)	Colour televisions with a video recorder or player
8528.12.22	(reported until 1999)	
8528.12.28	(reported until 1999)	
8528.12.52	With integral tube, with a screen width/height ratio less than 1,5, with a diagonal measurement of the screen not exceeding 42 cm	Colour television receivers with integral tube
8528.12.54	Exceeding 42 cm but not exceeding 52 cm	
8528.12.56	Exceeding 52 cm but not exceeding 72 cm	
8528.12.58	Exceeding 72 cm	
8528.12.62	Other, with scanning parameters not exceeding 625 lines, with a diagonal measurement of the screen not exceeding 75 cm	
8528.12.66	Exceeding 75 cm	
8528.12.70	With scanning parameters exceeding 625 lines	
8528.12.72		
8528.12.76		
8528.12.81	Other: With screen, with a screen width/height ratio less than 1,5	Flat panel colour TV receivers, lcd/plasma etc.
8528.12.89	Other	
8528.13.00	Black and white or other monochrome television receivers	

It is interesting to notice that a differentiation of four screen sizes classes (screen width diagonal in cm) is made for CRT televisions, however not for flat panel display televisions. The segments for CRTs are:

- < 42 cm (< 17”)
- 42 – 52 cm (17” - 20”)
- 52 – 72 cm (21”- 28”)
- > 72 cm (> 28”)

In conclusion we find a more detailed differentiation of various product types and functions, technologies and performance criteria (screen sizes) in particular. Accordingly the number of classifications (categories) is high. Some inconsistencies are noticeable (e.g. no screen size segmentation for FPD televisions).

1.1.1.3. Classifications according to Standards IEC 62087 and EN 50301

IEC 62087 and EN 50301 define television receivers (TV) as “appliance for the reception of television broadcast and similar services for terrestrial, cable and satellite transmission of analogue and digital signals”[1]. This definition is interesting because it indicates that television is not a “single” appliance, which integrates all functions for receiving and displaying a television broadcast. That the function of reproducing the picture (display) and sound (speaker) is not included in this particular definition reflects the option of having more than one device for providing the function of television. This aspect might be of relevance it particular when taking further developments in digital, high definition (HD) broadcasting and recording into account. IEC 62087 also distinguishes video recording equipment, set-top boxes (STB), audio equipment, and multifunctional equipment (TV/VCR combo) separately as related products to television receivers. The IEC 62087 does not differentiate screen sizes nor display technologies.

1.1.1.4. Group for Energy Efficient Appliances (GEEA)

The Group for Energy Efficient Appliances (GEEA) defines television as “mains operated television receiver (TV) with a visible screen diagonal of more the 20 centimeters (equivalent to 7,87”) for the reception of analog as well as digital television broadcasts”[2]. GEEA furthermore differentiates Set-Top-Boxes (IRD, digital decoder), Set-Top-Boxes (digital to analog converter), Video Equipment (VCR/DVD Playback only), Video Recording Equipment (VCR/Combos, DVD-R/Combo) as television related products. The GEEA definition is specifying the television receiver by a minimum display size (screen size diagonal) and power source (mains), thus having the display function defined as an integral part of the television receiver. The exception of small, battery powered portable devices from the scope of this definition should be noticed.

1.1.1.5. European Eco-Label for TV (AEA Technology, 2002)

The 2002 AEA Technology report for the “development of EU eco-label criteria for televisions” defines a full set of functionality by formulating “the function of a television is to receive broadcast transmissions (from cable, terrestrial or satellite sources), process these received transmissions, and display the resulting image while reproducing the accompanying sound”[3]. AEAT indicates that several types of television exists which are defined by display technology, screen size and different source of power supply. They also point out that “television broadcasts can also be received and displayed through the use of a computer which has been fitted with the television tuner unit”.

[1] IEC 62087 (2002-03): International standard on methods of measurement for the power consumption of audio, video and related equipment, page 5. For detailed description of the standards Cp. task 1.2.

[2] GEEA-Label criteria for television, in the Internet: http://www.efficient-appliances.org/Criteria.htm/. For further details refer to section 1.3.2.3.

[3] J. Poll, P. Dolley, N. Varey (2002), AEA Technology Report (AEAT/ENV/R0937 Issue 1): Development of EU ecolabel criteria for televisions, January 2002, page 8.

Against the background of rapidly developing television technology, AEAT suggests a broader definition for television by formulating “mains powered electronic equipment which is designed to receive, decode and display TV transmission signals, whether analogue or digital, broadcast via satellite, cable or antenna signals”. AEA like GEEA specifies a distinction of (portable) battery powered devices by means of minimum screen size (diagonal) of 14 inch. Unlike the IEC 62087 definition the AEAT report seems to indicate a “single” device approach by stating “the proposed definition also excludes a computer with a television tuner card because a computer is not specifically designed to receive, decode and display television transmission signals”. This aspect of “specifically designed television” can also be found in the current U.S. Energy Star requirements.

1.1.1.6. European Eco-Label for TV (AEA Technology, Revision 2006)

The European Union eco-labeling scheme (Euro-Flower) on the basis of the “ecological criteria for the award of the Community eco-label to televisions” defines the product group televisions as “mains powered electronic equipment which is designed to receive, decode and display TV transmission signals, whether analogue or digital, broadcast via satellite, cable or antenna signals and has a screen size of ten inches (25 cm) or more”[4]. A distinction of different display technologies is not made. The definition of mains power equipment with a minimum screen size (10”) indicates exemptions of battery powered (portable) devices. This definition is focused on TV-sets. However, please notice that a Revision of the European Eco-label for Televisions is currently in process. In the discussion paper for revising criteria, which was provided to the 2nd AHWG in Brussels on 13 November 2006, three main distinction criteria for the product group televisions where outlined comprising: screen size, broadcasting route, and merging of TV and computer technology. The following recommendation was given for the revision of the product group definition: “The product group television shall comprise: mains powered electronic equipment, the primary purpose and function of which is a device that receives, decodes and displays TV transmission signals”.[5]

1.1.1.7. Energy Star Program

In the current Energy Star Program the U.S. Environmental Protection Agency (EPA) defines specification for television as “a commercially available electronic product consisting of a tuner/receiver and a monitor encased in a single housing. The monitor usually relies upon a

[4] COMMISSION DECISION of 25 March 2002 establishing the ecological criteria for the award of the Community eco-label to televisions (2002/255/EC).
[5] Revision of the European Eco-label for Televisions, Discussion paper to the second AHWG, Brussels, 13 November 2006.

cathode-ray tube (CRT), liquid crystal display (LCD), or other display device. The TV is designed to receive and display a television signal broadcast by antenna, satellite, or cable. To qualify, the TV must be capable of being powered from either a wall outlet or a battery unit that is sold with an AC adapter. For purposes of this agreement (Energy Star), this definition includes analog and digital televisions in addition to televisions that require additional power to receive and process signals that contain information and/or data for electronic programming guides. This definition does not include TV/Monitor combination units (products that operate as both a TV and monitor) consisting of a tuner/receiver and a monitor encased in a single housing with a computer input port"[6]. This definition by the U.S. Energy Star Program makes a clear distinction of "a (single) product" which includes in "a (single) housing" both receiver (input of the television broadcast video/sound signal) and the display (output of the television broadcast as moving picture with sound). In a sense this definition is more conventional, however in line with other definitions that draw distinctions of television functionality that could also be provided by specially equipped computers, and a specifically designed television sets, which integrates television broadcasts signal input, modulation and audio-visual audio output through a display. Related functions like video replay, video recording or special decoders (set-top-boxes) should not be considered as televisions but additional (television related) equipment. The U.S. Energy Star Program does not differentiate within the TV category certain display technologies or performance parameter like screen sizes.

1.1.1.8. Self-Commitment (EICTA)

The EICTA Industry Self-Commitment to improve the energy performance of household consumer electronic products sold in the European Union" first edition form July 2003 covers two television product categories; CRT based televisions and non-CRT based televisions (e.g. LCD, PDP and Rear-Projection)[7]. The agreement does not cover CRT based nor non-CRT based televisions incorporating new technologies, (such as IDTV) and "combo" televisions, (such as the combination of TV/VCR, TV/DVD and TV/Hard Disk). These may be added later. The agreement also excluded televisions powered by batteries. The EICTA makes a clear distinction of CRT and non-CRT display technology as well as additional television related functionalities. This indicates that certain display technologies and added functionalities are resulting in different power consumption – one important aspect in regards to eco-design.

[6] EPA Energy Star Program requirements set for TVs, VCRs, DCR TVs with POD Slots, Combination Units, Television Monitors, and Component Television Units. Eligibility Criteria (Version 2.2)
[7] EICTA promoted power consumption targets, on the internet: http://www.eicta.org. For detailed description of the Self Commitment Cp. task 1.2.

1.1.1.9. Code of Conduct on Energy Efficiency of Digital TV Service Systems

The Code of Conduct on Energy Efficiency of Digital TV Service Systems, an initiative of the European Union and industry, covers equipment for "the reception, decoding, recording and interactive processing of digital broadcasting and related services. Examples of such equipment are stand-alone integrated receiver decoders and other set-top boxes, digital TVs with built-in integrated receiver decoder, internet TV and simple converters to adapt analogue TVs and equipment with recording capabilities (PVR: personal video recording equipment). Furthermore, the Code of Conduct also covers analogue PVR equipment for household use that is capable of receiving analogue broadcasts and related services, and of recording on non-volatile memory and of playing the recorded signals"[8]. This Code of Conduct is specifying product categories in regards to new technological developments of digital television. It recognizes the technical aspects related to digital signal tuning, decoding, and other means of data processing (e.g. concerning high definition).

1.1.1.10. Japanese Top Runner Initiative

The Japanese Top Runner Initiative provides one of the most comprehensive categorizations for TV sets[9]. The scope of this government supported initiative includes TV sets (CRT, LCD, PDP) to be used by alternating current electricity (rated frequency 50Hz or 60Hz, rated voltage 100V). Excluded are TVs for industrial use, ones of specifications for tourists[10], ones for CRT multi-scan supports types with horizontal frequency exceeding 33.8kHz, rear projection types, ones of TV set size of below size 10 or size 10V[11], wireless types, and plasma TVs whose number of vertical pixels exceeds 1080[12]. Despite these exclusions the Top Runner Initiative distinguishes all together 66 categories (20 CRT television categories, 38 LCD television categories, and 8 PDP television categories) by differentiating display shape (flat, other than flat), screen sizes, vertical pixel counts, added functions (e.g. build-in DVD or HDD). This approach differentiates technical aspects in accordance to the display type. It is not consistent over all display categories.

Some limit factors are interesting to notice. Screen Size distinction for LCD TV is "under 5 Inch" and "15 Inch or higher" as well as "below a vertical pixel count of 650", "a vertical pixel count of

[8] Code of Conduct Version 4 (March 2006), on the internet: http://energyefficiency.jrc.cec.eu.int/pdf/worksdhop%20digital%20TV%20CoC%20march%202006/Code%20of%20Conduct%20Digital%20TV%20Service%20Systems%20-%20version%204%20-%201%E2%80%A6.pdf

[9] Energy Conservation Center Japan (ECCJ), In the internet: http://www.eccj.or.jp/top_runner/index.html

[10] We assume this means build-in televisions in Hotels. Confirmation is needed.

[11] See calculation in the ECCJ Final Report (Material 5-11) page 1, foodnote 1.

[12] Resolution for High Definition TV.

650 or higher and below 1080”, and “a vertical pixel count of 1080 and higher”. For PDP TV a screen size limit is set for “below 43 Inch” and “43 Inch or higher” (notice also the exclusion of plasma TVs whose number of vertical pixels exceeds 1080). The mixed differentiation by screen size (diagonal width) and resolution (vertical pixel count) should be observed. Furthermore, the distinction of devices with additive signal tuning functions (e.g. receiving analog broadcasting only, capable of receiving digital broadcasting) is despite the usual video player/recorder functions (e.g. integrated VCR, DVD, HDD) interesting to notice.

1.1.2. Definition of Scope Lot 5 “Television”

The analysis of existing definitions has shown a heterogeneous picture. It is evident, that the definitions under consideration serve different purposes, and differ from each other to some extent. We notice inconsistencies in a sense that definitions of functions and products scope were mixed. It is also evident that some of the older definitions do not reflect ongoing technical developments such as the introduction of new display technologies, digital television broadcasting, merger or modular approach to devices which are capable of receiving, decoding and displaying TV transmissions. However, there are useful descriptions and parts of more current definitions available that serves the purpose of the assigned study. They will be incorporated.

Our approach of defining the scope of lot 5 televisions is based on a correlation of main functions and equipment types. We consider the following main functions:

- **Receiver** which enables tuning / amplifying of a TV signal broadcast. The television signal can be provided via antenna (terrestrial), satellite, cable, or other broadband communication access.
- **Monitor** which enables recovering and displaying the picture of a TV broadcast or video signal on a predefined screen size and resolution.
- **Speaker** which enables reproduction of an accompanying audio signal.[13]
- **Video** which provides video signal recording, storage (on various media such as videocassette, standard or high definition DVD, hard disk dive, memory chips, etc.), and replay.

Regarding typical components and devices (equipment) related to these TV functions we make following distinction:

[13] Following stakeholder comments (Mr. Siderius, SenterNovem) to our first task report form 15 September 2006, we have included speakers as a main function into the list.

- **TV Sets**, consisting of a receiver, monitor and speakers in a single casing, whereas video is optional.
- **TV Component Unit**, consisting of a receiver, speakers and a monitor in separate casing, video is optional and could be integrated.
- **TV/Video Combination Unit**, consisting of a receiver, monitor, speakers and video function in a single casing.
- **TV Peripherals**, receiver (STB) or video (VCR/DVD) as stand alone devices
- **TV Capable,** receiver component as PC or Laptop accessory (e.g. TV tuner card), receiver integrated in mobiles (e.g. TV capable Mobile Phone), as well as Beamer/Video Projectors that are not specifically designed TVs but capable of displaying a TV/video signal form an STB or PC.

Table 3: Tillustrates the above considerations and provides an overview of functions and typical equipment types related to the viewing of a television broadcast. A further analysis of the interaction of these functions and related equipment with the TV broadcasting system, audio/video equipment as well as the PC and the internet will follow in task 2.3 (technical trend analysis).

Table 3: TV functions and typical equipment types

Function	Typical TV Equipment Types				
	TV Set	TV/Video Combo	TV Component Unit	TV Peripherals	TV Capable
Receiver				Set-Top-Box stand-alone	PC accessory Mobile
Monitor				PC-Monitor Video Beamer	PC Media Laptop Mobile
Speaker				Audio-System stand-alone	
Video				VCR/DVD stand-alone	

We propose the following definitions for setting the scope of products to be investigated by the EuP Preparatory Study lot 5. The definitions reflect mostly product descriptions of the US Energy Star Program:

Television (TV-Set)

A commercially available product that is specifically designed to receive and decode a television transmission (broadcast from cable, terrestrial or satellite), whether analogue or digital (integrated tuner), and displays the resulting image on an integrated screen while reproducing the accompanying sound (main function). The tuner/receiver and monitor are encased in a single housing. The product should be mains powered.

TV/Video Combination Unit

A commercially available product in which the TV and a Video Recording/Storage/Replay System (e.g. videocassette, standard or high definition DVD, hard disk dive, memory chips, or combinations of them) are combined into a single housing. The product should be mains powered.

TV Component Unit

A commercially available system, which is market and sold as a TV, consisting of a receiver and monitor in separate casing. Video is a further optional unit or could be integrated in one of the other units. The system should be mains powered and may have more than one power cord.

TV Peripherals

A commercially available stand alone device such as a Set-Top-Box (STB), Videocassette Recorder/Player, and DVD Recorder/Player, which is mains powered.

TV Capable

A commercially available TV receiver component as PC or Laptop accessory (e.g. TV tuner card), receiver integrated in mobiles (e.g. TV capable Mobile Phone), as well as Beamer/Video Projectors that are not specifically designed TVs but capable of displaying a TV/video signal form an STB or PC.

On the next level we narrow the scope for the purpose of the EuP Preparatory Study Lot 5.
TV-sets are by far the economically most significant product category with more than 31 Million units sold in the European Union and a monetary value of more than 18 Billion Euro in the year 2005[14] - being the reason why we will primarily focus on television-sets in the scope of lot 5.

[14] CE-Market 2005, data by GfK Marketing Services Deutschland GmbH. For detailed market and trend analysis cp. task 2.

Besides TV-sets, TV/Video Combination Units and also TV Component Units are the most common equipment category for viewing television programs in the European Union. With TV Component Units we recognize modular approaches to television. In terms of standby requirements, for example, the current US Energy Star Program states that such Component Television Units are qualified if they meet (as a system) the same criteria as a stand alone TV. This indicates comparability to regular televisions sets and thus being the reason to put them into the scope of the EuP preparatory study Lot 5 as well. However, such modular approach is usually driven by the technical necessity to separate a new functionality (e.g. due to space, power, thermal requirements) or the option to increase the functionality (e.g. the integration of HDD or other video recording technology in a set-top-box). Therefore, in modular product concepts (e.g. STB) the amount of components and materials (e.g. chip sets, housing), system integration requirements (e.g. electronics packaging, thermal management), as well as functionality might not be comparable to a stand alone TV-set. TV peripherals like stand-alone Set-Top-Boxes, audio and video systems or other than TV monitors (e.g. PC monitors or beamers) will not be in the scope of further proceedings of the study as their (stand-alone) functionalities are not “television” and thus they are not comparable to a stand alone TV-set. The same is for devices that are TV capable – we notice a clear overlap with other product groups such as personal computers, mobiles, and related information and telecommunication equipment but as their main function is not television, those devices are meant to be separately analyzed (e.g. see EuP preparatory study Lot 3 on PCs).
Recapitulating, Table 4 is illustrating the scope of EuP Preparatory Study Lot 5.

Table 4: Scope of lot 5 TV

Function	In Scope of Lot 5			Not in Scope of Lot 5	
	TV Set	TV/Video Combo	TV Component Unit	TV Peripherals	TV Capable
Receiver				Set-Top-Box stand-alone	PC accessory Mobile
Monitor				PC-Monitor Video Beamer	PC Media Laptop Mobile
Speaker				Audio-System stand-alone	
Video				VCR/DVD stand-alone	

The next step, after defining the scope of the EuP Preparatory Study Lot 5, is to define technical parameters that describe the "playing field for eco-design" for television-sets. These parameters will not only set the boundaries for investigation of eco-design measures they will also support the structuring of product cases for the required assessments in task 4 and the definition of base cases in task 5.

1.1.3. Functional and Performance Parameters and their "eco"-relevance

In order to determine environmental improvement potentials for televisions it is first necessary to identify issues of environmental relevance (eco-impacts) and their influencing factors (technologies and design). Although this kind of assessment is the main objective of tasks 4 to 7, at this point of the study we have to determine which functional performance parameters and use aspect are of potential environmental significance. Furthermore, we have to answer the question which functional performance parameters are appropriate "standards of comparison" and can serve as benchmark criteria for environmental improvements over a longer period of time.

In anticipation of the market and trend analysis (cp. task 2.2 and 2.3) we can say that the television market is currently in the middle of a tremendous shift. This shift is mainly driven by an introduction of new flat panel display technologies with the capability of providing larger screen sizes in parallel with the change towards digital broadcasting and high definition pictures. The ongoing development is technology-driven and interrelated. The new technologies and related design concepts (convergence and modular approaches) are not mature yet. They are in a process of constant development.

1.1.3.1. Power consumption and energy efficiency of TV displays

The primary functionality a television provides for a user is to receive and reproduce picture and sound of a TV-broadcast or video signal (content) in a certain quality (e.g. standard resolution and color) over a period of time (e.g. 60.000 hours display lifetime). As regards this main function, an important technical feature is the display. The TV-display is of great economical importance in the television business. In talks with industry representatives and market experts it was made clear that the television display accounts to at least 60 percent of added value in television-set making. On a technical level we can differentiate various display technologies such as Cathode Ray Tube (CRT), Liquid Crystal Display (LCD), Plasma Display Panel (PDP), different Rear Projection (RP) and other emerging technologies such as Surface-conduction Electron-emitter Display (SED). Concerning particular performance parameters of the display and their influence on power consumption we have to distinguish:

- Viewable screen surface area (screen size [in inch or cm] and the format [normal 4:3, wide screen 16:9),
- Resolution (pixel per inch/cm, or based on fix standard of vertical lines),
- Response time or reaction speed (in ms), quality issue related to picture ghosting, fast response is imperative for good picture quality.
- Luminance (in cd/cm²) or luminance efficiency, i.e. the local variations in luminance over the screen surface with respect to the peak luminance,
- Contrast ratio (the trend is towards a higher ration such as 10000:1)
- Color reproduction and gradation form primary colors to more subtle hues
- Viewing angle, performance feature related to side viewing of the display

Additional technical parameters are:

- Analogue or digital signal processing, digitalization allows more integrated functions, picture adjustments, and coding/decoding of video signals (e.g. copy protection)
- Integrated receiver and decoder (IRD), specific for various routes of TV broadcasting

Trends regarding these parameters are outlined in chapter 2.3 of this report.

According to industry sources picture size and quality are the primary sales features despite the price (cp. task 3, buying decision), which in turn indicates the primary user benefit of a television-set. Technology is mostly a secondary sales aspect except regarding the form and weight feature (e.g. Flat Panel versus Cubic) and particular quality issues such as maximum luminance, highest color reproduction and response time. If the screen size is becoming such important sales issues we have to consider the environmental implications of apparently larger screen surface areas and related picture quality issues.

Testing power consumption of more than 300 television-sets in the USA Alan Meier and Karen Rosen of Lawrence Berkeley National Laboratory concluded in an older study (1999) that televisions active power draw is closely related to screen size (larger screen equals higher power consumption)[15]. A simple catalogue investigation of 160 TVs is confirming this general trend and shows the extent of power consumption of large-size screens. The power consumption of medium size TVs up to 84 cm (33 inch) lies in a range between 100 and 200 Watts. Large-size TVs feature an increasingly wider spectrum of power consumption with maximum values ranging from 200 to 400 Watts for 107 cm (42 Inch) display size. According to catalogue figures very large TVs of 165

[15] Karen B. Rosen, Alan K. Meier (1999), Energy Use of Televisions and Videocassette Recorders in the U.S., Environmental Energy Technologies at Lawrence Berkeley National Laboratories, in the internet: http://eetd.lbl.gov/ea/reports/42393/

cm (65 Inch) have power consumption in on-mode of 550 to 700 Watts. This is a considerable amount of power consumption for a single TV. The following Figure 1 provides a first impression of current TV on-mode power consumption. The figures were taken form product catalogues of 272 mostly HD Ready TVs of the year 2006. Screen sizes are differentiated as well as display technologies. The presented figures are clearly indicating that power consumption increases in correlation to the display surface area (screen size). Noticeable are the differences in power consumption regarding different display technologies. It is also evident that within the same screen size segment we have a wide range of power consumption even for the same display technology.

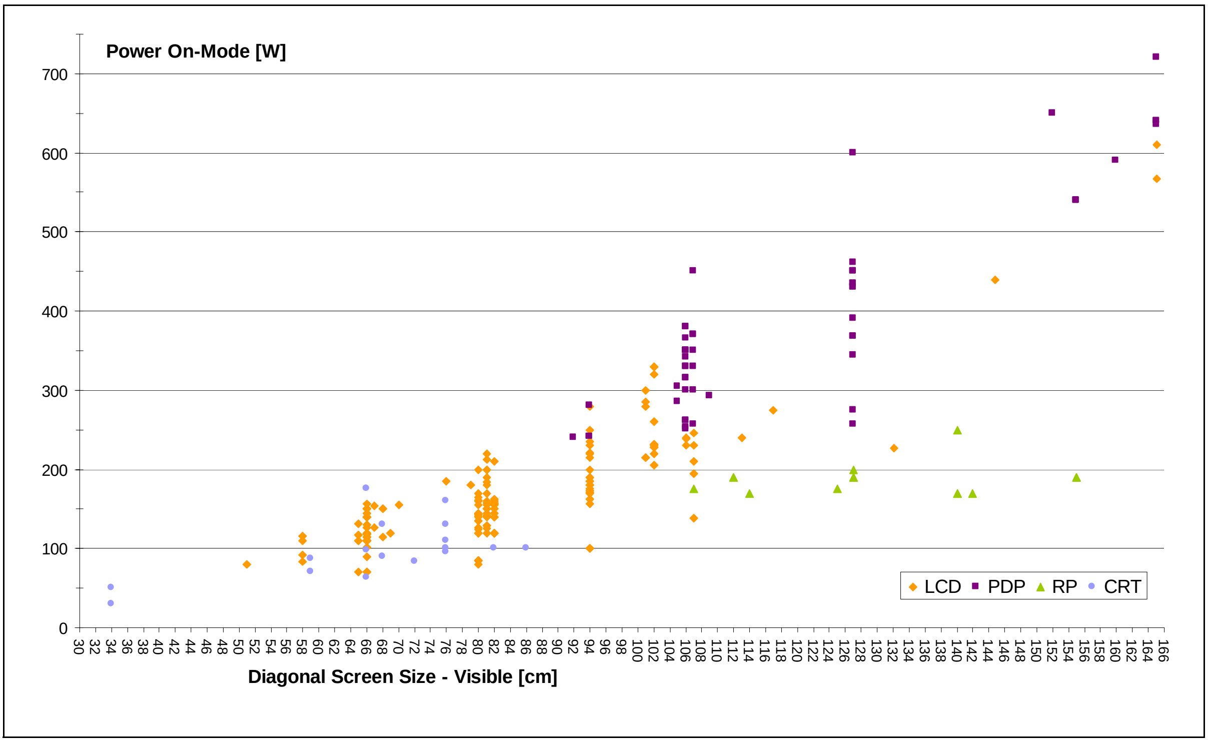


Figure 1: TV power consumption by screen size (Source: product catalogues 2006)

At this point we can consider the correlation of increasing screen size and power consumption as a significant environmental aspect, which should be further investigated throughout the study. However, we should also be aware that the data presented at this point are randomly chosen from product catalogues. As we will indicate in the proceeding of the study there are a couple of aspects related to the interpretation of power consumption:

- Test standards for measurement of power consumption reflecting specifics (differences in maximum and average power consumption) of different technologies (cp. task 1.2).
- Picture quality criteria regarding resolution (e.g. standard or high definition), maximum luminance, response time, etc.
- Very small and very large screen size segments (e.g. products that are not intended for average household usage)

- Lifetime of products (e.g. we understood that the lamps in rear projection TVs have a considerably shorter life time than other display technologies)

The reduction of power consumption in on-mode is a key eco-design objective for TVs. Further power consumption issues are standby and power consumption and off-mode losses. Following modes are distinguished[16]:

- Off-mode, appliances is connected to a power source, provides neither sound nor vision, can not be switched into another mode with the remote control, an external or internal signal.
- Passive standby, appliances is connected to a power source, provides neither sound nor vision, but can be switched into another mode with the remote control or an internal signal.
- Active standby low, and can additionally be switched into another with an external signal.
- Active standby high, and is exchanging/receiving data with /from an external source.

The reduction of standby power consumption, particular in active standby modes, is considered an eco-design objective for TVs.

1.1.3.2. Material and Resource Efficiency

Although very important, power consumption related to various operation modes and screen sizes is not the only eco-design aspect (performance parameters) which should be addressed in the study. Material properties and overall resource efficiency are similar important aspects due to the intrinsic trend towards:

- Sophisticated and large-size display technologies (electronic components manufacturing under clean room conditions, multiple chemical and thermal processes in panel manufacturing, potentially hazardous materials, etc.)
- Integrated digital functionality (increasing amount and complexity of chip sets and electronic boards for data processing, high content of precious metals in electronics, etc.)
- Potentially shorter product lifetime (triggered not by shorter technical lifetime e.g. of the display but by the fast development in peripheral technologies such as new video formats [HD/Blu-ray DVD] and data storage, signal coding/decoding standards [copy protection], etc.)

[16] The given mode descriptions are based on IEC 62087.

As a result of this development we have to assume that the complexity of the televisions electronic hardware and system integration will increase. This in turn might also influence the environmental impact of new products due to changes in material composition and the amount of advanced electronic components as well as packages in the products. Keeping in mind the efficiency trade-off from highly integrated microelectronics on the one hand and the "over-compensation" of the trade-offs through realization of more functionality on the other hand it is very difficult to define a general benchmark. We will have to investigate these issues over the period of the study in more detail.

1.1.3.3. Further technical parameters and environmental issues

In closing the following Table 5 provides a further technical aspects and trends in television development and their potential environmental effects.

Table 5: Technical Parameter and Environmental Issues

Situation (technical parameter)	Effects (environmental issues)
Single device concept by integrating digital tuners and decoder unit	High requirements on micro system integration and thermal management, potentially parallel integration, single power supply requires efficient power management for functions
Modular device concept by separation of receiver and display unit	Multiple housing, connectivity or interface issue, if needed two power supplies, potentially increase of overall power consumption/ power management issues
Larger screen sizes (>40") require higher resolution (HD)	Need of advanced electronics, finer display structures, material and manufacturing quality, high yield in production (costs)
High definition signal input and replay	Need of more data processing capability for decoding, data compression, digital picture functionality, recording etc., this requires advanced electronics and is related to power draw
Digital program downloads and other broadcast/network interaction	The growing problem of active standby does potentially contribute to total power consumption. It is an issue of standardization and should be also addressed to TV broadcaster

1.2. Test Standards

The investigation in task 1.2 has to identify and describe technical standards (existing EU and international standards and those under development) that are particularly related to environmental performance of televisions. This includes test standards for the measurement of:

- Power consumption (active or on mode, as well as active and passive standby modes)
- Safety and health (radiation, fire security)

A “test standard” is a standard that sets out a test method, but that does not indicate what result is required when performing that test. Therefore, strictly speaking, a test standard is different from a “technical standard”. Namely, in technical use, a standard is a concrete example of an item or a specification against which all others may be measured or tested. Often it indicates the required performance. However, “test standards” are also (but not exclusively) defined in the “technical standard” itself. A standard has a particular scope mostly product or sector specific.

Standards are documents that have been established by consensus and approved by a recognized standardization body. They provide common and repeated use, rules, guidelines or characteristics for certain activities. In the following references are made to:

- **EN**, European standard ratified by ether CEN (European Committee for Standardization), CENELEC (European Committee for Electrotechnical Standardization), or ETSI (European Telecommunications Standards Institute),
- **IEC**, International Electrotechnical Commission,
- **ISO**, International Organization for Standardization,
- **ITU**, The International Telecommunication Union,
- **UL,** Underwriters Laboratories,

In addition to “official” standards, there are other sector specific procedures for product testing that might have been compiled by industry associations or other stakeholders for specific purposes. These are usually labeling activities or voluntary agreements which are need of using same parameters or procedures. However, in most cases such activities refer to existing standards in order to ease implementation.

1.2.1. Measurement of Power Consumption

Test standards to measure the on-mode (active mode) power consumption and standby power draw in the context of product category televisions have been investigated. The current situation is determined by an ongoing revision regarding test methods and procedures for measuring on (average) power consumption of TVs.

Current static test procedures for the measurement of power consumption (three bar video test signals defined in CEI/IEC 60107-1:1997) are not reflecting the dynamic adjustment that occurs in on-mode power consumption of self-emissive displays such as CRT, PDP or SED when the luminescence level changes according to the black or white level (Average Picture Level – APL) of a dynamic video signal. IEC/TC 100 is working on a revised method of measuring average on-mode power consumption based on:

- static: test with four bar video signal (based on JEITA)
- dynamic: test with broadcast-content video signal (based on a APL histogram / Weber)

Draft test standard expected by March 2007 and voting on test standard by July 2007.

1.2.1.1. IEC 62087

Organization: IEC (International Electrotechnical Commissions)

Status/Year: International Standard issued 2003

Title/Scope: Methods of measurement for the power consumption of audio, video and related equipment (including television receivers).

Measurement of active mode:

Static video test signal:

- Three vertical bars of white over black background

Measurement of standby mode:

- Standby active (high, low)
- Standby passive

Issues: IEC 62087 replaced IEC 60107 and features their 3-bar black & white test pattern, which is generally preferred by industry. Definitions and set up conditions however are the same as in EN 50301. IEC 62087 is commonly used also as measurement method in eco-label schemes.

Revision: IEC TC100/1081/NP (IEC PT 62487) is revising the standard in order to specify on (average) power consumption measurement. There are two options for input video test signal: Input test signal might follow the four-bar static test video signals currently issued by JEITA, or a dynamic test video signal reflecting the average picture level (APL). The current discussion is focused on the specification of picture level adjustment (see task 8). The new standard is expected to be published in early 2008.

1.2.1.2. EN 50301

Organization: CENELEC (European Committee for Electrotechnical Standardization)

Status/Year: European Standard issued 2001 (1999)

Title/Scope: Methods of measurement for the power consumption of audio, video and related equipment (including television receivers)

Measurement of active mode:

Color bar according to ITU-R BT.471-1

Measurement of standby mode:

No information

Issues: EN 50301 provides definitions and test set-up conditions for TVs. Some manufacturers do not approve EN 50301 test set-up conditions (e.g. low test luminance).

Revision: CLC/TC 206 is revising the EN 50301 in order to adapt the standard to other display technologies rather than CRT televisions only. The revised standard is expected for 2007.

1.2.1.3. JEITA Test Standard (Top Runner Standard)

Organization: JEITA (Japan Electronics and Information Technology Industries Association)

Status/Year: Japanese Standard issued for Top Runner Initiative (rev. 1998)

Title/Scope: Method of Measuring Annual Energy Consumption of Televisions (LCD, PDP)

Measurement of active mode:

Static video test signal for measurement of operating power (Po):

- Pw: White level video signal (APL 100%)
- Pb: Black level video signal (APL 0%)
- Pc: Color bar video signal (75/0/75/0)
- Pt: Three vertical bars of white over black background (JIS C6101-1, 3.2.1)

For CRT: Po = (Pw + Pb) / 2

Tor LCD/PDP: Po = [(Pw + Pb) / 2 + Pc + Pt)] / 3

Measurement of standby mode:

- Ps: Standby power (Watt)
- Ps1: power is turned off by main power switch
- Ps2: power is turned off by remote control (main power remains on)

Ps = (Ps1 + Ps2) / 2

Measurement of Energy Efficiency:

- E: Annual energy consumption (kWh/year)
- Po: Operational power (Watt)
- Ps: Standby power (Watt)
- Pa: Reduced power consumption by energy saving function (Watt)
- T1: Annual standard operating time (hours) 1642.5 (365 days x 4.5 hours)
- T2: Annual standard standby time (hours) 7117.5 (365 days x 19.5 hours)

E = [(Po * Pa/4) x T1 + Ps x T2] / 1000

Issues: The JEITA test standard is used for Japanese government supported “Top Runner Initiative”. The specifications of the video test signal are drawn from JIS C 6101-1, Japanese Standards Association “Measuring Methods of Receivers for Television Broadcast Transmissions”.

Revision: no information

1.2.1.4. DOE Test Procedure, 10 CFR, Part 430, Subpart B, Appendix A-VIII

Organization: DOE (Department of Energy)

Status/Year: U.S. standard issued 2003

Title/Scope: Method of measuring annual energy consumption of Televisions

Measurement of active mode:

- Pa: active power draw
- Pw: Standard white pattern
- Pb: standard black pattern

Pa = (Pb + Pw) / 2

Measurement of standby mode:

- Ps1: power is turned off with a master or “vacation” switch
- Ps2: power is turned off with remote control

Measurement of Energy Efficiency:

- AEC: Annual energy consumption (in kWh)
- Pa: active power draw (Watt)

- Ps: standby power draw (Watt)

AEC = 2.2Pa + 6.5 Ps

Issues: The DOE test procedure references the American National Standard C.16.13-1961 "Method of Testing Monochrome Television Broadcast Receivers". This test procedure is issued in conjunction with DOE priority-setting activities regarding energy efficiency of appliances in 2002/03. Industry is not using the test procedure due to the fact that the method (evaluation of monochrome device) is outdated. As an interesting aspect it is worth mentioning that this standard assumes an 6 hours per day on-mode period[17].

Revision: *no information*

Despite these particular test standards on measurement of power consumption for televisions a further standard on measurement of standby power with the wider scope of household electrical appliances is the EN/IEC 62301.

1.2.1.5. EN/IEC 62301

The standard specifies methods of measurement of electrical power consumption in standby mode. It specifies the general conditions for measurements (test room, power supply, supply-voltage waveform and power measurement accuracy) as well as selection and preparation of appliance/equipment for measurement, and test procedure. The scope is product specific. The standard is applicable to mains powered electrical household appliances (this includes TV). The objective of the standards is to provide a method of test to determine the power consumption of a range of appliances and equipment in standby mode. The standard defines "standby" mode as the lowest power consumption when connected to the mains. The standard is dedicated to the measurement of energy consumption for the use phase of the equipment.

1.2.2. Electromagnetic Emissions and Fire Safety

Electromagnetic emission and fire safety requirements have an influence on the design of a device and choice of materials in particular. Televisions using emissive display technologies like CRT, PDP or FED create low levels of ionizing (x-ray) radiation and non-ionizing (electromagnetic)

[17] Comment added by Mr. Siderius of SenterNovem.

radiation. Furthermore, there are fire safety requirements for boards and housing of televisions[18]. The overall safety of televisions in the European market is regulated by the Low Voltage Directive (LVD) 73/23/EEC as well as particular standards on safety by the EN 60065.

1.2.2.1. EN 60065

This EN/IEC standard is on audio, video and similar electronics apparatus safety requirements. EN 60065 applies to electronic apparatus designed to be fed from the mains, from a supply apparatus, from batteries or from remote power feeding and intended for reception, generation, recording or reproduction respectively of audio, video and associated signals (this includes TVs). The standard is dedicated to the measurement of parameters for the use phase of the equipment: input; electric strength; earth continuity; touch current; humidity; heating; flammability; stability; stress relief; drop; steady force; steel ball; abnormal; over-voltage; accessibility; durability. The levels set by the EN 60065 for flammability are in line with the UL94 a plastics flammability standard released by Underwriters Laboratories of the USA. The UL94 standard divides plastics according to how they burn in various orientations and thicknesses:

- HB: slow burning on a horizontal specimen; burning rate < 76 mm/min for thickness < 3 mm.
- V0: burning stops within 10 seconds on a vertical specimen; no drips allowed.
- V1: burning stops within 30 seconds on a vertical specimen; no drips allowed.
- V2 burning stops within 30 seconds on a vertical specimen; drips of flaming particles are allowed.
- 5V: burning stops within 60 seconds after five 5 second applications of a flame (larger than used in V-testing) to a test bar.
- 5VB: plaque specimens may develop a hole
- 5VA: plaque specimens may not develop a hole
- 5VA is the strictest UL rating, HB the weakest.

The levels set by the EN 60065 for ionizing and non-ionizing radiation are higher that current televisions achieve. The Council Recommendation (1999/519/EC) of 12 July 1999 on the limitation of exposure of general public to electromagnetic fields (0Hz to 300 GHz) has to be mentioned in this respect. This Recommendation intends to improve the protection of health and safety workers and the general public regarding harmful effects from non-ionizing radiation. European manufacturers of electrical and electronic equipment have agreed to comply voluntarily

[18] The use of certain poly-brominated flame retardants in plastics and printed circuit boards are restricted the European Directive 2002/95/EC (RoHS).

with the EMF exposure limits set in the Recommendation 1999/519/EC for all apparatus while in normal condition. Televisions meet current safety requirements, but they can not some of the requirements set by this Recommendation[19].

1.2.2.2. Emission Standards

EN 55013:2001 Sound and Television Broadcast Receivers and associated equipment – Radio disturbance characteristics – Limits and methods for measurement
ECMA-328 (2nd Edition / June 2006): Determination of Chemical Emission Rates from Electronic Equipment.

[19] AEA Technology: Development of EU Ecolabel criteria for televisions, AEAT/ENV/R/0937, January 2002, page 16-17.

1.3. Existing Legislation and Voluntary Agreements

The general objective if this sub-task is to identify and describe mandatory regulations (legislation) as well as voluntary agreements which sets environmentally related obligations to manufacturers of product categories identified in task 1.1.

1.3.1. Existing Mandatory European Legislation

1.3.1.1. Directive 2002/96/EC (WEEE) and Directive 2002/95/EC (RoHS)

The European Community Directive 2002/96/EC on Waste Electrical and Electronic Equipment (WEEE)[20] together with the Directive 2002/95/EC on Restriction of the use of certain Hazardous Substances in electrical and electronic equipment (RoHS)[21] became European Law in February 2003, setting collection, recycling and recovery targets for all types of electrical goods. The directives aim on reducing the environmental impact of electrical and electronic equipment also through design measures which support disassembly and reuse.

The **WEEE** applies to televisions under category 4 of Annex IA, Consumer Equipment, stating that the rate of recovery shall be increased to a minimum of 75% by an average weight per appliances; component, material and substance reuse and recycling shall be increased to a minimum of 65 % by an average weight per appliance. Annex II of WEEE declares selective treatment for materials and components of waste electrical and electronic equipment in accordance with Article 6(1). With regards to television following requirements of annex II are relevant:

- Mercury containing components, such as switches or backlighting lamps,
- Plastic containing brominated flame retardants,
- Cathode Ray Tubes,
- Liquid Crystal Displays (together with their casing where appropriate) of a surface greater than 100 square centimeters and all those back-lighted with gas discharge lamps,

Within the procedure referred to in Article 14(2), the Commission shall evaluate as a matter of priority whether the entries regarding LCD are to be amended.

The **RoHS** applies to televisions as well and prohibits the use of the heavy metals lead, mercury, cadmium, hexavalent chromium, and brominated flame retardants (poly-brominated diphenyl

[20] Official Journal L 37, 13/02/2003, 24-39.
[21] Official Journal L 37, 13/02/2003, p.19-23.

ethers and poly-brominated biphenyls) in new electrical and electronic equipment placed on the market after 1 July 2006. There are some exemptions in annex to RoHS concerning televisions:

- Use of lead for shielding in glass (CRT) and mercury in florescent lamps in LCDs from 13 February (2002/95/EC),
- Use of lead and cadmium in optical glasses and glass filters relevant for television displays from 21 October 2005 (2005/747/EC),
- Use of lead oxide in glass used for bonding front and rear substrates of flat fluorescent lamps used for LCDs from 21 April 2006 (2006/310/EC).
- Lead oxide in plasma display panels (PDP) and surface conduction electron emitter displays (SED) used in structural elements; notably in the front and rear glass dielectric layer, the bus electrode, the black stripe, the address electrode, the barrier ribs, the seal frit and frit ring as well as in print pastes (TAC).

1.3.1.2. Low Voltage Directive (LVD) 73/23/EEC

The LVD applies to all electrical equipment designed for use with a voltage rating 50 – 1000 V ac and 75 – 1500 V dc. It requires products to have protection against hazards that could arise from within the product itself or from external influences. All risks arising from the use of electrical equipment, including mechanical, chemical, and all other risks. Noise and vibration, and ergonomic aspects, which could cause hazards, are also within the scope of the directive. The directive dates back to 1973 and after thirty years, it has been decided that the text of LVD “needs to be modernised and provided with the flexibility to deal with new risks that were not foreseen at the time of its adoption”. Work is ongoing at the Commission to develop a proposal. A consultation of stakeholders concerning a possible amendment of the directive was closed in October 2005[22].

1.3.1.3. Electromagnetic Compatibility (EMC) Directive 89/336/EEC, amended by Directive 92/31/EEC

The directive lays down requirements in order to ensure that an apparatus is compatible with its electromagnetic environment (covering frequency band 0 to 400 GHz). I.e. that it functions as intended without disturbing other equipment and without being disturbed by other equipment. Equipment must be designed to minimize any potential electromagnetic interference with other equipment and also must itself be immune to specific levels of interference. The directive will be replaced as from 20 July 2007 by the new Directive 2004/108/EC on the approximation of the

[22] http://ec.europa.eu/comm/enetrprise/electr_equipment/lv/index.htm/.

Laws of Member States relating to electromagnetic compatibility, published in the OJEU on 31 December 2004 (L 390/24).

The above two Directives are all based on the principles of the so-called "New Approach", prescribing essential requirements, the voluntary use of standards, and conformity assessment procedures to be applied in order to apply the CE marking.

1.3.2. Voluntary Agreements

1.3.2.1. EICTA Self Commitment

On 1 July 2003, EICTA (the European Industry Association for Information Systems, Communication Technologies and Consumer Electronics) submitted to the European Commission a Self Commitment to improve energy performance of household consumer electronics sold in the European Union. With regards to the EuP studies lot 5 this Self Commitment is covering:

- Analogue CRT based television receivers
- Non-CRT based analogue television receivers

Table 6 below is providing an overview on the agreed commitments.

Table 6: EICTA Self Commitment of 1 July 2003

	Passive Standby 2005	**Passive Standby 2007**	**Energy Efficiency Index 2007**	**Energy Efficiency Index 2010**
CRT analogue TV	Sales weighted average of 3.0 W	Maximum of 1.0 W	sales weighted target of 10%, minimum of 5%	sales weighted target of 15%, minimum of 10%
Non-CRT analogue TV	Sales weighted average of 3.0 W	Maximum of 1.0 W		
	For all new models introduced after 1st June 2004 manufacturers will provide information on the power consumption of the equipment in the ON, standby modes and estimated annual energy consumption (kWh to potential purchasers on, or alongside, the product point of sale. Energy Efficiency Index: EEI = E/Er			

The EICTA Self Commitment provides targets for maximum passive standby power consumption as well as an Energy Efficiency Index. On mode power consumption is measured according to IEC 62087:2002. The definition for passive standby is “The appliance is connected to a power source, fulfils not the main function but can be switched into another mode with the remote control or an internal signal”. The Self Commitment does not define active standby.

For the Energy Efficiency Index (EEI) the estimated annual energy consumption (E) is based on a duty cycle of 20 hours in standby and 4 hours in the ON mode. For TV with auto power off the duty cycle is 4 hours in ON mode, 4 hours in standby mode and 16 hours in OFF mode. In the equation (Er) is the reference energy consumption of the television calculated for a TV having certain features and sizes[23].

1.3.3. Eco-labelling

The objective of this section is to describe what eco-labels already exist that applies to televisions. A first overview of existing international and national labels is given in Table 7 below.

Table 7: Overview on existing (eco)-labels for TVs

Name	Applicable for	Criteria	Test method power measurement	No. of products labelled	Source
GEEA label	TVs with a visible screen diagonal of more than 20 centimetres.	- Energy efficiency → stand-by passive ≤ 1 W → stand-by active terrestrial ≤ 8 W → stand-by active cable ≤ 7 W → stand-by active satellite ≤ 9 W - Compliance with EICTA self-commitment for manufacturer	IEC 62087	27	http://www.efficient-appliances.org/
Nordic Swan	- TVs - TV-sets in combination with other equipment such as VHS/DVD or PC - Appliances that are solely battery powered are excluded	- Energy efficiency - Materials - Design - Efficiency/function - other requirements - testing and control	EN 50301	1	www.svanen.nu
Energy Star	TV, TV monitor, Digital Cable-Ready (DCR TV with Point of Development (POD) Slot, TV/VCR Combination Unit, TV/DVD Combination Unit, TV/VCR/DVD Combination Unit, Component Television Unit, TV with built-in EPG	- Energy efficiency stand-by: Stand-by ≤ 1 W for all categories except for TVs with POD where stand-by ≤ 3 W when POD not installed and ≤ 15 W when POD installed	Own test method described in product specifications	US: 296 TVs 4 TV/VCR/DVD combo units 5 TV/DVD combo units 1 TV/VCR combo unit 50 DCR TVs	www.energystar.gov www.energystar.gov.au
European Eco-label (Euro-Flower)	Mains powered TVs (transmission signals analogue or digital), broadcast via satellite, cable or antenna signals; screen size of ten inches (25 cm) or more	- Energy efficiency during use and stand-by → passive stand-by ≤ 1 W → active stand-by (IRD) ≤ 9 W → EEI_{on} < 65% base case	EN 50301	21 TVs	www.eco-label.com http://ec.europa.eu/environment/ecolabel/index_en.htm

[23] For detailed description cp. Annex I of the Self Commitment, page 9.

Name	Applicable for	Criteria	Test method power measurement	No. of products labelled	Source
		- Limitation harmful substances - Higher product durability and recyclability - take-back policy, reduced solid waste - instructions for correct environmentally friendly use			
TCO ’06 Media Displays	Multifunctional displays for displaying moving pictures (even intended for simple TV apparatus), primarily of the LCD-type	- Ergonomics (moving picture quality) - Emissions (magnetic + electrical fields) - Energy (stand-by) - Ecology (materials, recyclability	Test method used for Energy Star US	Only 3 PC monitors, but no TVs labelled by the end of November 2006	www.tcodevelopment.com

1.3.3.1. The European Eco-Label “Euroflower”

Reference documents to European Eco-Label are:

- Commission Decision 2002/255/EC established the ecological criteria for the award of the Community eco-label for televisions.
- Commission Decision 2005/384/EC had prolonged the validity of these criteria until 31 March 2007.

The **product category** definition reads “Mains powered electronic equipment which is designed to receive, decode and display TV transmission signals, whether analogue or digital, broadcast via satellite, cable or antenna signals and has a screen size of ten inches (25 cm) or more.”

General Criteria

- Reduced energy consumption during use and stand-by
- Limitation of substances harmful for health and the environment
- Designed for higher product durability and recyclability
- Reduced solid waste production through take-back policy
- Instructions for correct environmental use

Specific Criteria

- Ecological criteria
- Manufacturing
    - Limitation of the use of substances harmful to the environment and health

- Plastic parts heavier than 25 gram: Restriction of the use of a list of flame retardants containing organically bound chlorine or bromine.

Energy saving in use phase

- Off switch clearly visible at the front of the TV.
- Passive stand-by consumption ≤ 1 W.
- Active stand-by consumption for TVs with integral digital receiver/decoder (IRD) ≤ 9 W.
- On–mode efficiency index (EEIon) < 65% of the base-case consumption for the same TV format.

User instructions for environmental use

- Information on how to minimise energy consumption and hence overall cost:
  - Switching off the TV with the off switch button.
  - Avoid leaving the TV in stand-by.
  - Reducing the level of brightness.
- Information on the guarantee and availability of spare parts.
- Environmental declaration of manufacturer available to users.

End of Life

Reduction of ecological damage related to the use of natural resources by encouraging product upgrading and recycling

- Easy dismantling and disassembling (standardized connections, easily accessible)
- Incompatible and hazardous materials to be easily separable
- If labels are required, they should be easily separable or inherent
- Recyclability of :
  - 90% (by volume) of plastics and metal materials used in chassis and housing.
  - 90% (by weight) of glass used in the cathode ray tube.
- In plastic parts:
  - No lead or cadmium or metal inlays that cannot be separated.
  - One polymer or compatible polymers.
  - Permanent marking identifying the material (except extruded plastic materials and the light-guide of flat panel displays)

Limitation of solid waste through take-back policy

- Free of charge take-back for recycling of the product and its components except items contaminated by the user.

- Consumer information on how to make use of the take-back offer.

Performance criteria

Life time extension shall be guaranteed by the manufacturer through:

- Functioning of the television set for at least 2 years from date of delivery to the customer.
- Availability of compatible electronic replacement parts: 7 years from cease of production.

Remarks / Relevance to EuP

The European Eco-Label for televisions is nearly not used at all. Only one manufacturer (Sharp) has applied for the label until now.

With regard to power consumption measurement, the Euroflower defines an on-mode Energy Efficiency Index (EEI_{on}) as well as the terms passive and active stand-by[24]. The calculation of the EEI_{on} is based on the ratio between the energy consumption in the on-mode measured using EN 50301 and the so-called base-case energy consumption. Factors used for the calculation of the base-case energy consumption are:

- Availability of digital picture scanning
- Screen format (4:3 or 16:9)
- Screen size (screen diagonal in cm)
- Screen area
- Availability of integrated digital decoder for digital broadcast signals

1.3.3.2. TCO'06 Media Displays

Reference Document regarding TCO'06 Media Displays is the TCOF1076 version 1.2, 16 August 2006, www.tcodevelopment.com.

The **product category** has been defined as "Multifunctional Displays that are used for displaying moving pictures in, for example, surveillance or for displaying moving graphics but it is even intended for simple TV apparatus, primarily of the LCD type."

[24] "Passive stand-by: the TV is connected to a power source, produces neither sound nor vision, and is waiting to be switched into the modes 'off', 'active stand-by' or 'on' on receipt of a direct or indirect signal, e.g. from the remote control.
Active stand-by: the TV is connected to a power source, produces neither sound nor vision, and is exchanging/receiving data with/from an external source."

Criteria

- high visual ergonomics
    - high picture quality and good colour rendition
    - good quality even when the screen displays moving pictures by means of short response time, good black level and expanded requirements of grey level
- Emission
    - reduction of magnetic[25] and electrical fields[26]
    - limitation of noise
- Electrical Safety
    - The FPD shall be certified according to IEC/EN 60 950 or IEC/EN 60 065.
- Energy
    - low energy consumption in stand-by mode
- Ecology
    - manufacturer certified according to ISO 14001 or EMAS
    - reduced dispersion of brominated and chlorinated flame-retarded material and heavy metals (compliance with RoHS Directive from 1 July 2006),[27]
    - Preparation of display unit for recycling facilitating recycling of materials.

The criteria of TCO’06 build on requirements of TCO’03 displays but some requirements have been modified to conform to function and the modes of functionality (three new requirements have been introduced that measure picture quality in the moving picture). If the display monitor is a multifunctional unit, both labels may be applied.

Remarks / Relevance EuP

The TCO’06 label is the only eco-label also referring to picture quality with a certain number of criteria. It is also the only eco-label quantitatively setting criteria for the reduction of electrical and

[25] Band I: 5 Hz to 2 kHz, ≤ 200 nT
FPDs ≤ 26” are measured at 30 cm in front of- and at 50 cm around the FPD.
FPDs > 26“ are measured at 50 cm and around the FPD.
Band II: 2 kHz to 400 kHz, ≤ 25 nT
All FPDs are measured at 50 cm around the FPD.
[26] Band I: 5 Hz to 2 kHz, ≤ 10 V/m
FPDs ≤ 26” are measured at 30 cm in front of- and 50 cm around the FPD.
FPDs > 26“ are measured at 50 cm and around the FPD.
Band II: 2 kHz to 400 kHz, ≤ 1.0 V/m
FPDs ≤ 26” are measured at and at 30 cm in front of- and 50 cm around the FPD the FPD.
FPDs > 26“ are measured at 50 cm and around the FPD.
[27] The material specifications shall be provided for plastic parts and PWB laminates that weigh more than 25 grams and which have flame retardant concentrations above 0.5 percent by weight. Plastic parts that weigh more than 25 grams shall not contain chlorine or bromine as a part of the polymer. Laminates for printed wiring boards, PWBs and all kinds of cable insulation are exempted.

magnetic fields as well as for limitation of noise. Concerning electrical safety the TCO label explicitly refers to the corresponding IEC / EN standard.

With regard to energy consumption applicants to the TCO'06 label need to provide data inter alia on:

- Diagonal screen size in inches
- Aspect ratio
- Screen resolution
- Max. no. of pixels for declared screen size
- Luminance level
- Voltage level and frequency used
- No of lamps in background lightning

The document describing the criteria necessary to obtain the TCO'06 label also includes very detailed description of testing conditions and methodology. These will be further analysed in the course of the project with regard to their overall relevance. So far it has to be stated that concerning measurement of energy consumption in the stand-by mode, the document refers to the methodology presented by the Energy Star (version 2.2). TCO however requires equipment to be tested in a TCO certified laboratory.

1.3.3.3. Nordic Swan

Reference Document

Swan labelling of Audiovisual Equipment, version 2.2, 19 March 2003 – 31 March 2009.

Product Category

The Nordic Swan label can be obtained for the categories “televisions” and “TV-sets in combination with other equipment such as VHS/DVD or PC”. Appliances that are solely battery powered are excluded.

Criteria

Energy Efficiency

- The television shall have an off-switch. The off-switch shall be clearly visible.
- The passive stand-by energy consumption of the television shall be at a maximum 1 watt.
- For televisions, which have an integrated digital receiver/decoder (IRD), the active stand-by consumption shall be at a maximum 9 watts.

- The television shall have an on-mode energy efficiency index (E1) which is lower than 75 % of the base-case consumption for a television of that format[28].
- The on-mode energy efficiency index E1 shall be derived from a specific equation (see below).

Materials / Design

- Requirements with regard to plastics
    - Chlorinated plastics are not permitted with the exception of electrical components in circuit boards.
    - Plastic parts (>25 g) must not be painted with varnishes that reduce the recyclability.
    - Plastic parts (>25 g) must be marked in accordance with ISO 11469.
- Requirements on plastic additives
    - Lead, cadmium and phthalates must not be added to the plastics.
    - Halogenated flame retardant must not be added to the plastics.
    - Other flame retardants added to the plastics shall be specified with Cas-number.
    - Other flame retardants added to plastic parts (>25 g) can not be assigned any of the following risk phrases: R 45 (may cause cancer), R46 (may cause heritable genetic damage), R60 (may impair fertility) or R61 (may cause harm to the unborn child), in accordance with Council Directive 67/548/EEC and its subsequent amendments.
- Requirements regarding displays
    - CRT-displays: Cadmium shall not be added to the picture tube.
    - LCD-displays: The background illumination for flat displays must not contain more than 1 mg of mercury per lamp (average value). The method for testing of mercury content is described in the specifications.
- Requirements on design
    - 65 % by weight of the materials used in the appliance, shall be recyclable, in accordance with the WEEE-Directive.
    - The use of hazardous materials shall be avoided (for a definition of hazardous waste, see Annex III, WEEE-Directive). If this is not possible, hazardous components must be easy to separate from the appliances.
    - The maximum dismantling time must not exceed 15 minutes for TV/VCR-combinations and 10 minutes for other appliances.

Efficiency / function

- Requirements regarding life-time extension

[28] Measurements on-mode power consumption to be done in accordance with EN 50 301.

  - The manufacturer shall offer a commercial guarantee to ensure that the product will function for at least two years. The guarantee shall be valid from the date of delivery to the customer.
  - The availability of compatible electronic replacement parts shall be guaranteed for 7 years from the time that the production ceases.

- Requirements on operating instructions

  The product shall be sold with an operating instruction containing advice on how the product is best used from an environmental point of view. The instruction shall, among other things, contain the following:

  - information that the television should be switched off using the off-switch on the television if it is not to be watched for some time, as this will reduce the energy consumption,
  - information that the product consumes electricity during stand-by, and how this could be minimised,
  - information on how to switch off the product,
  - information about the guarantee and the availability of spare parts,
  - information about the fact that the product has been designed to enable re-cycling and that used appliances shall be returned to a recovery station or other place referred to by the producer,
  - information on how the consumer can make use of the possibility of recovery offered by the manufacturer,
  - information that the product has been awarded the Swan, with a brief explanation as to what this means and that more information about the ecolabel can be found at the web-site of the ecolabelling organisation.

Other requirements

- Requirements from the authorities as to safety, working environment and the external environment

  The holder of an ecolabelling licence is responsible for ensuring that the production of ecolabelled products complies with applicable provisions on safety, working conditions, environmental legislation and plant specific conditions/concessions in the country of production.

  The manufacturer or importer of the ecolabelled product shall ensure the compliance to national legislation/regulations or industry-specific agreements concerning the recycling of products and packages.

  The appliance must comply with regulations concerning electrical safety and electromagnetic compatibility as well as regulations concerning fire safety in the countries where the product is marketed as a Swan labelled product. Discovery of non-compliance may result in revocation of the licence.

- Environmental and quality assurance
  Manufacturers who hold an ecolabelling licence themselves or through retailers/importers must have documented procedures and instructions to ensure:
  - that the requirements in the ecolabelling criteria are fulfilled,
  - that the requirements are verifiable during the period of validity of the licence,
  - the quality level regarding function and efficiency of the products encompassed by the licence,
  - that there is an organisational structure to guarantee that the requirements of the ecolabelling criteria are being met,
  - that there is a contact person towards the ecolabelling organisation

Testing and Control

- Requirements on test institutions / laboratories
  The test institute/test laboratory must be impartial and competent and fulfil the general requirements in accordance with the standard EN 45001/DS/EN/ISO/ IEC 17025 or be an official GLP approved analysis laboratory. The applicant must meet costs for documentation and analysis.
  The manufacturer's own laboratory may be approved for the performance of analyses and tests if the sampling and analysis process is monitored by the authorities or if the manufacturer has a quality system in place which includes sampling and analysis and which is certified in accordance with ISO 9001 or ISO 9002.

Remarks / Relevance EuP

The Nordic Swan Ecolabel is to be further harmonised with the Eu ecolabel in future. Furthermore it is thought of the possibility to impose requirements on auto-off function[29].

As regards the calculation of the Energy efficiency index, the product specifications refer to the criteria set up for the GEEA label (see below).

1.3.3.4. GEEA ”green tick”

Reference Document

Product Sheet “Television Sets”, reference CE01-2004, www.efficient-appliances.org

[29] i.e. the appliance changes automatically from stand-by to off-mode after a specific time.

Criteria for TVs (duty cycle); analogue and digital broadcasting (GEEA Working Group on Consumer Electronics).

Product Category

Mains operated television receivers (TV) with a visible screen diagonal of more than 20 centimetres. TVs for reception of analogue broadcasting as well as TVs for reception of digital broadcasting are eligible for the GEEA Label.

Criteria (Part I Criteria for stand-by modes)

The model to be registered for the GEEA-label should comply with the following criteria:

Mode	Criteria	Value
Standby passive	$P_{standby-passive}$	≤ 1 W
Standby active (applies only to TVs with integrated digital receiver and decoder (set top box)		
• Terrestrial	$P_{standby-active}$	≤ 8 W
• Cable		≤ 7 W
• Satellite		≤ 9 W

Power consumption is measured according to IEC 62087:2002

Part II Compliance with the industry self-commitment

The manufacturer of the model to be registered should have signed the EICTA industry self-commitment to improve the energy performance of household consumer electronic products sold in the European Union, and should not be noted for failing to meet the self commitment (according to article 5.3 of the self commitment)[30]. The self commitment refers to the calculation of an energy efficiency index which itself reflects the ratio between the energy consumption of a TV in all modes and a corresponding reference energy consumption.

Remarks / EuP Relevance

The GEEA label is not widely spread among TVs sold in Europe. In total 27 TVs not older than three years have applied and can carry the label. The label is only related to energy efficiency and not to any other environmental criteria.

According to information from September 2006, GEEA will in future not register anymore products. It will rather focus its technical work on the development of demanding criteria in view of usage for procurement in different areas.

[30] Although the self-commitment at the moment excludes some types of TVs, e.g. IDTV, any type of TV can be registered for the GEEA-label, since the compliance with the self-commitment refers to the manufacturer and not to the model.

1.3.3.5. Australian Equipment Energy Efficiency Programme

The Australian Equipment Energy Efficiency Programme[31] has been in place since 1992. The goal of the programme is to improve the energy efficiency of household appliances and commercial and industrial equipment. The main tools used to achieve this outcome are:

- Mandatory minimum energy performance standards (MEPS);
- Mandatory energy efficiency labelling; and
- Voluntary measures including endorsement labelling, training and support to promote the best available products.

Televisions are part of some of the sub-programmes but are not regulated yet. A regulatory impact assessment is planned in 2007. The measures that target energy efficiency of TVs are:

- The stand-by power strategy

  Product-specific plans are set up to address excessive standby over ten years, 2002 - 2012, within the umbrella of the IEA "One Watt" initiative. Specific product types will be targeted for specific action. Each product will then be dealt with in potentially a two-stage action plan designed to reduce standby to levels acceptable for that product as quickly as economically viable. The first stage is development of product profiles for each major product group. A product profile for TVs does not yet exist.

  However, target values for TVs have been recommended within the publication on the stand-by strategy[32]:

  - Less than 0,3 Watt for TVs in the off mode[33]
  - Less than 1,0 Watt for TVs in the stand-by mode[34]

  Australia has published a standard on measurement of stand-by power in 2005 (AS/NZS62301) which is based on the existing IEC standard 62301.

- MEPS / High efficiency voluntary label

  The NAEEEC[35] is considering options for energy labelling and MEPS for TVs. Unlike many product types included in the standby strategy, TVs use a majority of their energy in the on mode.

  A preparatory study[36] recommended setting up a labelling scheme following the already existing six star rating system[37], with an algorithm based on the Energy Efficiency Index (EEI) used within the EICTA voluntary agreement. The formula would though be adapted

[31] Formerly known as the National Appliance and Equipment Energy Efficiency Programme
[32] "Money isn't all you're saving – Australia's Standby Power Strategy 2002 – 2012", November 2002
[33] Lowest power when connected to the mains
[34] When switched off using a remote control, where applicable
[35] National Appliance and Equipment Energy Efficiency Committee
[36] Analysis of the Potential Policy Options for Energy Efficiency Improvements to Televisions, October 2004
[37] See www.energyrating.gov.au

to Australian market surveys on reference power consumption[38]. The label could be a comparison label across all screen types compared to the efficiency of a standard CRT TV or a label relative to the particular screen type.

Table 8: Proposed EEI and MEPS as well as rating for labeling in Australia

Table 12: Energy Efficiency Index and Star Rating Index

Star Rating	EEI – min	EEI – max
MEPS	>1.35	
1	1.08	1.35
2	0.86	1.08
3	0.69	0.86
4	0.55	0.69
5	0.44	0.55
6		=<0.44

In the context of this measure it is also planned to develop a new standard on power measurement.

- Energy allstars

  The website www.energyallstars.gov.au lists the most energy efficient appliances and equipment currently available on the Australian market. It is designed to encourage suppliers to market efficient products and to be used by public procurers as well as by individuals for the purchase of efficient products. For each product type, a set of performance criteria will be established each year for eligible models together with a process for listing efficient products. TVs are currently not listed.

1.3.3.6. ENERGY STAR® Program (Australia, New Zealand and USA)

The U.S. Energy Star specification for TV was published in January 1998 for the first time. Revised specification was launched on 1 July 2002 featuring a three phase approach with the third phase coming into effect by 1 July 2005. Further amendments were made over time with the current (2006) version 2.2.

Table 9 provides the Energy-Efficiency Criteria for ENERGY STAR Qualified TVs, VCRs, DCR TVs with POD Slots, TV/VCRs, TV/DVDs, VCR/DVDs, TV/VCR/DVDs, Television Monitors, and Component Television Units.

[38] It is assumed that the measurements for the on mode are most likely to be lower than those if measured against IEC 62087, since the data relies on store surveys where the TV has no audio output and the channel is selected as AV (i.e. a dark screen is usually shown).

Table 9: Energy Efficiency Criteria for Energy Star TV

Product Category	Phase I Standby Mode (effective 7/1/02)	Phase II Standby Mode (effective 7/1/04)	Phase III Standby Mode (effective 7/1/05)
TV	≤ 3 Watts	Analog: ≤ 1 Watt Digital: ≤ 3 Watts	≤ 1 Watt
VCR	≤ 4 Watts	≤ 1 Watt	≤ 1 Watt
Television Monitor	Analog: ≤ 1 Watt, Digital: ≤ 3 Watts		≤ 1 Watt
Component Television Unit	≤ 3 Watts		≤ 1 Watt
TV/VCR Combination Unit	≤ 6 Watts		≤ 1 Watt
TV/DVD, VCR/DVD, and TV/VCR/DVD Combo	≤ 4 Watts		≤ 1 Watt
DCR TVs with POD Slots	No POD Installed: ≤ 3 Watts, POD Installed: ≤ 15 Watts		

Regarding TVs a differentiation was made for integrated analogue and/or digital tuner devices. The current Energy Star provides definitions for a wide spectrum of product reflecting ongoing technical development. It also provides definition of various “power” modes.

The **definition of Standby Power/Mode** reads: “Standby power use depends on the product being analyzed. At a minimum, standby power includes power used while the product is performing no function. For many products, standby power is the lowest power used while performing at least one function. Standby power use occurs during what is referred to as the standby mode of the product. Specifically, for this specification, standby power is defined as *the power being used when the product is connected to a power source, produces neither sound nor picture, does not transmit nor receive program information and/or data* (excluding data transmitted to change the unit’s condition from “standby mode” to “active mode”), and is waiting to be switched to “on” (active/play mode) by a direct or indirect signal from the consumer, e.g., with the remote control”.

This definition of standby indicates that digital program downloads or other interaction with the network/broadcast is out of scope. A distinction like “active standby high” (IEC 62087) is not made. On the other hand the Energy Star Program provides a definition for a so called Download Acquisition Mode (DAM). It reads: “The product is connected to a power source, may be producing sound and/or picture, and is downloading channel listing information according to a defined schedule for use by the electronic programming guide. The power requirement in this mode is typically greater than the power requirement in standby mode and less than that in active mode”.

Remarks / EuP Relevance

The US Environmental Protection Agency – the institution responsible for managing the US Energy Star Programme – is currently revising the product specifications for TVs with the target to develop a 3.0 version. The process has started in September 2005 and is linked to efforts made on IEC level in developing a new standard power measurement testing method. The reason for which the revision is taking place is the fact that the current specifications do not reflect the energy used by a product when it is operating (active power consumption is becoming increasingly important due to changes in product technology and usage patterns that result in increased energy consumption). Regarding **Energy Star TV specification revision**, the EPA published on 6 January 2006 a research paper in which the "next steps" were formulated. According to this paper the "EPA strives to develop energy efficiency specifications that are performance-based and technology neutral". It also reads "EPA plans to develop one test method and specification for all technologies". Furthermore was indicated that EPA plans to "develop a new test procedure to measure the amount of energy consumed by a television in active or on mode". A globally harmonized test standard is envisioned. A first Draft release of the new specification is expected by August 2006. Release of the final version by January 2007 and coming into effect one year later.

Similar efforts are also made in Australia /New Zealand where the current test method for power measurement is the Australian / New Zealand standard AS/NZS 62087-2004 (identical to the corresponding IEC 62087:2002 standard)[39]. A revised test method is also under discussion here and linked to overall efforts made within IEC and other labelling schemes and voluntary measures. Until now the EU has not taken over the specifications of the Energy Star for TVs in the framework of its agreement with the Energy Star Programme; only office equipment is covered by the agreement. However, in theory, manufacturers having applied for an Energy Star label could also use this label in Europe.

[39] As referred to in the schedule of changes and updates of 1 June 2006 relating to products regulated for energy efficiency in Australia [www.energyrating.gov.au].

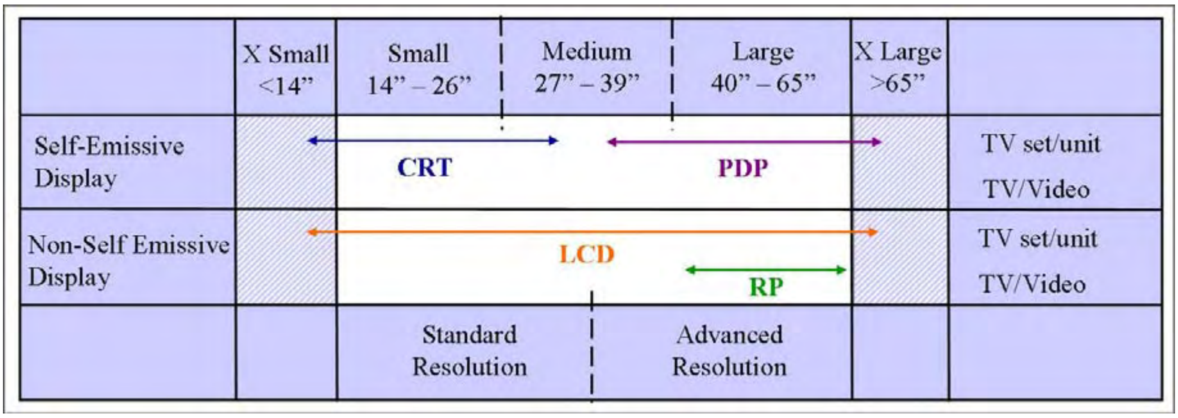
1.4. Conclusion

1.4.1.1. Structure of Product Case Assessments

In conclusion of the definition process (task 1.1) the focus of the study is put on regular TV-sets and to a lesser degree on TV/Video combinations and component units. The differentiation of display technologies and screen surface area (screen sizes) has been determined as an important differentiation criteria’s in regards to an environmental impact assessment. Based on these assumptions we will define now product groups for the environmental assessments under task 4. The product groups provide a first structure for analyzing technical differences and performance parameters in terms of environmental impacts and improvement potentials. The following definition of product groups will consider two main technical product features:

- **Display technologies**, source of light and principle of pixel modulation as main technical differentiation criteria
  - Self emissive displays such as plasma (PDP), cathode luminescence (CRT, SED) and electro luminescence (OLED)
  - Non-self emissive display such as backlight systems (LCD) and projection systems (DLP, 3LCD, LCoS)
- **Screen parameters,** screen size / surface area as well as resolution
  - Small / Medium: standard resolution as performance criteria for volume products
  - Medium / Large: advanced resolution as performance criteria for value products
  - X Small / X Large are not considered

Table 10: Options for structuring product case assessments



Taking these considerations into account we have a spectrum of options for structuring the product assessment in task 4 and 5 (see Table 10). In comparison to the earlier[40] proposed structure (see Table 11) we have changed the technological differentiation criteria by focusing on the technical principle of the displays. This structure provides the option to allocate different (emerging) display technologies. SED[41] could be allocated to self-emissive display technologies. Rear projection technologies such as HTPS, DLP, and LCoS can be allocated to the backlight / reflective display technologies. It is also possible to build further sub-structures e.g. for the distinction of typical types of equipment such as TV-sets, TV/Video combinations or TV component units. In parallel we have the option to allocate further performance aspects such as screen size sub-segments or standard resolutions.

Table 11: Old Proposal for Product Groups

TV-Set	Criteria:	Small Screen Size 14" – 26"	Medium Screen Size 27" – 39"	Large Screen Size 40" – 65"
▪	**Cubic Display** (Product Cases)	**Product Group 1** CRT	**Product Group 2** CRT and [RP]	**Product Group 3** RP
▪	**Flat Panel Display** (Product Cases)	**Product Group 4** LCD	**Product Group 5** LCD and [PDP]	**Product Group 6** LCD and PDP

Industry representatives and other stakeholders suggested in their comments to our discussion paper from 4 July 2006 that a differentiation of single technologies like CRT, LCD, and PDP would be preferable[42]. The main argument was that these common display technologies are technically not comparable and have different performance characteristics. It was also assumed that environmental impact might differ. On the other hand some comments indicated that CRT is phasing out (no further technology development) and therefore would need no special attention. With the new approach we have taken these considerations into account. Regarding the task of base case assessment it has to be mentioned that VHK EcoReport provides an entry and data set for CRT and LCD displays. In terms of other technologies such as PDP we are in the situation that VHK is not providing a particular entry or applicable data set respectively. This indicates a difficulty for the required environmental assessment. From our point of view it is essential to conduct assessments for a wide range of technologies in order to determine similarities or structural distinctions in products of different technologies. We are currently collaborating with industry in order to obtain VHK compatible data for PDP.

[40] Cp. discussion paper from 4 July 2006.

[41] SED, Surface-conduction Electron-emitter Display, a type of field emission display developed by Canon and Toshiba.

[42] Rear Projection televisions were also differentiated by some stakeholders, however as a single technology, what is problematic due to the fact that we have a range of different technologies in the field of RP televisions.

The second set of criteria, which provides a structure for the product groups, considers multiple aspects of product performance. The new approach differentiates two screen size segments (medium and large) which correlate to resolution (standard definition and advanced definition). This segmentation is not randomly chosen. When compared to the classifications analyzed in task 1.1 it is noticeable that they reflect the important aspects of setting minimum and maximum screen size limits. The limitation of minimum screen size of 14 Inch follows the consideration that smaller products are not commonly used as home television-set. Small products are usually portable, could have the capability of being battery powered, and underlie different use patterns. These specifications result in a different technical design. As for the maximum screen size of 65 Inch, we took the feedback from the industry into consideration[43]. It was strongly argued that the market share of televisions of larger format is comparably small and that such very large devices (X Large) are usually used in a business environment. Therefore use patterns would differ from televisions used in average homes.

The definition of the screen size ranges is problematic. In order to define the segments we have to consider technical as well as market aspects. From a technical point of view we consider display resolution. Standard resolution such as Standard Definition TV (SDTV) is currently sufficient for medium size televisions[44]. Advanced resolution such as High Definition TV (HDTV) is necessary for good picture quality of larger screen sizes[45]. The idea to define a very simple two-fold segmentation (medium and large) resulted from the correlation of standard and advanced resolution application to typical screen sizes. A third consideration was that products that have been defined as "medium" are dominating the current sales. This group reflects therefore "volume products", whereas products that fall into the "large" category are usually equipped with many features, are more expensive, and therefore reflect "value products".

1.4.1.2. New Test Standards in Development

Test Standards concerning the methods for the measurement of power consumption are an important aspect in regards to the assessment of environmental performance of a television device (see chapter 1.2.1). The ongoing revisions of IEC 62087 and EN 50301, as well as developments in Japan (JEITA) and the USA (IEEE) are reflecting the necessity to improve current test standards in

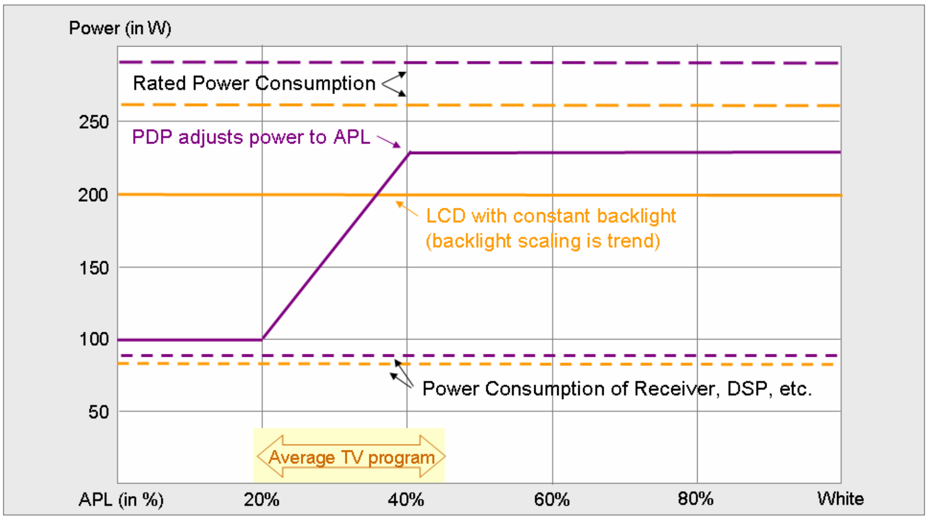
[43] One company suggested limiting the large screen segment at 50 Inch due to a predicted small market penetration and high price of devices over 50 Inch.
[44] Standard Definition TV signal is broadcast analogue with interlaced frames e.g. 576i (PAL) up to 33 Inch.
[45] High Definition TV signal is broadcast digitally with 1080i active interlaced lines, or 720p progressive lines applied in products of 36 Inch upwards.

order to measure average power consumption more realistically. The power consumption profile of television devices applying different display technologies varies according to their technical principles in which a picture is reproduced on the screen. As an example, the power consumption of a plasma display depends on the Average Picture Level (APL) of the image because the average current drawn by a pixel depends on its brightness. There are two definitions of APL:[46]

- Type 1 (Pre-Gamma) is the time average of a video signal input voltage to a TV set, which is usually expressed as a percentage of the full (100%) white signal level voltage.
- Type 2 (Post-Gamma) is the time average of the average luminance of all pixels in the TV set, which is usually expressed as a percentage of the peak white luminance level.

PDP as a phosphor-based self-emission technology shows a power consumption profile in correlation to APL more similar to CRT (cp. Figure 2). LCDs with constant backlighting show a constant (not changing) power profile in correlation to the Average Picture Level (APL). For low APL[47] the power consumption of a plasma display can fall by more than 50 percent from its peak value at high APL, and may be less than a comparable size LCD panel (because its power consumption doesn't vary with APL)[48]. However the current development of dynamic backlighting in LCD television also suggests that in the future power consumption of LCD may vary according to APL.

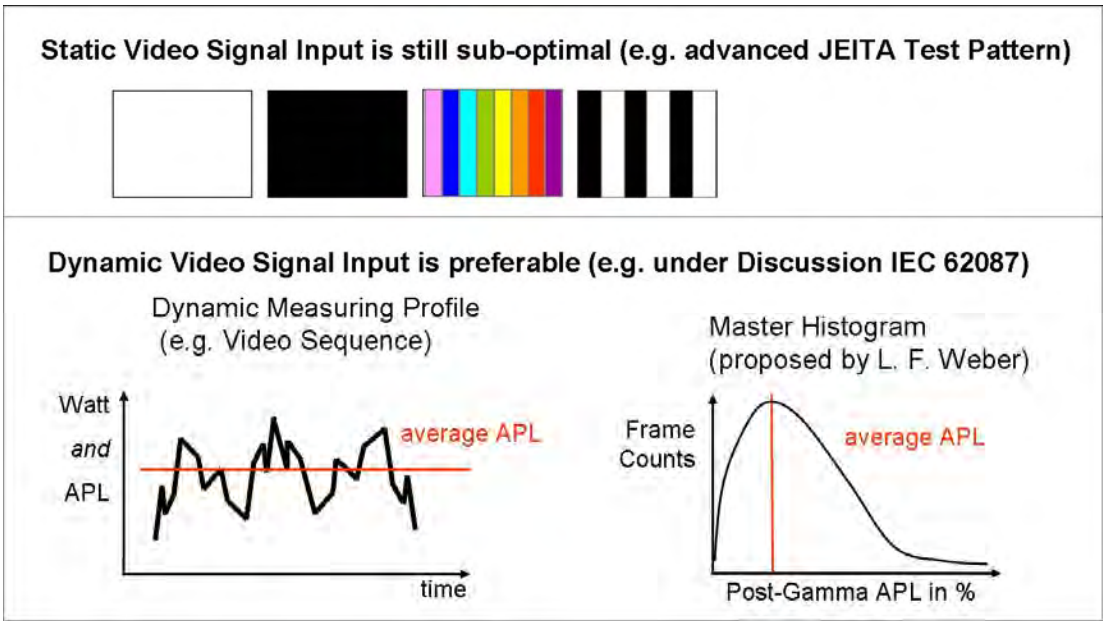
Figure 2: Power consumption profiles of LCD and PDP are different.



[46] Larry F. Weber (2005): Challenges of Measuring Annual Energy Consumption of TV sets, IDW/AD#05, page 1430.
[47] APL data on average TV broadcast are indicating a range of 10 to 25 Post-Gamma APL (%).
[48] http://www.extremetech.com/article2/0,1697,1747602,00.asp/

Keith Jones, Digital CEnergy Australia, presented such power consumption profiles for PDP and CRT at the EPA TV workshop this year[49]. He also suggested at the EEDAL 2006 (International Energy Efficiency in Domestic Appliances & Lighting Conference) a possible replacement of power consumption test method. A new test method was proposed by Larry F. Weber based on a standard power test video which would be composed on a small number of video clips having different post-gamma APL. These video clips would have to represent an actual TV signal used by TV consumers[50]. The following Figure 3 shows the advanced test pattern of JEITA as well principle illustrations of the proposed dynamic video signal test patterns.

Figure 3: Power consumption emerging test methods



The revised IEC 62087 dynamic broadcast-content test video signal has a 38% APL on average. This means that self-emitting displays such as CRT and PDP will show somewhat lower (and more realistic) power consumption values that with the conventional three-black-and-white-bar test video signal. The brightness setting of 80 cd/m² that is required by IEC 62087 is however relatively low and should be increased to a level of 130 or even 160 cd/m² in order to reflect the energy efficiency of the display panel. Another aspect is the timing of power measurement. A CRT for example will show improved power consumption under "warm" conditions. This applies to electronics in general. To measure power consumption in the moment when a device is switched on does not give an average result.

49 http://www.energystar.gov/ia/partners/prod_development/revisions/downloads/tv_vcr/TestClipProposals.pdf

50 Cp. Larry F. Weber (2005): Challenges of Measuring Annual Energy Consumption of TV sets, IDW/AD#05, page 1432.

The ongoing revisions of test standards are addressing these – only brief discussed – issues. It is necessary to follow the developments in standardization. In talks with specialists involved in the standardization processes (IEC/TC100) we received the information that draft versions of the new test standard (dynamic measuring profile based on APL) will be provided by early 2007 and that a voting on the standard could follow in July 2007.

It is recommended to apply the new IEC 62087 dynamic broadcast-content video signal test method for the measurement of standard on-mode power consumption.

EuP Preparatory Studies “Televisions” (Lot 5)

Final Report on Task 2
“Economic and Market Analysis”

Compiled by Öko-Institut and Fraunhofer IZM

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Berlin, 2nd August 2007

Content

Introduction

This is the final report on Task 2 “Economic and Market Analysis” for the EuP Preparatory Studies on televisions (lot 5). The findings presented in this report are results of the research conducted by the IZM consortium and the continuous feedback from a wide range of stakeholders. The statements and recommendations presented in the final report however are not to be perceived as the opinion of the European Commission.

We like to acknowledge the fruitful collaboration and trustful working relationship with various industry partners, non-industry stakeholders, and the European Commission throughout the study. We like to thank all stakeholders for their contributions and critical reviews of our reports.

2nd August 2007

Task 2: ECONOMIC AND MARKET ANALYSIS

2.1. Generic Economic Data

To place the product category television defined in task 1.1 within the total of EU industry and trade policy, first of all the following generic economic data will be investigated:

- EU-Production,
- Extra-EU Trade,
- Intra-EU Trade,
- Apparent EU-consumption.

2.1.1. EU Trade Statistics

In order to be coherent with official EU data, information for subtask 2.1 is derived from Eurostat, the statistical office of the European Communities. Production and trade data for more than 7000 product groups can be extracted from Eurostat's external trade database PRODCOM. Since 1995 Eurostat provides in addition to Prodcom another EU-25 trade statistic, whose classification is based on the Combined Nomenclature (CN). Prodcom sub-classifies the product category "television receivers" into ten product groups (Prodcom code 32.30.20.xx), trade statistic provides more detailed data on televisions and defines 15 sub-categories (8528.xx.xx), as already described in chapter 1, Table 1 and 2. Trade statistics differentiates nine sub-groups representing different size ranges or scanning parameters for CRT televisions, Prodcom only one. Flat panel TVs (8528.12.81 and 8528.12.89) are characterized by different width/height ratio so that classical 4:3 screen format can be found in the first, up-coming 16:9 format in the second sub-group.

The following Table 1 shows the Prodcom nomenclatures corresponding to EU trade statistic for those categories further analysed as regards generic economic data. Relating to the scope of the study as described in chapter 1, Table 2, the Prodcom category "Colour televisions with a video recorder or player" reflects "TV/Video Combination Units". As there is no detailed definition of the remaining sub-categories, the Prodcom categories "Colour television receivers with integral tube", "Flat panel colour TV receivers, LCD/Plasma, etc." and "Black and white or other monochrome television receivers" are assumed to fall into the category "TV-Set" with integrated screen and speakers. For the first Prodcom category "Colour television projection equipment and video projectors", both TV-sets (e.g. rear projection TV) and TV Component Units as well as TV Peripherals (video projectors) could be meant.

Table 1: Prodcom classification and corresponding CN-Codes applicable to televisions

Prodcom-Code	Description of Prodcom-Codes	Corresponding CN-Code	TV equipment type (scope of the study)
32.30.20	**Television receivers**	**8528**	
32.30.20.20	Colour television projection equipment and video projectors	8528.12.10	TV Set? TV Component Unit? TV Peripherals?
32.30.20.30	Colour televisions with a video recorder or player	8528.12.2x	TV/Video Combination Unit
32.30.20.50	Colour television receivers with integral tube	8528.12.5x 8528.12.6x 8528.12.7x	TV Set
32.30.20.60	Flat panel colour TV receivers, LCD/Plasma, etc.	8528.12.8x	TV Set
32.30.20.85	Black and white or other monochrome television receivers	8528.13.00	TV Set

2.1.1.1. Television Production in EU-25

According to Prodcom statistics in 2004 domestic production of televisions was reported only by Germany, Italy, United Kingdom, Denmark, Spain, Finland, Poland, Slovakia and Hungary (cp. following Table 2). France and the Netherlands have not provided data on television production for the past years, although domestic companies like Thomson and Philips are strong market players.

Table 2: Television EU-25 domestic production in 2004 (Prodcom statistic)

		Colour TV projection equipment and video projectors[1]		Colour TVs with video recorder/player[2]		CRT TUBE colour TVs[3]		FLAT PANEL colour TVs[4]	
		000 units	**Mio Euro**	**000 units**	**Mio Euro**	**000 units**	**Mio Euro**	**000 units**	**Mio Euro**
1	France	:	:	:	:	:	:	:	
3	Netherlands	0	0	0	0	:	:	:	:
4	Germany	:	:	0	0	423	258	79	92
5	Italy	6	15	0	0	433	118	:	:
6	UK	:	114	0	0	3655	754	190	321
7	Ireland	0	0	0	0	0	0	0	0
8	Denmark	0	0	0	0	:	:	141	52
9	Greece	0	0	0	0	0	0	0	0
10	Portugal	0	0	0	0	0	0	0	0
11	Spain	:	:	:	:	2569	539	:	:
17	Belgium	:	:	:	:	:	:	0	0
18	Luxemburg	0	0	0	0	0	0	0	0
30	Sweden	0	0	0	0	0	0	0	0
		Colour TV projection equipment and		**Colour TVs with video**		**CRT TUBE colour TVs[7]**		**FLAT PANEL colour TVs[8]**	

1 Prodcom-Code 32.30.20.20
2 Prodcom-Code 32.30.20.30
3 Prodcom-Code 32.30.20.50
4 Prodcom-Code 32.30.20.60

		video projectors[5]		recorder/player[6]					
		000 units	Mio Euro	000 units	Mio Euro	000 units	Mio Euro	000 units	Mio Euro
32	Finland	0	0	0	0	85	45	0	0
38	Austria	:	:	0	0	0	0	0	0
46	Malta	0	0	0	0	0	0	0	0
53	Estonia	0	0	0	0	0	0	0	0
54	Latvia	0	0	0	0	0	0	0	0
55	Lituania	0	0	:	:	:	:	0	0
60	Poland	0	0	0	0	6481	1110	526	98
61	Czech Republic	:	:	0	0	:	:	0	0
63	Slovakia	0	0	0	0	919	178	:	:
64	Hungary	2089	376	1468	432	0	0	:	:
91	Slovenia	0	0	0	0	0	0	0	0
600	Cyprus	0	0	0	0	0	0	0	0
	EU15 Totals	***:***	***:***	***:***	***:***	***:***	***:***	***2012***	***1849***
	EU25 Totals	***4242***	***1524***	***:***	***547***	***16552***	***3895***	***2954***	***2191***

Note: ":" means that the production has not been reported by the country and is unavailable.

The new member states Poland, Slovakia and Hungary are developing into strong production sites within the EU. The increased production in Eastern Europe is mostly driven by a beneficial cost structure in these countries. United Kingdom, Spain, Denmark, and to a lesser extent Germany remain production locations although they are high labour cost countries. Poland, the UK and Denmark are leading production in new flat panel display technology televisions. Prodcom does not give an indication if television production consists of the display panel production as well. In general, the television production in the EU is less important as advanced display panels are mostly produced in Asia (Japan, Korea, Singapore, China), and in Europe is only the final set making.

2.1.1.2. Television total EU trade

Table 3 provides Prodcom trade data (Intra- and Extra-EU trade) in regards to unit volume and unit value of particular product groups in 2003 and 2004 respectively. Except for monochrome televisions, imports have been increasing in all TV categories. Striking are the 2.7-times increased imports of flat panel televisions, indicating the growing domestic market. However, conventional CRT televisions have still a considerable larger market penetration, even with increasing export figures.

[7] Prodcom-Code 32.30.20.50
[8] Prodcom-Code 32.30.20.60
[5] Prodcom-Code 32.30.20.20
[6] Prodcom-Code 32.30.20.30

Table 3: Television EU-25 Trade total (Intra- and Extra-EU) in 2003 and 2004 (Prodcom statistic)

Product Class	Volume (1000 units)				Value (Million Euro)			
	Export		Import		Export		Import	
	2003	2004	2003	2004	2003	2004	2003	2004
Projection TV	431	598	1317	2250	364	416	1160	1448
Color TV/video	112	168	2692	3749	22	21	335	389
CRT TV	6837	7608	22554	26139	1132	1306	3496	3770
Flat Panel TV	1010	407	746	2051	141	382	299	1080
Monochrome TV	91	72	2780	2708	4	3	47	34

In general, there is approximately a four to one ratio in import numbers compared to exports. This means that television production in the EU is less important and three out of four televisions in the EU is manufactured abroad. Strong manufacturing locations are in Turkey and East Asian countries like China, Korea and Japan. In terms of value we can notice a three to one ratio in regards to import and export of televisions which indicates a higher price level of imported televisions. The following Table 4 provides Prodcom trade data of all EU-25 countries in 2004. This statistic makes no difference between Intra- and Extra-EU trades which means that you cannot distinguish if e.g. imports of one EU country from other EU- or Extra-EU countries.

Table 4: Television domestic imports and exports of EU-25 countries, 2004 (Prodcom statistic)

		Colour TVs with video rec./player		CRT TUBE colour TVs		FLAT PANEL colour TVs		Black & white TVs	
		Import	Export	Import	Export	Import	Export	Import	Export
		1000 units		1000 units		1000 units		1000 units	
1	France	438	37	4698	1032	410	588	284	28
3	Netherlands	298	53	2238	1124	341	159	301	79
4	Germany	182	42	6439	1789	805	324	347	67
5	Italy	256	14	3628	147	958	26	603	57
6	United Kingdom	2413	68	3449	2072	822	258	297	9
7	Ireland	26	0,8	428	43	18	1	2	75
8	Denmark	127	62	659	347	77	203	168	96
9	Greece	48	0,3	1014	31	50	1	31	0
10	Portugal	9	0,2	779	16	35	0,6	12	0
11	Spain	106	3	3589	2192	307	794	290	2
17	Belgium	61	20	957	425	131	290	283	304
18	Luxemburg	7	2	46	24	14	3	5	2
30	Sweden	70	16	1181	477	218	68	36	4
32	Finland	12	4	463	257	35	17	3	0,2
38	Austria	18	13	760	221	86	47	16	12
46	Malta	0,1	0	31	0	0,5	0	2	0
53	Estonia	9	0	75	10	2	1	1	0,1
54	Latvia	0,6	0	167	11	2	0,1	4	0
55	Lituania	0,8	0	560	1176	4	10	2	0
60	Poland	9	9	769	6085	35	241	115	2
61	Czech Republic	5	1	997	2004	31	11	64	5
63	Slovakia	9	0,3	143	1209	9	0,1	7	0,5
64	Hungary	6	321	811	2851	31	108	13	0,2
91	Slovenia	0,3	0	134	26	7	1	10	1
600	Cyprus	1	0	79	0,1	1	0	0,4	0
EU25 totals (calculated)		*4112*	*667*	*34094*	*23569*	*4430*	*3152*	*2896*	*744*

The same data from EU-25 trade statistic are presented in the following Table 5, showing the distribution between Intra- and Extra-EU trades of the above calculated sums.

Table 5: Television Intra- and Extra-EU trade of EU-25 countries, 2004 (EU-25 trade statistic)

	Colour TVs with video rec./player		**CRT TUBE colour TVs**		**FLAT PANEL colour TVs**		**Black & white TVs**	
	Import	**Export**	**Import**	**Export**	**Import**	**Export**	**Import**	**Export**
EU-25 totals	1000 units		1000 units		1000 units		1000 units	
Intra-EU trade	786	605	20018	20991	2844	2859	290	727
Extra-EU trade	3324	64	14077	2588	1586	291	2607	17
EU25 totals: calculated sum Intra-/Extra-EU trade	*4110*	*669*	*34095*	*23579*	*4430*	*3150*	*2897*	*744*

Imports from Extra-EU countries are significantly higher than imports from Intra-EU countries. As for the internal trading of televisions it is very interesting to notice that an almost perfect balance exists between imports and exports. Some more detailed statistics regarding Extra- and Intra-EU trade over a longer period of time are given in the next two chapters.

2.1.1.3. Television Extra-EU trade

Table 6 presents the same analysis of EU-25 trade statistic, solely stating Extra-EU trade data in comparison of the years 2003 and 2004. This short term view is indicating a slight increase in overall trade volume for televisions, particular regarding imports. This can be explained by the fact that overall economic situation was improving in 2004 resulting in higher consumer spending.

Table 6: Television Extra-EU trade of EU-25 totals, 2003 and 2004 (EU-25 trade statistic)

	Volume (1000 units)				**Value (Million Euro)**			
	Export		**Import**		**Export**		**Import**	
Product Categories[9]	**2003**	**2004**	**2003**	**2004**	**2003**	**2004**	**2003**	**2004**
Projection TV	122	197	88	247	25	35	41	67
Color TV with video	51	64	2046	3324	11	15	243	343
CRT TV	2543	2588	10757	14077	513	554	1334	1600
Flat Panel TV	158	291	708	1586	124	280	289	705
Monochrome TV	68	17	2618	2607	3	2	45	33

Table 7 and Table 8 present the development over the long term with details regarding Extra-EU imports and exports in 1996, 2000 and 2005. In this period we can notice an increase in overall imports and exports throughout all television product segments. The average prices of imported and exported televisions declined in most of the product categories except for flat panel TVs.

[9] Projection TV: CN-codes 85281210/14/16/18 ; Colour TVs with video: 85281220/22/28; CRT TVs: 8281252/54/56/58/62/66/7072/76; Flat panes TVs: 85281281/89; black&white TVs: 85281300

This development can be interpreted in a way that televisions become for the European Union an important trading good. On the other hand we have to notice the extension of the EU as well as the changing market situation throughout the nineties in the Eastern European countries, which could lead to the increased trading.

Table 7: Television Extra-EU trade: Imports of totals in 1996, 2000 and 2005 (EU-25 trade statistic)

		volume (1000 units)			value (Million Euro)			average price (Euro)		
		1996	2000	2005	1996	2000	2005	1996	2000	2005
Projection TVs	**85281210**	:	75	117	:	52	24		694	204
	85281214	107	:	:	32	:	:	303		
	85281216	2	:	:	3	:	:	1602		
	85281218	15	:	:	13	:	:	891		
Colour TVs with video	**85281220**	:	655	2989	:	112	287		171	96
	85281222	159	:	:	37	:	:	234		
	85281228	109	:	:	16	:	:	146		
CRT colour TVs	**85281252**	*1408*	*3368*	*4503*	165	346	285	117	103	63
	85281254	*401*	*2056*	*1761*	60	247	152	150	120	86
	85281256	*410*	*4214*	*4660*	85	631	536	207	150	115
	85281258	8	208	518	5	78	117	571	377	225
	85281262	60	205	429	11	37	64	183	178	149
	85281266	8	62	71	2	32	22	229	524	315
	85281270	:	:	7	:	:	1			180
	85281272	0,7	23	:	0,1	2	:	190	91	
	85281276	11	16	:	2	2	:	153	150	
Flat panel TVs	**85281281**	*291*	*167*	*961*	16	19	246	54	*112*	*256*
	85281289	*47*	*43*	*2063*	4	10	676	93	*224*	*328*
b&w TVs	**85281300**	*302*	*702*	*1813*	12	21	18	40	30	10

Table 8: Television Extra-EU trade: Exports of totals in 1996, 2000 and 2005 (EU-25 trade statistic)

		volume (1000 units)			value (Million Euro)			average price (Euro)		
		1996	2000	2005	1996	2000	2005	1996	2000	2005
Projection TVs	**85281210**	:	115	238	:	38	36		329	151
	85281214	58	:	:	34	:	:	588		
	85281216	3	:	:	1	:	:	398		
	85281218	10	:	:	5	:	:	473		
Colour TVs with video	**85281220**	:	75	104	:	16	82		215	789
	85281222	15	:	:	5	:	:	309		
	85281228	32	:	:	9	:	:	273		
CRT colour TVs	**85281252**	236	434	302	37	51	49	159	118	162
	85281254	241	257	517	50	38	32	208	147	61
	85281256	946	847	1061	312	226	172	330	267	162
	85281258	119	273	424	75	152	129	625	557	304
	85281262	27	198	80	18	57	13	648	286	168
	85281266	20	52	176	15	53	83	778	1020	475
	85281270	:	:	24	:	:	26			1107
	85281272	2	2	:	0,9	0,5	:	413	263	
	85281276	8	5	:	2	3	:	303	642	
Flat panel TVs	**85281281**	1	5	169	0,7	1	80	505	*274*	*474*
	85281289	37	50	630	7	31	480	196	*617*	*762*
b&w TVs	**85281300**	20	28	43	5	6	2	242	224	42

Table 9 presents particular trading figures for flat panel televisions in 1996 and 2000. By the end of 2000 trade numbers of flat panel TVs declined. One reason could be that in the past also for CRTs the term “flat TV” was used, indicating TVs with a flat CRT surface and not curved. Since 2003 trade numbers of flat panel televisions have been strongly increasing which backs up the trend towards LCD and plasma flat panel televisions.

Table 9: Flat Panel televisions Extra-EU trade of totals, 1996-2005 (EU-25 trade statistic)

		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
volume (1000 units)	import	338	224	215	155	210	242	583	708	1586	3024
	export	39	29	51	40	55	67	102	158	291	798
value (Mio Euro)	import	20	19	20	20	28	53	174	289	705	922
	export	8	5	21	15	32	32	72	124	280	560
average price (Euro)	import	59	84	95	132	135	219	299	408	445	305
	export	208	182	410	379	584	480	701	788	962	701

2.1.1.4. Television Intra-EU trade

The unit volume and monetary value of the overall intra-EU trade in 2005 is shown in Table 10.

Table 10: Television Intra-EU trade of totals in 2005 (EU-25 trade statistic)

<table>
<tr><th></th><th></th><th colspan="3">Import</th><th colspan="3">Export</th></tr>
<tr><th></th><th></th><th>volume (1000 units)</th><th>value (Million Euro)</th><th>Average price (Euro)</th><th>volume (1000 units)</th><th>value (Million Euro)</th><th>average price (Euro)</th></tr>
<tr><td rowspan="4">Television projection equipment</td><td>85281210</td><td>662</td><td>291</td><td>440</td><td>299</td><td>190</td><td>634</td></tr>
<tr><td>85281214</td><td>:</td><td>:</td><td></td><td>:</td><td>:</td><td></td></tr>
<tr><td>85281216</td><td>:</td><td>:</td><td></td><td>:</td><td>:</td><td></td></tr>
<tr><td>85281218</td><td>:</td><td>:</td><td></td><td>:</td><td>:</td><td></td></tr>
<tr><td rowspan="3">Colour TVs with video</td><td>85281220</td><td>792</td><td>144</td><td>182</td><td>464</td><td>67</td><td>143</td></tr>
<tr><td>85281222</td><td>:</td><td>:</td><td></td><td>:</td><td>:</td><td></td></tr>
<tr><td>85281228</td><td>:</td><td>:</td><td></td><td>:</td><td>:</td><td></td></tr>
<tr><td rowspan="9">CRT colour TVs</td><td>85281252</td><td>2299</td><td>313</td><td>136</td><td>2482</td><td>218</td><td>88</td></tr>
<tr><td>85281254</td><td>2192</td><td>302</td><td>138</td><td>1703</td><td>213</td><td>125</td></tr>
<tr><td>85281256</td><td>6267</td><td>1283</td><td>205</td><td>6237</td><td>964</td><td>155</td></tr>
<tr><td>85281258</td><td>1882</td><td>737</td><td>392</td><td>2691</td><td>855</td><td>318</td></tr>
<tr><td>85281262</td><td>830</td><td>177</td><td>213</td><td>619</td><td>112</td><td>181</td></tr>
<tr><td>85281266</td><td>1009</td><td>412</td><td>408</td><td>1116</td><td>409</td><td>366</td></tr>
<tr><td>85281270</td><td>43</td><td>16</td><td>375</td><td>402</td><td>472</td><td>1175</td></tr>
<tr><td>85281272</td><td>:</td><td>:</td><td></td><td>:</td><td>:</td><td></td></tr>
<tr><td>85281276</td><td>:</td><td>:</td><td></td><td>:</td><td>:</td><td></td></tr>
<tr><td rowspan="2">Flat panel TVs</td><td>85281281</td><td>1426</td><td>655</td><td>459</td><td>2133</td><td>995</td><td>466</td></tr>
<tr><td>85281289</td><td>5664</td><td>4157</td><td>734</td><td>6328</td><td>4867</td><td>769</td></tr>
<tr><td>B&w TVs</td><td>85281300</td><td>232</td><td>10</td><td>42</td><td>619</td><td>14</td><td>22</td></tr>
</table>

Interesting to notice here again is the flat panel television market development. The following figures in Table 11 indicate the volume and corresponding value of Intra-EU imports of flat panel televisions between 1996 and 2005, showing a significant increase in trading volume after 2003 and 2005 in particular. These figures might indicate the current shift towards flat panel television.

Table 11: Flat Panel Televisions Intra-EU trade of totals (EU-25 trade statistic)

		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
volume (1000 units)	import	89	97	131	237	488	293	405	738	2844	7089
	export	87	66	99	147	191	190	404	1076	2859	8461
value (Mio Euro)	import	22	19	23	32	86	91	193	575	2193	4812
	export	7	13	27	38	118	116	293	837	2376	5862
average price (Euro)	import	248	193	175	135	176	311	475	780	771	679
	export	85	198	278	256	616	612	725	777	831	693

2.1.1.5. Apparent EU-consumption

Apparent EU-consumption is calculated from production plus imports minus exports. As there are quite a number of difficulties, it might be quite a challenge to interpret those calculations and take them as basis for further proceedings:

- The figure for apparent consumption can only be calculated if production, import and export data are all available. There are several gaps, especially for production data.
- There are temporal delays between the various operations taken into account: production, sale and export. Storage explains a part of these delays which are reduced or even disappear when the data are considered over several years.
- The value of exports cannot always be compared directly with that of sold production.

Due to these facts and other problems, described in [Williams 2003], in certain cases the product markets may appear negative.

Table 12: Apparent EU-consumption of CRT and flat panel TVs in 1995, 2000 and 2004

		CRT TUBE colour TVs			FLAT PANEL colour TVs		
		1995 (000 units)	2000 (000 units)	2004 (000 units)	1995 (000 units)	2000 (000 units)	2004 (000 units)
1	France						
3	Netherlands					-3	
4	Germany	4500		5073	46	94	561
5	Italy	2345	3912	3915		78	
6	United Kingdom	3193	4827	5032	1169		755
7	Ireland	201	293	385	9	0,9	17
8	Denmark				0,2	-46	15
9	Greece	446	671	983	3	4	49
10	Portugal	624	698	763	3	2	35

		CRT TUBE colour TVs			**FLAT PANEL colour TVs**		
		1995 (000 units)	**2000 (000 units)**	**2004 (000 units)**	**1995 (000 units)**	**2000 (000 units)**	**2004 (000 units)**
11	Spain	2100	3441	3966	21	315	
17	Belgium				8	-48	-159
18	Luxemburg		27	21		0,8	12
30	Sweden	380	524	704	3	8	150
32	Finland		951	292		1	17
38	Austria			538	21	0,7	39
46	Malta			31			0,4
53	Estonia		63	65		0,4	1
54	Latvia			156			2
55	Lituania		128			0,7	-6
60	Poland			1164			320
61	Czech Republic						20
63	Slovakia		162	-147			
64	Hungary			-2040			
91	Slovenia			109			6
600	Cyprus			79			1
	EU15 Totals						3639
	EU25 Totals			35083			4598

Table 12 above shows the apparent EU-consumption for CRT colour televisions and flat panel televisions in 1995, 2000 and 2004, calculated from Prodcom data. Table 13 below is an extract of those countries providing a complete data set for CRT colour TVs between 1995 and 2004.

Table 13: Apparent EU-consumption of CRT colour TVs (32303050), 1995-2004

		1995	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
5	Italy	197	222	-12345	-19678	-21695	-45576	66553	87152	31279	14660
6	UK	2515	142715	8855	10140	11754	3906	-161	5561	9356	49452
7	Ireland	3473	2243	3633	2542	2013	2425	1047	2040	12454	34736
9	Greece	8381	-28297	3893	-49880	-64939	-48038	-38695	0	0	-158871
10	Portugal	0	0	0	0	244	768	328	-2216	-1278	11716
11	Spain	2639	2488	7867	8860	6928	8085	9477	4196	30738	150224
30	Sweden	0	0	0	0	0	0	0	0	109	446

2.1.2. Conclusions EU statistics

2.1.2.1. Conclusions regarding data quality

In task 2.1 generic economic data have been derived from official EU statistics to place the product categories defined in task 1.1 within the total of EU industry and trade policy. In doing so several general difficulties of statistical data have to be taken into account:

- Official EU statistics don't provide data prior to 1995.
- Reliable and complete data sets for EU25 countries are available not until 2003, being the joining date of ten EU countries. Some statistical data before 2003 match EU15 data, whereas other data sets already integrate reported numbers of single candidate countries.
- Data can be derived from two separate statistics: Prodcom and EU-25 trade statistic. Both vary in the grade of differentiation of product categories as well as in nomenclature.
- To some extent, Prodcom data are too broad for the scope of this study. For example, Prodcom subsumes colour television projection equipment and video projectors in one product category which is not applicable as video projectors are out of scope.
- For Intra- and Extra-EU trade data, trade statistic delivers more precise results. Prodcom statistic provides no differentiation between Intra- and Extra-EU trades i.e. you can't identify if e.g. exports go to Intra- or Extra-EU countries.
- There occur several data gaps, especially for domestic production data. Several data has not been reported by various countries.
- Due to quite a number of difficulties in calculating apparent consumption data (see 2.1.2.5); it might be a challenge to take them as basis for further proceedings.

In this context, generic economic data derived from official European statistics rather can serve for a general comparison with 'real' market data than as a precise basis for further calculations of life cycle costs or environmental impacts planned in task 5.

2.1.2.2. Conclusions regarding generic economic data

Prodcom and EU trade statistic categories don't match exactly the product categories defined for the scope of the study. "Colour televisions with a video recorder or player" reflects "TV/Video Combination Units"; for the statistical categories "Colour television receivers with integral tube", "Flat panel colour TV receivers, LCD/Plasma, etc." and "Black and white or other monochrome television receivers" there is no detailed definition but they are assumed to fall into the category "TV-Set" with integrated screen and speakers. For the Prodcom category "Colour television projection equipment and video projectors", both TV-sets (e.g. rear projection TV) and TV Component Units as well as TV Peripherals (video projectors) could be meant.

Official statistics show that all product groups have a significant volume of Extra- and Intra-EU trade. Trade with CRT televisions (EU25 in 2004: 34 million imports, 24 million exports) is approximately seven times higher than for flat panel TVs (4,4 million imports, 3,1 million exports) or TV/Video Combination Units (4,1 million imports and 0,7 million exports). Even the relevance of monochrome TVs is in a similar dimension (2,9 million imports in 2004, and 0,7 million exports).

2.2. Current Market and Stock Data

The following market analysis intends to serve two purposes. Firstly, to give rationales supporting the definition of the product category, the particular product groups, and the hereby chosen structure of the base case assessments (see task 1.1). Secondly, to provide a basic economic data set for the assessment of "environmental significance" regarding the product category televisions. In order to project and assess environmental issues in the product category we will provide data on:

- **Annual unit sales:** Unit sales volume reflecting the market penetration of different display technologies and screen sizes.
- **Actual stock data**: Number of televisions in EU-25 households (installed base of primary and secondary used units), disposal rates or total tonnage of discarded televisions.
- **Average product life:** Usual lifetime of a device (technical life of the display), and typical replacement cycles and their changes.

The data should provide a profound picture for the mid term past (2000) and an estimate for the mid term future (2010). As required, this investigation will also reflect Kyoto Protocol reference years 1990 and 1995, and a long-term projection on the situation 2020.

The mid term market analysis is based on an own compilation of data from various public and non-public sources. The market data until year 2004 have been taken from the IPTS Report on "Environmental, Technical and Market Analysis concerning the Eco-design of Television Devices" (White et al.: 2006). Our market estimates derive from open source data of commercial market survey institutions like GfK, MEKO or DisplaySearch. These estimates are not coherent. The data available have different scopes regarding the definition of product categories and segments as well as the regional scope that they are cover. Market data also differ largely by publication data. We also discussed market trends with individual companies, however received partially contradicting assessments. At this point we like to make some general remarks on the market forecast. The current dynamics of the European television market does not allow a proper forecast even for the next 2 or 3 years. In that respect we are only capable of providing an analysis of broader trends rather than a highly detailed analysis of single market segments. On the other hand, this market analysis only serves the purpose of indicating significant changes in technology and screen size segments.

2.2.1. Television Annual Unit Sales

The Figure 1 below shows annual unit sales figures for the EU television market for the year 2000 until 2004 with an estimate for the year 2005 to 2010[10]. The diagram is differentiating three different display technologies (CRT, LCD, and PDP) as well as rear projection (RP) televisions as single market segments. At first the data show an overall increase[11] in product sales over the next five years. Secondly, this compilation indicates a fundamental shift towards flat panel television and LCD technology in particular.

Conventional CRT televisions, virtually the only television display technology in general use until 2000, is predicted to phase out over the next ten years. However, CRTs are still dominant in current sales due to the maturity of the technology which is manifested in high quality television pictures for a small price. A reason for the phase out is the introduction of new flat panel display technology, starting commercially about ten years ago. Light weight and capable of achieving larger screen sizes flat panel displays seem to clearly dominate further sales. Various commercial forecasts predict a 50% to 75% EU market share of flat panel television already by 2008.

The industry is expecting that LCD television will dominate sales in the mid term future. The market potential of PDP television might have to be reassessed, because some industry representative and market surveys are predicting a stronger growth that indicated in our estimate. At least for Europe, market forecasts do not see an increase in market share for Rear Projection televisions and other flat panel technologies over the next five years.

[10] Diagram 1 is an own compilation of data from various public and non-public sources. The data until year 2004 have been taken from: White et al. (2006): Environmental, Technical and Market Analysis concerning the Eco-design of Television Devices, IPTS (Institute for Perspective Studies) Report to the European Commission provided by AEA Technology in April 2006, Technical Report EUR 22212EN, Appendix 7 Market Analysis. The Estimates were made on data form: “9th DisplaySearch Forum” in: Iwai et al: FPD Saishindoukou. Tokyo, 2005; “GfK News” in: VDI Nachrichten 03-03-2006/Nr.9; and estimates provided directly form industry sources.

[11] Some companies expect a 20% increase of the overall European market until 2010, which reaches final saturation in the same year (Source: Company interviews, commercial market forecasts).

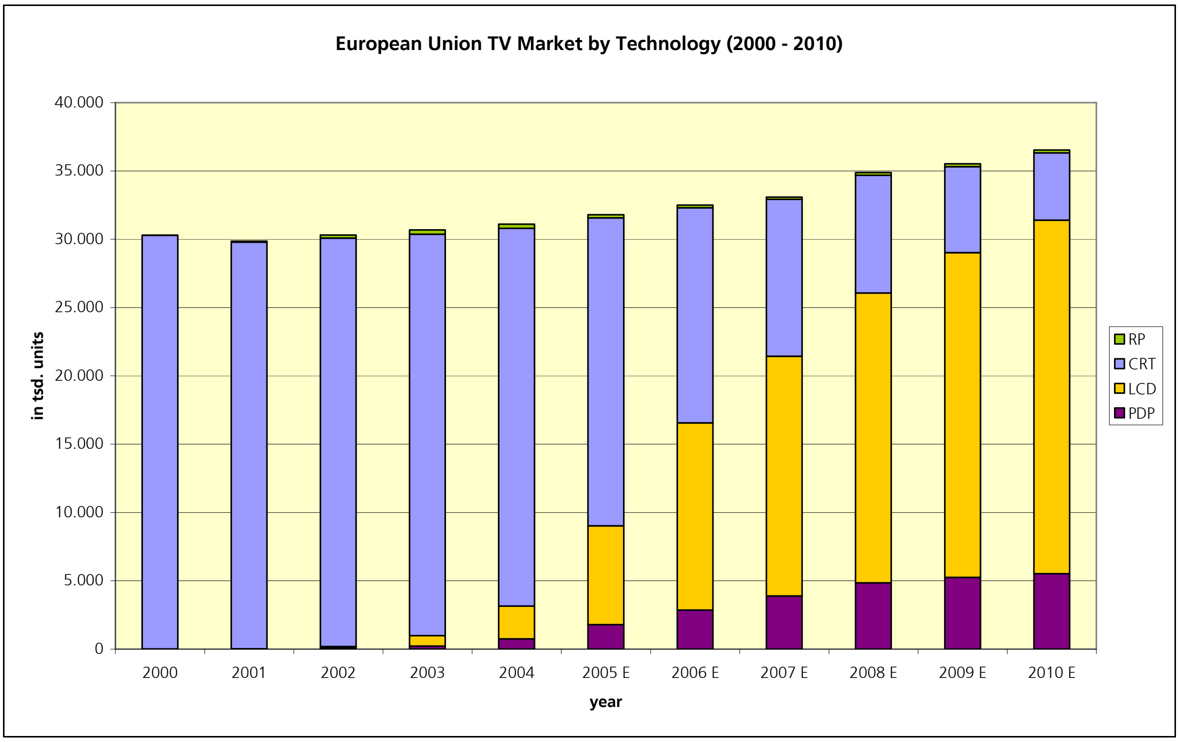

Figure 1: European Union TV Market by Technology 2000 - 2010

European Union Television Market by Technology 2000 - 2010 (in 1.000 Units)

	2000	2001	2002	2003	2004	2005 E	2006 E	2007 E	2008 E	2009 E	2010 E
PDP	8	18	73	224	756	1.796	2.863	3.894	4.862	5.257	5.518
LCD	5	16	109	770	2.402	7.232	13.694	17.530	21.194	23.759	25.889
CRT	30.270	29.753	29.901	29.374	27.630	22.536	15.743	11.493	8.613	6.293	4.907
RP	15	75	227	307	311	237	201	168	204	214	215
Total:	30.300	29.860	30.310	30.675	31.100	31.800	32.500	33.085	34.873	35.523	36.530

In terms of screen size most market surveys predict an increase in sales of medium to large size televisions. The Figure 2 is indicating this trend[12]. Whereas in the past the smaller sizes up to 26 Inch clearly dominated the market, this trend projection shows a steady increase of sales in the medium segment up to 39 Inch as well as a quite dynamic increase of sales for the large screen sizes. The trend towards medium and large screen televisions is driven by the maturity of flat panel display technologies, higher manufacturing productivity as well as related decrease in retail prices for flat panels (cp. task 2.3.2.1).

[12] Own compilation of market data and estimates based on the same sources as for the Diagram 1. The market data and estimates that were available had to be modified to the chosen screen size segmentation (e.g. 14”-26” for small screens). The sources in general did not provide this particular distinction pattern.

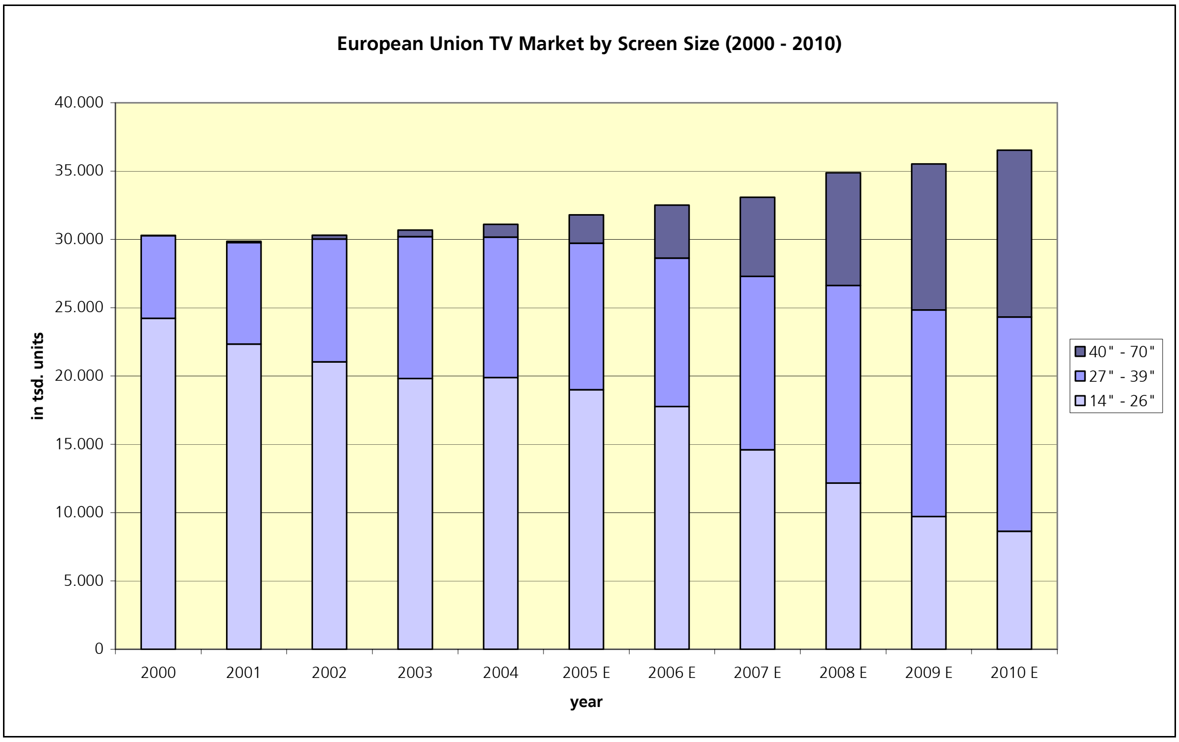

Figure 2: European Union TV Market by Screen Size (2000 – 2010)

European Union Television Market by Screen Size 2000 - 2010 (in 1.000 units)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
14" - 26"	24.221	22.331	21.039	19.817	19.881	18.988	17.765	14.609	12.162	9.716	8.640
27" - 39"	6.054	7.440	8.992	10.388	10.287	10.726	10.857	12.680	14.466	15.109	15.684
40" - 70"	23	91	280	471	931	2.088	3.879	5.796	8.245	10.698	12.205

Of interest for determining the significance of a particular market segment is also the correlation of technology and screen size. CRT television technology is limited in reaching larger screen sizes (excess of 36 Inch) by the weight of the TV and the required longer tube, which would result in a non-practically extended cabinet. Therefore, Rear Projection and FPD are the alternative. Figure 3 shows an own compilation for the EU television market 2000 to 2004 and an estimate for 2005 to 2010 in reference to different display technologies and screen size segments.

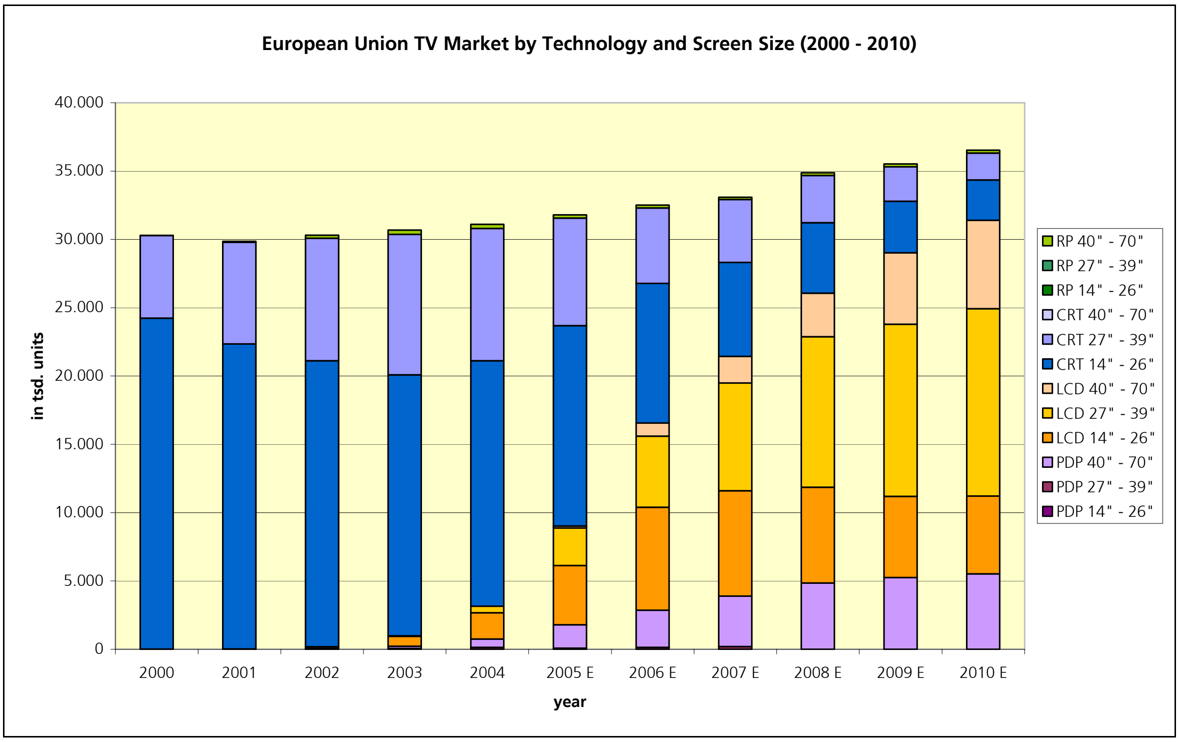

Figure 3: European Union TV Market by Technology and Screen Size Segments 2000 - 2010

European Union Television Market by Technology and Screen Size 2000 - 2010 (in % of total)

		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
PDP	14" - 26"	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	27" - 39"	5%	11%	28%	27%	18%	5%	5%	5%	0%	0%	0%
	40" - 70"	95%	89%	72%	73%	82%	95%	95%	95%	100%	100%	100%
total		8	18	73	224	756	1.796	2.863	3.894	4.862	5.257	5.518
LCD	14" - 26"	100%	100%	99%	94%	80%	60%	55%	44%	33%	25%	22%
	27" - 39"	0%	0%	1%	6%	20%	38%	38%	45%	52%	53%	53%
	40" - 70"	0%	0%	0%	0%	0%	2%	7%	11%	15%	22%	25%
total		5	16	109	770	2.402	7.232	13.694	17.530	21.194	23.759	25.889
CRT	14" - 26"	80%	75%	70%	65%	65%	65%	65%	60%	60%	60%	60%
	27" - 39"	20%	25%	30%	35%	35%	35%	35%	40%	40%	40%	40%
	40" - 70"	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
total		30.270	29.753	29.901	29.374	27.630	22.536	15.743	11.493	8.613	6.293	4.907
RP	14" - 26"	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	27" - 39"	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	40" - 70"	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
total		15	75	227	307	311	237	201	168	204	214	215

According to this forecast, the sales of medium size LCD televisions will gain the biggest market share over the next five years until 2010.

LCD televisions will account for the most significant market shares in all screen size segment. LCD has currently the best market potential due to a good price-performance ratio in comparison to competing technologies. The improvement of moving picture resolution, contrast and viewing angle are the most important performance drivers. The LCD TV industry is exploring all screen size segments and moves into the large segment as well. By size, the single strongest market segment in LCD TV is 32 Inch with a share of approximately 35% according to latest DisplaySearch data from November 2007[13].

CRT televisions sales might decline more rapidly as indicated in the tables above, however the price advantage and good picture quality in the small and medium screen size segment are factors that have to be taken into account when analyzing sales in the new EU member states, where the spending capacity of customers is considered lower. Unclear is the further development regarding slim CRT and picture quality (HD) due to the very mature technology. Most experts indicate no further technical development. According to a 2006 DisplaySearch report, China controls most of the global supply chain for CRT TVs, both slim and wide screen[14]. The technical development potential will depend on competition pressure in terms of picture quality and price in comparison to LCD. The currently excellent picture, low price and long lifetime gives CRT still a competitive advantage in the small to medium segments up to 34 Inch wide screen. By size, the strongest market segments in CRT TV seem to be 21/23 Inch.

PDP televisions market in a screen size range of 36 Inch and larger will increase over the next years[15]. PDP will have to compete with LCD and to some extent RP televisions in this growing segment. Industry and market surveys however indicate an incoherent picture of the development regarding the large screen size segment. The picture quality (HD) such as a clear moving picture and full color reproduction, the contrast with true black and white, are performance aspects, that will be considered by costumers when buying an expensive large screen TV. PDP has some advantages in this field but competition is strong and the price factor will also play an important role. By size, the strongest market segment in PDP TV is 42/43 Inch.

RP televisions market share is stagnant at low level. With the introduction of new technologies such as digital light processing (DLP), high temperature poly silicon (HTPS), and liquid crystal on silicon (LCoS) not only the size but also the brightness and overall picture quality improved. If the

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[13] http://www.displaysearch.com/free/paneltrack/
[14] http://www.displaysearch.com/free/China_TV_Market_Trends_by_Technology.pdf
[15] Although this trend is predicted in the forecasts it is interesting to notice that the Advanced PDP Develeopment Center Corporation (APDC) promotes the developemnt of small size full HD Plasma TV such as 27 Inch. APDC was established in July 2003 to co-develop basic technology for advanced PDPs in league with five (Japanese) PDP companies. http://www.advanced-pdp.jp

consumer market will response to these products is not clear yet. Commercial applications such as in police and traffic command and control centers are a growing market. By size, the strongest market segment in RP seems to be 50 Inch.

For the purpose of this study we have excluded the consideration of other **“disruptive” display technologies** that might enter the market in the mid-term. Some sources predict that OLED technology will gain significant market shares following the year 2010[16]. From our own research we conclude that it is very difficult to clearly predict future developments regarding this particular issue. In order to compete with more mature, established technologies, a manufacturer who has the intention to bring a new technology on the market must be able to mass produce this new display technology with high yield. Despite potential technical difficulties this requires considerable investments. A second aspect might be even more important and that is how to differentiate the new technology on the market. Picture quality and price performance are common criteria. Quality and price however are closely related to the maturity of technology and manufacturing processes. Therefore, when analyzing new display technologies it is important to examine technical features as well as the maturity of manufacturing technology.

[16] White, P.; Armishaw, M.; Dolley, P.;Harrison, R.; Graziano, T.; Lindblom, J.. Environmental, Technical and Market Analysis concerning the Eco-design of Television. Technical Report EUR 22212 EN, 2006; Market Transformation Program (MTP) BNTV01: Televisions: Future Stock and Energy Trends. Briefing Note Version 2.0, 2006.

2.2.2. Actual Stock Data

In this task we will provide stock data for TVs differentiated by technology and screen size for the years 1995 and 2003, and forecasts for the years 2010 and 2020. Whereas for the past data we have used available sources our forecast will include some considerations from our market and trend analysis.

Table 14 shows those statistical data which will be provided for the required stock analysis. At some places in the subsequently shown data there are slight differences in single figures due to rounding errors and different statistical sources.

Table 14: Terminology and Data Deduction

Parameter	Explanation
Sales [number of TV sets/year]	Sales data from different sources. EU25 data were not available. Against this background it was necessary to go back to deducted data. See tables below for details.
Share of technology in sales	Percentage of units sold in the different TV technologies considered.
Annual sales growth rate	Difference of sales volume from one indicated year to another.
Replacement sales [number of TV sets]	Replacement sales were derived from the overall sales volume minus the volume of new sales.
New sales [number TV sets]	New sales were calculated by multiplying the annual sales growth with the number of units sold in the specific year, assuming that sales growth indicate new sales in the saturated TV market.
Stock [number of TV sets]	Calculated from sales data, based on the assumed lifetime of TV sets being 10 years. The same method e.g. was used in Roth et al. 2002
Share of technology in stock	Percentage of units in stock of the different TV technologies considered.
Penetration rate [number of TV sets per household]	Calculated from number of TV sets in stock and data on household numbers in EU. For some years only data on EU15 were available; see tables below for explanation how EU25 data were generated.

2.2.2.1. Retrospect 1995

In order to provide a comprehensive picture of actual stock for television sets in the EU we first look at the situation of the year 1995 in retrospect. Table 15 and Table 16 are showing the required stock data for EU15+ (incl. Norway and Switzerland). EU15 was assumed to have 147 million households. Data for the new member states were not available for this year. In 1995 only CRT television-sets were on the market. The screen size categories do not follow exactly the categories defined in the project. This is due to lack of adequate data. The data derive from following sources: Huenges Wajer et al. 1998a and 1998b for data on TVs, and Eurostat 2003 for data on households. Product life time of the TV sets was assumed to be 10 years. As the penetration rate is over one TV per household, a certain share of households owns two TV sets: a main TV also called primary TV and a secondary TV. Basing on data from Huenges Wajer et al. 1998a and 1998b and EU 2003 in Table 17, figures are shown for the stock of primary and of secondary TVs in Europe (EU15+). In summary, the 1995 actual stock of CRT televisions in EU15+ was approximately 195 million units with 80% in the small screen size segment up to 26 Inch. Penetration rate in households were 1,32.

Table 15: 1995 data on CRT television sales, stock and penetration rate for EU15+

Retrospect 1995 EU15+	CRT
Sales [number of TV sets/year]	22.935.000
Share of technology in sales	100%
Annual sales growth rate [1994-1995]]	2,59%
Replacement sales [number of TV sets]	22.339.952
New sales [number TV sets]	595.048
Stock [number of TV sets]	194.580.000
Share of technology in stock	100%
Penetration rate [number of TV sets per household]	1,32

Table 16: 1995 data on CRT television sales, annual sales growth, stock differentiated by screen size

Restrospect 1995 EU15+	Sales volume	Annual Sales Growth (1994 – 1995)	Stock in 1995	Share of screen size in stock
CRT by screen size	**Number of TV sets/year**	**Percentage**	**Number of TV sets**	**Percentage**
<12"	735.000	4,3%	5.660.000	2,9%
12" - 26"	17.475.000	1,8%	153.060.000	78,7%
>26"	4.725.000	5,2%	35.835.000	18,4%
Total	22.935.000	2,6%	194.555.000	100%

Table 17: 1995 data on the overall stock of primary and secondary TV sets in households

Parameter	1995 / EU15+
Number of TV households	138.640.000
Primary TV set in stock, number of TV sets	140.270.000
Secondary TV set in stock, number of TV sets	54.310.000
Overall stock, number of TV sets	194.580.000
Number of color TV sets in stock	192.600.000
Percentage non color TV sets of stock	1,02%

2.2.2.2. Status Quo 2003

For the 2003 stock data shown in Table 18, a product lifetime of 10 years and 182.8 Million Households (2002) in EU25 were assumed for calculation. As Sources the following data were used: White et al. 2006, Huenges Wajer et al. 1998a and 1998b; population data: Eurostat 2003 with an addition of 13.8 % households, according to the share of the new member states in households in 2002 (EU 2003, p. 147). New member states were not considered in Eurostat 2003. The data of White et al. 2006 base on data for UK that were up scaled for the whole EU25 (including Norway and Switzerland) by using population numbers as parameter. Additionally White et al. 2006 used a correction factor concerning velocity of uptake of new technologies and increase of penetration of TV sets in households. It was assumed e.g. that the sales of CRTs in the UK will decrease rapidly in the next years whereas in the whole EU25 the shift towards other technologies will be slower. White et al. 2006 had access to industry data and could that way integrate knowledge and expectations of different producers into their projections.

Table 18: 2003 data on CRT, LCD and PDP television sales, stock and penetration rate for EU25+

Status Quo 2003 EU25+	CRT	LCD	Plasma	Total
Sales [number of TV sets/year]	29.681.130	769.943	223.928	30.675.000
Share of technology in sales	96,76%	2,51%	0,73%	100,00%
Annual sales growth rate [2001 – 2002]]	-1,48%	605,62%	207,83%	1,20%
Replacement sales [number of TV sets]	29.681.130	286.167	-	30.305.605
New sales [number TV sets]	-	286.167	83.228	369.395
Stock [number of TV sets]	269.971.292	905.459	318.250	271.195.000
Share of technology in stock	99,55%	0,34%	0,12%	100%
Penetration rate [number of TV sets per household]	1,48	0,005	0,002	1,48

In the overall TV stock LCD and Plasma TV only make up less then 1% with an emphasis on small screens (LCD) and larger screens (Plasma) respectively. Annual sales growth from 2002 to 2003 of 613% (LCD) and 203% (Plasma) let expect an increasing share for the future. The absolute sales volume still is small compared CRT TVs. In Table 19 sales and stock data for 2003 are shown differentiated by screen sizes. LCD screens with sizes up to 21" have the highest sales volume. Whereas the highest sales volume for Plasma TV sets lays in the range of 41-49". Due to lack of adequate data the screen size categories differ slightly from the defined categories in the project. Due to lack of data, the screen size in stock of CRT could only be assumed. The assumption was based on the particular share of sales of the previous years.

Table 19: Data on TV sets by screen size and technology in 2003 EU25+.

Status Quo 2003	Screen size	Sales volume	Annual Sales Growth (2002-2003)	Stock in 2003	Share of screen size and technology in stock
TV sets by screen size		**Number of TV sets/year**	**Percentage**	**Number of TV sets**	**Percentage**
PDP	14-35"	40.000	150%	59.000	0,02%
PDP	>36"	184.000	217%	266.000	0,10%
LCD	14-32"	768.000	611,00%	897.000	0,33%
LCD	>=33"	2.000	-	2.000	0,00%
CRT	14" - 26"	20.930.700	-8,8%	222.726.316	82,1%
CRT	27" - 39"	8.970.300	14,6%	47.244.976	17,4%
CRT	40" - 70"	0	-	0	0,0%
Total	**-**	**30.675.000**	**1,2%**	**271.195.000**	**100%**

In summary, the 2003 actual stock of CRT televisions in EU25+ was approximately 270 million with other technologies accounting for less than 1%. The small screen size segment up to 26 Inch dominated the market with over 80%. The penetration rate in households grew and is calculated with 1.48%.

2.2.2.3. Prospect 2010

For the calculation of the 2010 stock data shown in the table below various assumptions were necessary. The actual stock data are based on sales data for the years 2001 until 2010 (10 years) and a product lifetime of 10 years. Over this time period the overall market sales increased 20%. The replacement of devices (after 10 years) however was not calculated by 100%. We figured that the market increase of 20% reflects an earlier replacement of devices due to the introduction of new flat panel display technology as well as secondary usage of products in the households (e.g. for children or in the bedrooms). Following this consideration we therefore calculated that only 80% of the products (all CRT) were replaced. For the year 2010 this means that we accumulated the sales volume since 2001 and added 20% to the sum in order to calculate the actual stock. In order to determine the household penetration rate we assume 193,4 million households in EU25. It has to be said that this approach to calculate the actual stock and penetration rate includes a high factor of simplification. In reality we have to deal with multiple purchase and use patterns. However, we should also keep in mind the purpose of this task; the documentation of economical and environmental significance of the product category televisions.

Table 20: 2010 data on CRT, LCD, PDP, and RP television sales, stock and penetration rate for EU25

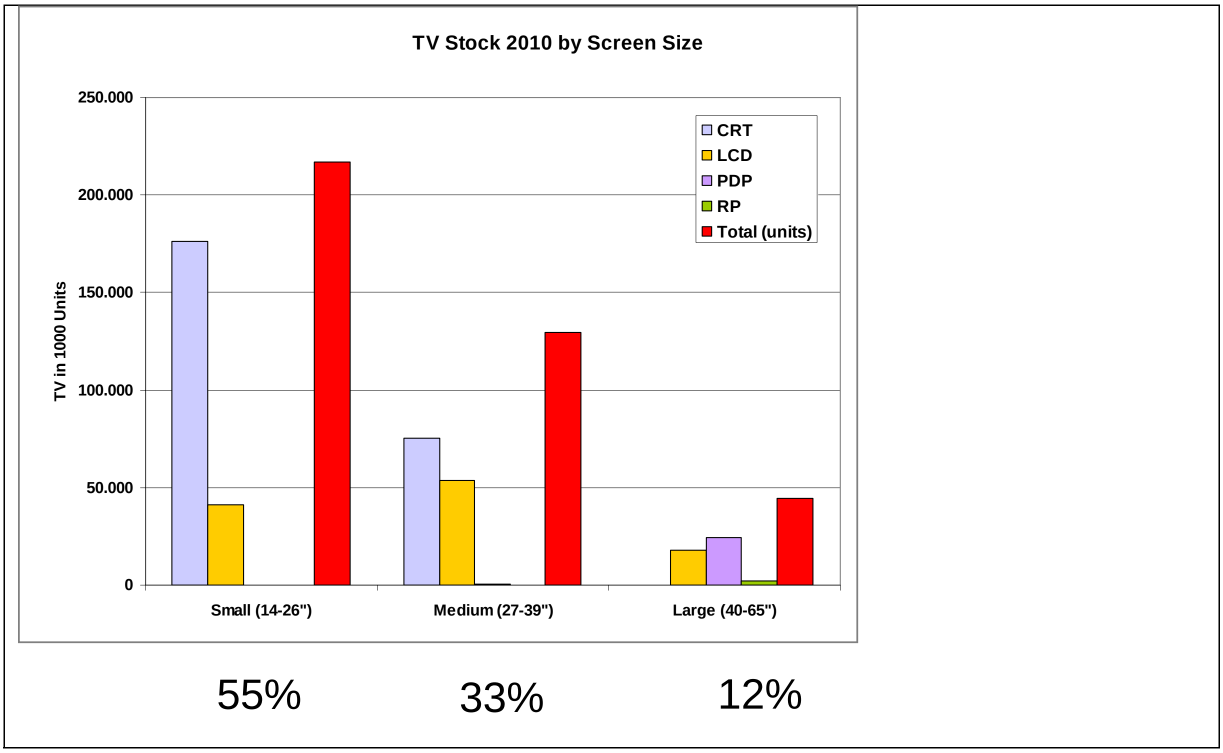
Prospect 2010	CRT	LCD	PDP	RP	Total
Sales in 2010 [number of TV sets/year]	4.907.000	25.889.000	5.518.000	215.000	36.530.000
Share of technology in sales 2010	13,4%	70,9%	15,1%	0,6%	100,00%
Annual sales growth rate [2009 – 2010]	-22,1%	+8,9%	+4,9%	+0,5%	+2,8%
Accumulated sales 2001 – 2010 (100%) [number of TV sets]	186.243.000	112.595.000	25.260.000	2.159.000	326.256.000
Accumulated sales 2001 – 2010 (120%) [number of TV sets]	223.491.000	135.114.000	30.312.000	2.591.000	391.513.000
Stock in 2010 Replacement in CRT only [number of TV sets]	251.499.000	112.595.000	25.260.000	2.159.000	391.513.000
Share of technology in stock 2010	64,2%	28,8%	6,5%	0,5%	100,00%
Penetration rate 2010 [number of TV sets per household / 188 million]	1,34	0,59	0,13	0,01	2,02

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2001 - 2010
PDP 100%	18	73	224	756	1.796	2.863	3.894	4.862	5.257	5.518	25.260
PDP 120%	**21**	**87**	**269**	**907**	**2.155**	**3.435**	**4.672**	**5.835**	**6.308**	**6.622**	**30.312**
LCD 100%	16	109	770	2.402	7.232	13.694	17.530	21.194	23.759	25.889	112.595
LCD 120%	**19**	**131**	**924**	**2.882**	**8.678**	**16.433**	**21.036**	**25.433**	**28.511**	**31.067**	**135.114**
CRT 100%	29.753	29.901	29.374	27.630	22.536	15.743	11.493	8.613	6.293	4.907	186.243
CRT 120%	**35.703**	**35.881**	**35.249**	**33.157**	**27.043**	**18.891**	**13.792**	**10.335**	**7.551**	**5.889**	**223.491**
RP 100%	75	227	307	311	237	201	168	204	214	215	2.159
RP 120%	**90**	**273**	**368**	**374**	**284**	**241**	**201**	**244**	**257**	**258**	**2.591**
Total 100%	29.860	30.310	30.675	31.100	31.800	32.500	33.085	34.873	35.523	36.530	326.256
Total 120%	**35.832**	**36.372**	**36.810**	**37.320**	**38.160**	**39.000**	**39.702**	**41.848**	**42.628**	**43.836**	**391.507**

Sales and stock data differentiated by screen size and technology are shown in the subsequent Table 21. Small screen sizes are still dominating the stock with approximately 55%. The medium screen size segment is steadily growing and reaching approximately 33% in 2010. The large screen sizes are the smallest segment with approximately 12% share. Regarding the penetration rate of different display technologies we still have 64% CRT in the households, followed by 29% LCD and 7% PDP televisions. This configuration will change towards flat panels. In consequence we will see an increase in discarded FPD in the subsequent years.

Table 21: Data on TV sets by technology and screen size in 2010 EU25+.

Prospect 2010	**Screen size**	**Sales volume**	**Stock in 2010 per technology**	**Stock in 2010 per screen size**	**Share of screen size and technology in stock**
TV sets by screen size		**Number of TV sets in 2010**	**Number of TV sets in 2010**	**Number of TV sets in 2010**	**Percentage**
PDP	14" - 26"	0		0	0
PDP	27" - 39"	0	25.260.000	646.500	0,17%
PDP	40" - 70"	5.518.000		24.614.000	6,29%
LCD	14" - 26"	5.695.580		40.982.500	10,47%
LCD	27" - 39"	13.721.170	112.595.000	53.702.000	13,72%
LCD	40" - 70"	6.472.250		17.910.000	4,57%
CRT (70%)	14" - 26"	2.944.200		176.049.000	44,97%
CRT (30%)	27" - 39"	1.962.800	251.499.000	75.450.000	19,27%
CRT	40" - 70"	0		0	0
RP	14" - 26"	0		0	0
RP	27" - 39"	0	2.159.000	0	0
RP	40" - 70"	215.000		2.159.000	0,55%
Total	-	**36.529.000**	**391.513.000**	**391.513.000**	**100,00%**



2.2.2.4. Prospect 2020

The projection of actual stock data for the year 2020 is complicated and must be seen under reserve. One should be aware of the fact that technology in consumer electronics develops fast and the innovation cycles are short. To predict the influence of so called disruptive technologies is very difficult keeping in mind that we have to look 15 years ahead. In order to provide some data we have based our calculation of the 2020 stock data on following estimates.

We again assume an average product lifetime of 10 years and projected the TV stock based on a correlation of an assumed penetration rate of 2,1 and 195,6 million households in EU25 by 2020. This results in an average stock of 410 million TV sets in EU-25 households. Regarding the distribution of display technologies we have made very rough assumptions based on the projected sales figures. Table 22 and Figure 4 summarize the EU-25 TV stock data for the reference years 2005, 2010, and 2020.

Table 22: Summary of EU-25 TV Stock for the reference years 2005, 2010, 2020

	CRT	LCD	PDP	RP (other)	Total	Penetration
2005	261,3	10,5	2,9	1,2	275,9	1,4
2010	251,5	112,5	25,3	2,2	391,5	2,0
2020	41,1	225,9	102,7	41,1	410,8	2,1

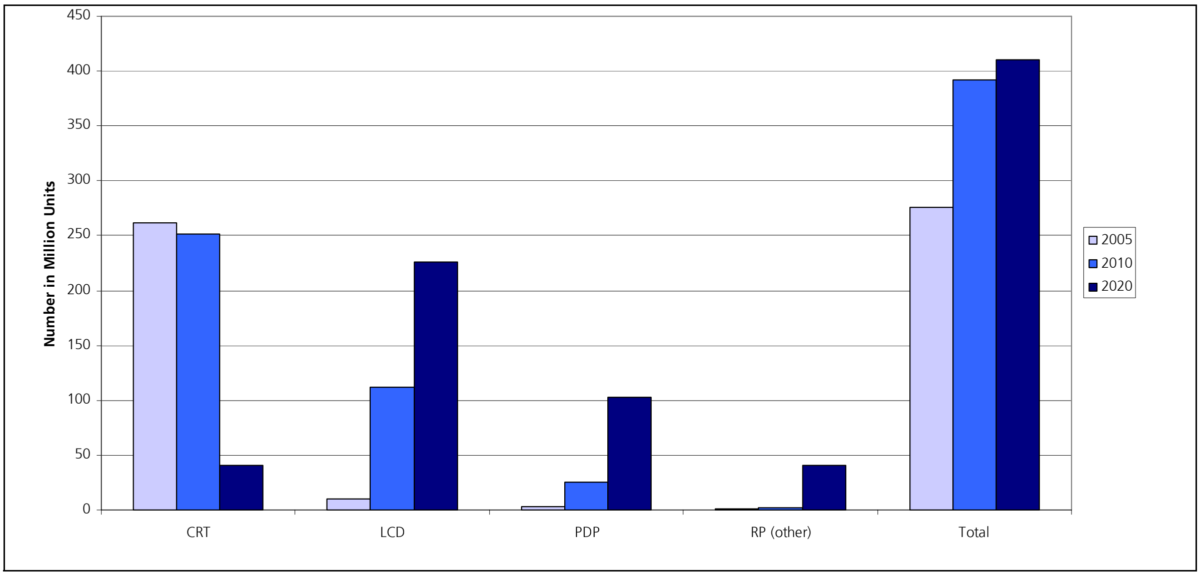


Figure 4: Summary of EU-25 TV Stock for reference years 2005, 2010 and 2020

2.2.2.5. Television Product Life Time

In literature product life of TV sets is cited to be between 7 years (MTP 2006a) and up to 15 years (NAEEC 2004). A range of literature sources is shown in the subsequent table. Adjustments with sales and stock data make believe that the time TV sets are in use is rather near to 10 rather than to 7 years. Although the literature sources refer to different countries no data are available that would give a sound picture of product life of televisions in the different countries of EU25. Likewise there are no data available that differentiate between the time the products are in service and the overall product life.

Table 23: Data from literature on the product life of TV sets

Technology	Product life time [years]	Mean age in stock [years]	Country	Source
Existing stock	10 - 15	8 - 9	Australia	NAEEC 2004
CRT	11	-	USA	Rosen and Meier 1999
CRT	10	-	Germany	Strubel et al. 1999
CRT	8	-	EU25	White et al. 2006
CRT, LCD, Plasma	7	-	UK	MTP 2006a

Differences between primary and secondary TV sets: Data from UK (MTP 2006a) indicate that falling prices and the demand for the latest TV models and features have led to a lifestyle purchasing of TV sets: The purchase of a new primary television is triggered by the old one being out-dated rather than malfunctioning. Thus this leads to shorter periods of product use. A telephone survey from 2004 showed that primary TV’s were replaced after 4.9 years in average (MTP 2006a). Secondary televisions are still being used as long as they function. For whole EU25 the trend seen in UK probably can be expected to be weaker and be delayed by several years. Still it is to be expected that product life of TV set will decrease in future due to changes in consumer behaviour.

2.3. Market Trends

Technology and related market trends have been investigated and discussed with representatives from leading display panel and television manufacturers. We also consulted experts from market research institutions. As a result of this research we conclude that the television market is currently under the condition of a tremendous shift. This shift has such a dimension that the situation five year ago will hardly be comparable to the situation five years from now. Figure 5 is illustrating this general market trend over a ten year period from the 2000 to 2010.

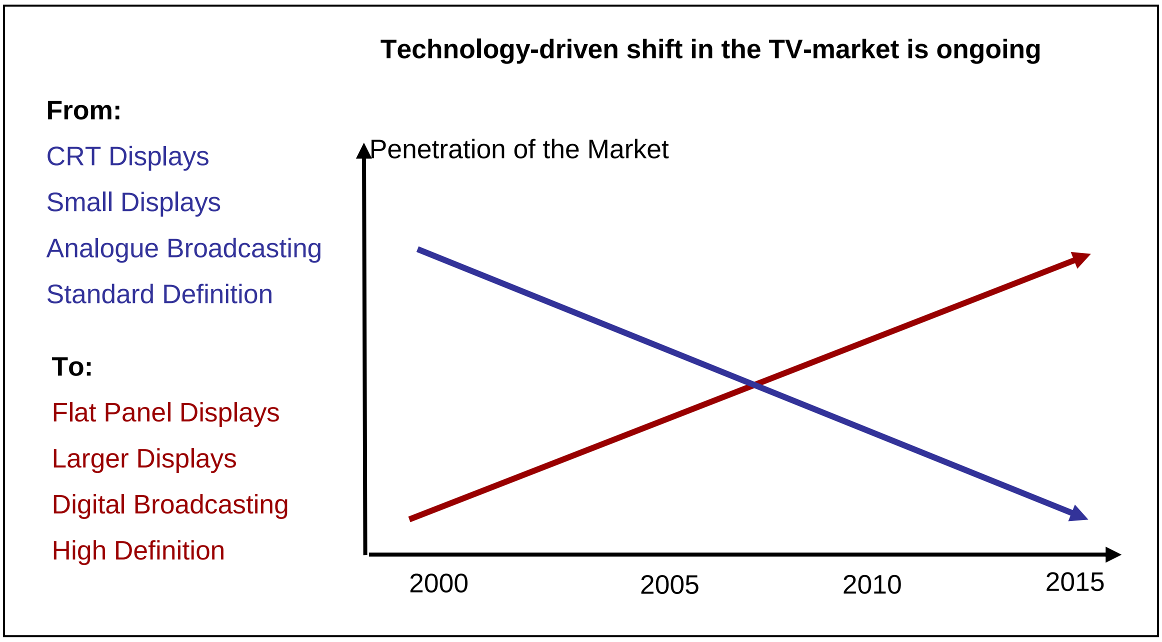


Figure 5: Technology Shift in the TV market

The fundamental shift we can currently observe is mainly driven by the dynamics of technology change. There are three main factors to mention that influence market development:

- Flat Panel displays
- Larger Screen Sizes
- Digital television broadcasting
- High resolution television (HDTV)

The following analysis will provide more detailed technical and economical information on the current developments as well as discuss general consequences of these technology and market trends from an environmental point of view. There are some constraints that should be mentioned regarding the assessment of technology trends. Under the dynamic situation in which established technologies are further developed as well as new (disruptive) technologies emerge today it is fairly difficult to give a precise evaluation of the mid to long term situation. Assessments regarding market potential of certain technologies are changing rapidly. Slightly older studies on a particular technology might be totally outdated although feasible at the date when they were compiled. For the purpose of this study we have focused on the most recent publications available as well as taken arguments form direct consultation with industry and other experts into consideration.

2.3.1. New Display Technologies

Flat Panel Displays (FPD) and to some extent Rear Projection (RP) technologies have increasingly entered the European television market over the past five years. A phase out of conventional Cathode Ray Tubes (CRT) television is predicted for the mid to long term (cp. task 2.2.2.1). In comparison to the situation of the past, where CRT was the only technology, we are now facing the situation of competing display technologies in the television market. Although currently only two major flat panel display technologies, Liquid Crystal Display (LCD) and Plasma Display Panel (PDP), have entered the market, there are potentially more display technologies under development such as Organic Light Emitting Diode (OLED) or Field Emission Display (FED) that show excellent optical properties as well as energy efficiency, and which might enter the market in the future. If such technologies are competitors to LCD and PDP in the mid to long term future will depend on a range of technical and economical factors that are discuss in task 6. Table 24 gives an overview of display technologies suitable for televisions.

Table 24: TV display technologies

TV display technologies			
Market Category	**Abbr.**	**Technology**	**Types**
CRT TV			
(Self-Emissive)	CRT	Cathode Ray Tube	regular, flat type
Rear Projection TV			
(Non-self emissive)	HTPS	High Temperature Poly Silicon	LCD type
(Non-self emissive)	DLP	Digital Light Processing	DMD type
(Non-self emissive)	LCOS	Liquid Crystal On Silicon	e.g. D-ILA, SXRD
Flat Panel Display TV			
(Non-self emissive)	LCD	Liquid Crystal Display	a-si TFT type
(Self-Emissive)	PDP	Plasma Display Panel	
(Self-Emissive)	FED	Field Emission Display	e.g. SED (SCE, CNT types)
(Self-Emissive)	EL	Electro Luminescence	e.g. OLED, Non-OLED
(Self-Emissive)	VFD	Vacuum Fluorescent Display	

The brief analysis that is following will discuss current developments in picture performance and product features. At this point we will not examine all technological aspects but rather indicate qualitative differences and trends in the most common display technologies such as CRT, LCD, PDP and rear projection technologies.

2.3.1.1. High Picture Quality

The competition in today's TV market is driven by the improvement of various performance characteristics, which can be distinguished form factors and picture as well as sound quality factors. Form factors are the dimensions and weight of a TV as well as the options to mount the device or and accessories. Picture performance or quality factors comprise:

- High brightness
- High contrast ratio, color reproduction and smooth gradation
- High moving and still picture resolution (full HD with 1920 x 1080 pixels)
- High viewing angle and no reflections

High brightness is clearly recognizable if the TV picture is view from a distance or under bright light conditions. The brightness is reduced by squared distance. LCD TV due to there backlight system provide constantly peak brightness. In contrary, PDP TV with a still low luminescence efficiency causes less brightness and this is directly correlated to their higher power consumption (higher brightness/higher power consumption). PDP manufacturer therefore are targeting to improve the panels in order to realizing luminous efficiency of 5 lm/W to even 10 lm/W, which is 2.5 times that of existing products.[17] PDP manufacturer also argue that the technology based dynamic brightness control is less stressful to the human eye.

High contrast ratio, color reproduction and smooth gradation are important in order to improve the visual image. All manufacturers try to improve contrast and color reproduction in order to display true black and white as well as the full range of colors with all nuances present in a TV or video image. The improvement of contrast characteristics focuses on a better contrast under bright room conditions (200 lux) with a ration of 500:1 or higher.

High moving and still picture resolution for reproduction of fast moving video images is an important aspect when watching sports programs or action movies. PDP show good performance in that respect and their manufacturers describe this aspect as a weakness of LCD panels. However LCD TV manufacturers are improving the animated response speed continuously in order to overcome this problem of shadowing. Still picture resolution is determined by the size and number of pixel. Full high definition is a target for all manufactures in the medium and large screen size

[17] http://www.advanced-pdp.jp/english/apdc/greet/index.html

segments and first models have been introduced in 2006. LCD and PDP manufacturers are working on new technologies to create smaller cell sizes and a higher density.

High viewing angle and no reflections are important for a TV when used by a group of people like by a family in the living room. PDP have the advantage of a good viewing angle however the thick front glass panel[18] can cause reflections LCD on the other hand have been known for a poorer viewing angle performance but latest models show strong improvements in this field.

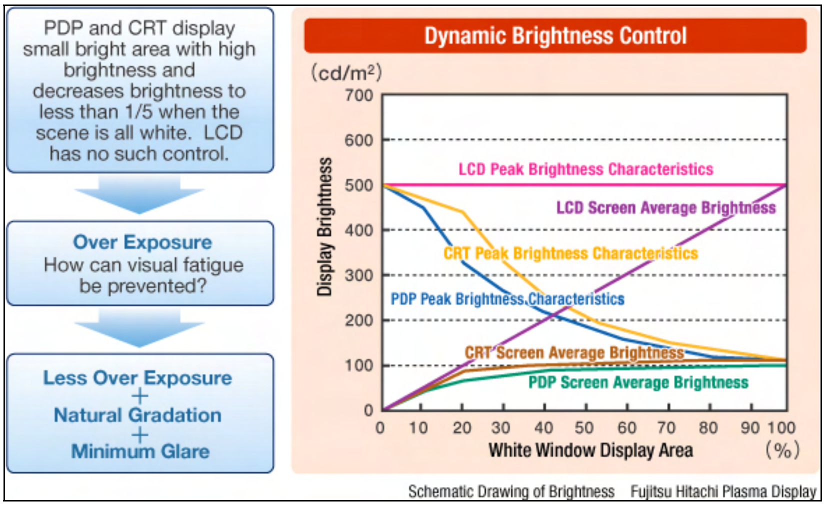


Figure 6: Difference in screen brightness (Scource: APDC)

2.3.2. Digital Television Broadcasting

Digital television broadcasting whether terrestrial, via cable or satellite has tremendous effects on television devices. Many countries currently provide a simulcast service which offers users both analogue and digital television at the same time. As planned transition to digital television continuous it is likely that the existing analogue services will be removed over the next five to ten years. Therefore digital television will ultimately replace the analogue systems in Europe and later in the entire world.

The digital transmission allows transporting more information while requiring the same bandwidth as analogue standard do due to new compression algorithms such as MPEG-2[19]. This quality not

[18] In order to avoid ultraviolet and electromagnetic emissions PDP TVs feature a relatively thick (ca. 3mm) soda lime glass, which is also more heavier than the thin (0.7mm) non alkaline glass of a LCD.
[19] MPEG2: „Motion Picture Experts Group“ it define a coding and compression standard for video and audio to broadcast-quality television

only offers a wider range of channels but also a better quality of TV signals given distribution network bandwidth. One terrestrial channel is able to send up to 4 digital programs in addition to the actual program as well as additional information with nearly the same signal quality. This development marks a trend that is similar to the development on the video sector (e.g. additional information for movies on DVD´s). When using MPEG-2 compression methods only the changes between frames are send. Consequently the transmission speed is raised and the amount of data is reduced. Digital television produces pictures with a higher resolution than traditional analogue television with the benefit of digital surround sound and the possibility of high definition television[20]. Further add ones of digital TV combined with a return channel offer(s) a wide range of interactive services like interactive TV, an electronic program guide (EPG), video on demand (VOD) or Pay TV. Interactive TV defines a lot of new marked concepts for TV: there will be the possibility to implement voting on game shows or to get information about the accessory of movie stars.

There are different existing standards for digital television such as Digital Video Broadcasting (DVB), Advances Television System Committee (ATSC) and Integrated Services Digital Broadcasting (ISDB). Table 25 shows a summary of key functions of these standards and their application range.

Table 25: Digital video broadcasting specifications (Source: Peng, 2002)

Standard	System type	Video coding	Audio coding	Modulation scheme	Channel bandwidth	Bit rate (Mbps)	Adopted countries
DVB	DVB-S	MPEG-2	MPEG-2/1 digital sound	QPSK	8 MHz	38	All European countries, Australia, New Zealand, Russia, etc.
	DVB-T			QPSK/QAM/OFDM		24 15 (Mobile)	
	DVB-C			QAM		38	
ATSC	ATSC-T	MPEG-2	AC-3	8 VSB	6 MHz	19.28	North America, South Korea, Taiwan, Mexico, Argentina, etc.
	ATSC-C					38.57	
ISDB	ISDB-S	MPEG-2	MPEG-2 AAC	TC8PSK/QPSK/BPSK	34.5 MHz	52	Japan
	ISDB-T			DQPSK/QAM	5.6 MHz	21.47 4.06 (Mobile)	
	ISDB-C			64QAM	6 MHz	31.644	

All European countries have recently adapted to the DVB standard. DVB defines transmission standards for Cable TV (DVB-C), Satellite (DVB-S), terrestrial (DVB-T) and Handheld TV (DVB-H). More than 260 broadcasting stations, manufactures and companies specialized in network distribution from more than 35 countries are part of the DVB-Project, defining a new worldwide digital standard.[21]

[20] see also HDTV on page 3
[21] DVB Project: http://www.dvb.org/, 19.10.2006

Referring to the European household survey, 50% of EU 25 households use antennas to receive their TV program, 33% using cable TV and 22% using satellite TV.[22] Only 5% of the EU 25 households are using digital TV with room or house antenna. This survey shows possible marked segments for TV–broadcasting in Europe. At least, dispensation can be very diverse from one country to another. In Spain the terrestrial TV is used by 90% of households while only 9% use cable TV. On the contrary in Germany 5% of households use terrestrial TV and 56 % cable TV.

2.3.2.1. DVB-T

In 2008 the penetration rate of digital terrestrial TV in Germany will have reached 90% of German households[23]. Other EU-States like Spain, Italy or GB changed to simulcast with DVB-T and Pal Signal. The table below shows the timeline of different EU-States for switching from analogue terrestrial TV to DVB-T TV.

Country	**Official launch**	**Closedown finished**
Belgium	2002/2003	?
Denmark	2006	2009
Finland	2001	2007
France	2005	2011
Germany	2002	2008
Greece	2006	?
Italy	2004	2012
Netherland	2003	2007
Portugal	2006	2012
Spain	2000	2010
Sweden	1999	2007
Switzerland	2001	2009
United Kingdom	1998	2012
Austria	2006	2010

The reasons why all EU-States switch their broadcast transmission types are the big benefits of this new technology. These benefits lie mainly in the greater range of programs and each with higher

[22] E-Communications Haushaltsumfrage: http://ec.europa.eu/public_opinion/archives/ebs/ebs_249_de.pdf, 19.10.2006
[23] http://www.ueberallfernsehen.de/, 05.09.2006 / BMWA; Digitaler Hörfunk und digitales Fernsehen in Deutschland, Digitaler Runfunk im 21. Jh., 2005. (http://www.bmwi.de, 05.09.2006)

quality. In many areas of Europe only the public TV stations send their program by DVB-T. That reduces the power used for the transmission in comparison to analogue transmission.

Concerning the customer it is to be said, that he requires new receiving units. As already shown, the digital signal are encoded by MPEG and have to be decoded and modulated to analogue signals for the existing analogue TVs. Today, most costumers use digital television via a set-top box, which decodes the digital signals into signals that can be read by analogue televisions. In 2006 leading manufactures have started to integrate this function into television sets as digital tuners. However, multiple tuners are currently necessary depending on the means (terrestrial, cable, satellite) by which the television broadcast is received. The integration of the digital tuner into the television set is one market trend. A more modular approach (set-top-box) by separating the receiver/decoder unit (and maybe other digital functions such as video recording/replay) from the television display shows another trend.

2.3.2.2. DVB-H

To underline these trends the focus should also take on DVB-H, DVB-S and DVB-C. DVB-H is closely connected to DVB-T standard that comes with the advantage of 30 to 40 programs per channel and each with a data rate of 400Kbit/s[24]. This could mark a new direction for terrestrial TV because technical specification of DVB-H provides more advantages for private broadcasters than DVB-T. Presently, DVB-H is tested in England, Germany and France. In consequence the application of handheld TV is very demanding on mobile technology. Small displays have to be brighter and to have a higher contrast while power consumption is increased only minimal. One option would be to put a further afford in the development OLED technology and on mobile phones with OLED displays already on the marked. Secondly, the sources for mobile applications have to be more efficient.

2.3.2.3. DVB-C

The digital standard has been developed for cable networks. Yet it is not very common in Europe because most countries in Europe have concentrated on satellite TV. Nevertheless, in some countries such as Germany cable network is very important for TV broadcasting, according to the European household survey. Program in DVB-C is encoded in MPEG-2 and modulated with

[24] Technology Review Nr.9 09/2005 “Fokus Fernsehen von Morgen” page 80.

different QAM[25] standards. In relation to DVB-T and DVB-S the digital TV via cable has teething troubles. Regarding to sales units of Set-Top-Boxes, DVB-t and DVB-S units are sold four to five times better than DVB-C STB. In Germany sale rates for DVB-T and DVB-S units are 4 to 5 times higher than DVB-C Set-Top-Boxes[26].

On the one hand this is a matter of expense on the other hand there is only a small range of offered programs. During the first transfer phase only the public TV-stations and pay TV push their program digital on cable. Since the beginning digital programs were encoded and only public programs were free of charge. That caused a lot of different encoding technologies with different hardware, such as the integration of a Common Interface (CI) and a Conditional Access Module (CAM). It is to be expected that there will be standing charges additional to installation charges. Cable providers know about this problem and therefore follow a new market strategy called “triple play”. Combined with TV and radio services they also offer broadband internet and telephone services. Bundles of this form, that combines Telecommunication broadcasting and internet in one product, supply a distribution channel for TV (IPTV).

2.3.2.4. DVB-S to DVB-S2

Digital satellite TV (DVB-S) is the central technological base for digital TV and HDTV. DVB-S furthermore has the big advantage of having a greater frequency range than other DVB-standards, such as DVB-H, DVB-T. The data will be encoded in MEPG2 and modulated with QPSK. DVB-S2 is a subsequent technology to DVB-S with a higher compression rate (MPEG-4 AVC) and a better error correction. This standard has the same problems with hardware decoder as do DVB-C but at this moment all programs except of pay TV are free of charge. In the future it will be possible to pay for digital programs via a technical tax. DVB-S2 has a high potential for becoming the main transmission path for the digital TV of the future including HDTV.

In analogy to the development and the distribution of PCs a study called “TV 2010 Reloaded” analyzed the development and distribution of digital TV in Europe. Regarding to this study the switch-off for analogue TV in industrial countries is set between 2010 and 2013.[27] This presumption could increase the average power consumption for terrestrial TV due to the necessity of having an integrated digital tuner or external digital tuner (STB).

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[25] QAM: Quadrature amplitude modulation, it is a modulation scheme which conveys data by changing the amplitude of two carrier waves

[26] gfu, consumer electronic market in germany: http://www.gfu.de, 20.10.2006.

[27] Becker, Thomas; Hauptmaier, Helmut: TV 2010 Reloaded, Neunkirchen, 2005. http://www.sceneo.tv, 20.10.2006.

2.3.2.5. Internet Protocol Television (IPTV)

Furthermore a new transmission path for TV is the combination of the IT-Technology with digital broadcasting. One way is MHP[28] standard for interactive television (iTV), another one is the new technology of IPTV. IPTV defines the transmission of moving pictures over the broadband internet to a TV or a computer. It contains "On Demand Services" such as video on demand also like broadcast services. Figure 7 below points out a typical configuration for IPTV supplied household.

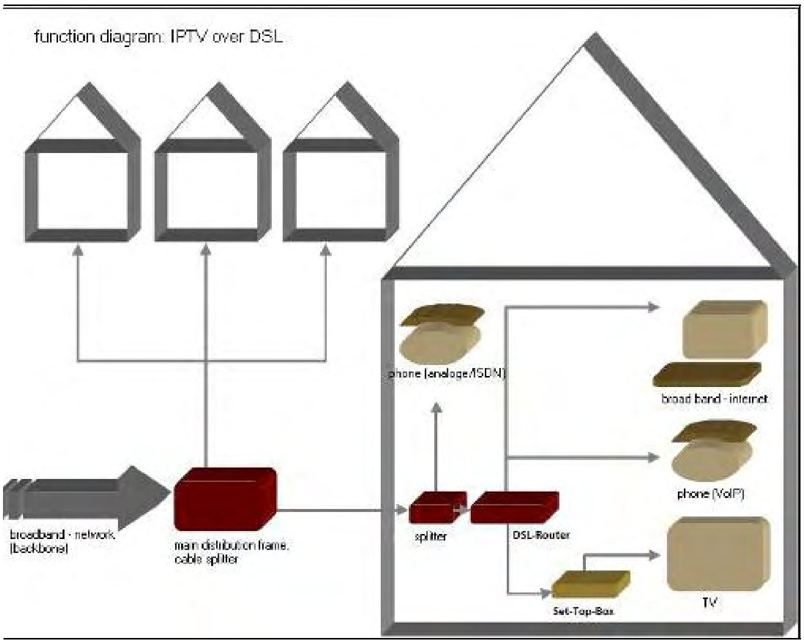


Figure 7: Typical configuration of IPTV 2010 (source: Goldmedia 2006)

As already mentioned in chapter (DVB-C), cable providers use the new market strategy of triple play. This strategy creates a new business competing to telecommunication providers. The reaction of telecommunication companies is IPTV – in order to offer a triple play themselves. Due to rising data rates from the telecommunication network up to 28 MBits/s (France) over DSL, today IPTV with an amount of 100 TV-Channel, is already worked on in some countries like France and Italy. Regional distinctions are tremendous. Only France supplies more than 500.000 households with IPTV[29] since 2005. The situation is similar in Italy and Spain. In Germany, only in some regions IPTV is available. Since spring 2006 the test phase of VDSL from Deutsche Telekom started. A market survey of “Goldmedia GmbH Media Consulting & Research” shows an annual growth rate

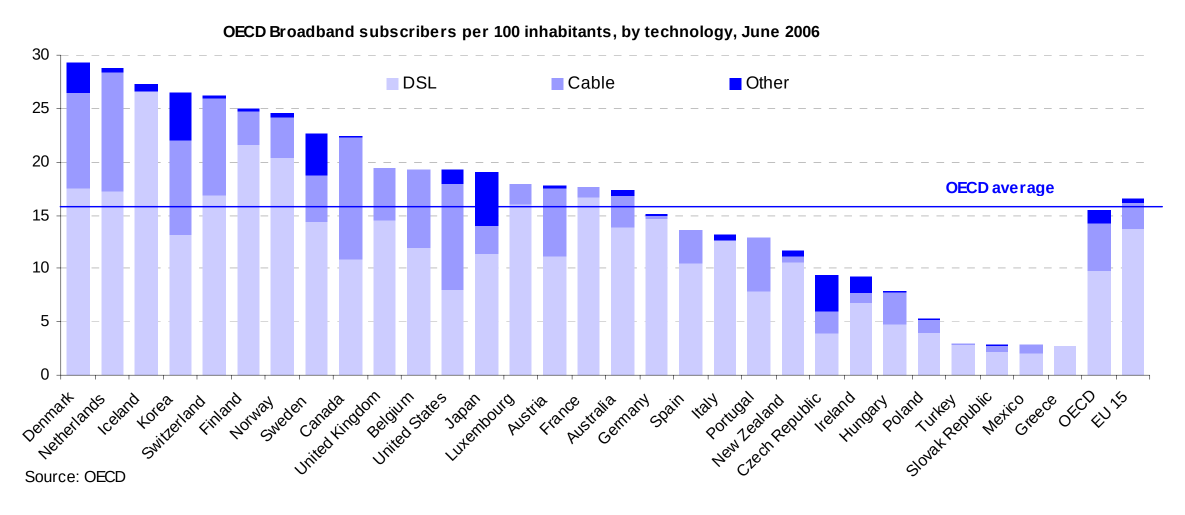
[28] MHP, „Multimedia Home Platform“ is a European standard for interactive television
[29] Accenture, IPTV Monitor - Issue 1,06,2006 http://www.accenture.com, 26.10.2006.

from 75% of earned profit for the next 4 years until 2010. An example for this progress is the marked situation in France and Italy.

The base for a growing IP-TV market is given by the demand of the consumer who wants to be more actively involved in self-selecting TV programs ("Pull")[30] at any time. Fabel describes the new generation (from 18 to 35 years old) as extreme online affine. Moreover IPTV combines the advantages of broadcasting and internet. At least the installed broadband connection with a penetration rate of 23% in the EU-25 generates the technical fundament for IPTV.

Table 26 below shows the potential of IPTV of a broadband connection specified through DSL subscribers in Europe compared to other main broadband states in the world.

Table 26: OECD broadband statistics, June 2006[31],



Internet TV of the last generation has some problems. One problem was the limited bandwidth. Today this problem is solved with broadband accesses via ADSL[32] and VDSL[33] in combination with new compression methods like WM9 and H2.64. Television service that is broadcasted over a broadband connection does not have the bottleneck of low data rates. As an example may serve a SDTV signal that is encoded for IPTV: it has a band width from 1.2 to 1.8 Mbit/s. HDTV signals get a specified data rate from 8 to 12 MBit/s. In relation to a 20 Mbit/s downstream rate for an ADSL2 connection it seemed not too much. Regarding to the fact that some households have more

[30] Pull: active User interaction opposite is Push: the passive consuming form, broadcaster push their program to user

[31] http://www.oecd.org/document/9/0,2340,en_2649_34225_37529673_1_1_1_1,00.html, 27.10.2006.

[32] ADSL (Asynchron Digitel Subscriber Line) new Standards are ADSL2 and ADSL2+ with data from 12 to 24 MBit/s downstream also with benefit of Power Enhancement (http://www.dslprime.com/a/adsl21.pdf, 27.11.2006)

[33] VDSL (Very high bit rate DSL) 25 MBits/s up to 50 MBit/s downstream / VDSL2 data rate up to 200Mbit/s

than one TV and additional a PVR[34] record in background another TV channel, the required band width is growing enormously.

2.3.2.6. New market concepts require new hardware

To bring the IPTV into the living room, the Set-Top-Box is the key technology. It is an optimized computer with a hard disk and Ethernet port that decodes the TV-Signal and gives the benefit of “Time Shift”. At the moment the STB from one provider could be incompatible with another provider (e.g. pay TV). In future times a consistent set of standards will be necessary. A clear application trend is not possible yet but the TV experts are agree to that PC and classic TV will join more and more together in regard to the development of digital broadcasting and especially to IPTV. In the near future TV and PC will be not one device. But a new generation of hardware could bring the advantages of both technologies together. The best known technology is a so called “media-center” a computer with a comfortable handling over remote control, that should have a fast boot, work silently and with a design that is oriented to hi-fi components. More and more customers prefer one device for many different tasks such as watching TV, play DVDs and Mp3 or see their own photographs in a slide show.[35]

To attend this applications in combination to the background that in the EU states is a full supply with TV’s[36] a STB in form of “media-center” would be the most preferred hardware solution to make IPTV available to more the average household. A further trend in hardware development causally determined by new ways of utilization is the use of additional devices like Web Cam, microphones and digital video cameras. Based on new broadcast types such as a live feed from the living room of the consumer over a simple web-cam on the user’s side, those additional devices could reach a greater market. The next step in development could be to give the consumer the opportunity of his own web space for uploading self produced videos and to generate his own TV-Channel via Internet.[37] IPTV could generate every observer with a camera to a potential TV-Sender.

In conclusion, digital television broadcast is potentially changing the product functionality e.g. picture in picture, digital program information and integrated digital recording. It will also influence standards for television/video signal compression and coding. As a result of this development we have to assume that the complexity of the televisions electronic hardware and

[34] PVR (personal video recorder) video recorder that records without tape on harddrive or other digital storage medium like DVD
[35] Flohr, UDO; Honsel Gregor: Kampf der Kästen, Technology Review 09/2006.
[36] E-Communications Haushaltsumfrage: http://ec.europa.eu/public_opinion/archives/ebs/ebs_249_de.pdf, 19.10.2006
[37] Blau, Wolfgang: Ich-TV auf Sendung; Technology Review 09/2006.

system integration will increase. The trend of digital TV also influences new products for home entertainment. More and more products close the circle of home network. The market has already found solutions for a media-server that provides videos, mp3s and pictures to other linked devices. Based on streaming concepts for home entertainment a different movie could be played in every room of the house from the same media server that is wirelessly connected with the other media-devices in the household. Companies such as Phillips have already a product line ("Showline Media Center") with the according specifications. This development could dramatically force the rate of home entertainment products in European households. The technology of IPTV enforces such Media-server and Media-center, iTV and new TV program strategies. Digital TV and IPTV could enforce the HDTV standard and on the other side HDTV also could enforce digital TV. Vice versa this might influence the environmental impact of new products due to changes in the material composition and the amount of advanced electronic components as well as packages in the products.

2.3.3. High Definition (Resolution)

High-Definition television (HDTV) refers to the broadcasting of television signals with a higher resolution than the Standard-Definition television (SDTV) - that means traditional analogue formats like PAL[38] and SECAM[39] in Europe. HDTV is defined as 1080 active interlaced lines[40], or 720 progressive lines[41] (16:9 aspect ratio in ITU-R BT.709). The following Table 27 compares the digital and analogue standards and displays of the most common resolution standards.

Table 27: TV display resolution standards

TV-Video standard	Resolution in pixel	Rate (Hz)	
		interlaced	Progressive
NTSC / PAL-M	640 × 480	60	24-30
PAL / SECAM	768 × 576	50	25
SDTV	480 x 720, 576 x 720	50,60	
HDTV	720 × 1280, 1080 × 1920 or 1152 × 2048	50, 60	24 – 60

[38] PAL, short for phase-alternating line, is a color encoding analogue television system (625-line/50 Hz) commonly used in Europe and other parts of the world. PAL was developed by Walter Bruch at Telefunken in Germany.
[39] SECAM, short for sequential color with memory (French: Séquentiel couleur à mémoire), was the first analogue color television system (625-line/50Hz) used in France and Russia. SECAM was developed by Henri de France working at Compagnie Française de Télévision (later Thomson).
[40] The format 1080i50 is 1920 × 1080 pixels, interlaced encoding with 50 fields (25 frames) per second.
[41] The format 720p60 is 1280 × 720 pixels, progressive encoding with 60 frames per second.

HDTV services in Europe began with Belgian pay TV channel Euro180 in 2004. The number of HDTV channels available in Europe increased in 2006 particularly in Germany with Pro 7 and SAT 1 and in the UK with Telewest, Sky and the BBC[42]. A label "HD-ready" has been created to inform consumers of the benefits of High Definition. The purpose of the label is to create a single norm to simplify the purchase of a HDTV in Europe. Compliant sets accept all current SD and HD resolutions at 50- and 60-hertz rates, they need to have a native resolution of at least 720 lines at a 16:9 aspect ratio and the video interface have to provide two interfaces, analogue via YPbPr and digital via DVI[43] or HDMI[44]. Capable inputs also have to support HD formats 720p and 1080i. At least the DVI and HDMI input have to support the content protection[45]. The logo ensures that the TV supports the preferred picture quality of HD broadcasts and supports the correct connector needed to hook up to HD products such as set top boxes, games consoles and next generation HD-DVD and Blu-Ray Disk players.

HDTV is set from most experts as the key-technology for the TV of future. Referring to TV, PVR and video player, inclusive new storage media like HD-DVD or Blu-ray Disk, HDTV is the main technology that forces those other new technologies inclusive new media. For European HDTV market forecast we should reflect ongoing developments in Japan. Over 10 percent of Japanese households are using HDTV (5.25 Mio households to all over 48 Million households). Hurdles for fast distribution of HDTV are the applicable hardware like TV and PVR. Most of actual delivered displays have the “HD-ready” label. But all existing TV are not compatible with HD-Signals. Nearly same problems have the transmission pass over satellite. Refer to the chapter “DVB-S and DVB-S2” only the DVB-S2 standard is used to transmit the HDTV channels. All old receivers on DVB-S standard are not able to decode the DVB-S2 signals (also upgrade is not possible). On other side only few channels broadcast their program in HDTV, such as Pay TV, Sat1 and Sky. Last fact is the missing standard for current HDTV storage systems due to the new technology HD-DVD vs. Blu-ray.

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[42] BBC News of 13 June 2006, in the internet: http://news.bbc.co.uk/2/hi/technology/5071314.stm/
[43] DVI (Digital Visual Interface) is a video interface standard to provide digital displays an maximum on visual quality
[44] HDMI (High-Definition Multimedia Interface) is a audio- video interface standard to transmit uncompressed streams. http://www.hdmi.org/about/faq.asp, 10.10.2006.
[45] EICTA License Agreement (http://www.eicta.org, 10.10.2006)

2.3.4. Optical storage systems

New high definition video technologies/formats (e.g. HD DVD, Blu-ray Disc), video data compression standards (e.g. MPEG-4 AVC [H.264], Microsoft VC-1), and audio formats (e.g. Dolby Digital Plus, Dolby True HD, DTS-HD) are developments that influence the product policies (hard- and software configuration) of main equipment manufacturers as well as the product policies of broadcasters and the movie industry. Optical data storage systems have an impressive growth in the last few years, in part due to a faster-than-expected DVD mass market penetration. This trend is will be continue, with growing consumer demand for DVDs and HDTVs. HD-DVD and Blu-ray established as the two main storage systems for home video marked. A further trend is the competition of recording on optical disk against the fast growing hard disk technology as an archival storage system.

The “Blu-ray” disc was developed by thirteen leading companies from PC and consumer electronic marked. This format also like HD-DVD was developed to enable the playback, recording and rewriting of HD-data, like HDTV. The Blu-ray disk technology operate with a Blue laser diode that offer the recording of more than 2 hours HDTV or more than 13 hours SDTV on a 25 GB disc. Blu-ray was also designed to direct record MPEG-2 Transport Streams witch is used by digital broadcasts.[46] That makes it high compatible with European digital television standards. The HD-DVD comes with similar specifications like the Blu-ray disk. This format is promoted by Toshiba and NEC. The most important difference is the lower storage capacity of 15GB in each layer in comparison to 25GB from Blu-ray system. In spring of 2006 four different HD-players were set on European marked, two HD-DVD players from Toshiba and with only 4 HD-DVDs. A half year later more than 60 HD-DVDs are available. The first two Blu-ray Disk players are since October 2006 on European marked. The Disk portfolio for Europe consists of 20 different movies.[47]

We have to assume that the shift towards high resolution for medium and large televisions might show environmental implication due to the increasing miniaturization and complexity of display manufacturing processes technology and their integration in TV sets. Furthermore the handling of larger data packages will increase the demand on semiconductor-based processor and memory capacity. Vice versa this will increase the material complexity and amount of advanced electronics in the television set.

[46] Frost & Sullivan: “Advances in Blu-Ray and other data storage technologies”, 2004.
[47] http://www.cinefacts.de/blu_ray/termine/termine.php?monat=12&jahr=2006, 02.11.2006.

2.3.5. Conclusion

As we have point out there are technological developments in the field of display technology and broadcasting that has a potential to change the market. We also recognize that an outlook on long-term developments is critical due to various other factors. The digitalization in broadcasting and emerging high definition standards are interrelated trends. They lead to new functionalities and change of product concepts. Furthermore we should consider the general progress in semiconductor-based microelectronics following so called Moore’s Law. Resulting from the developments in material sciences (nano-structures) and a heterogeneous combination of packaging technologies we also see continuous progress towards even higher system integration (more than Moore). These intrinsic developments are leading to a steady increase in digital data processing and storing capacities, wired and wireless data transmission capability (broadband), new data storage media, and other applications. Disruptive technologies in digital non volatile memory (storage) might lead to new video recording, replay, and storage principles that can be easily integrated into television-sets. In conclusion, we have to consider changes in the television concept and product design due to the dynamics of technological progress. Long-term prediction of market development is therefore problematic.

2.4. Consumer Expenditure Base Data

This subtask will provide a practical dataset of prices and rates to be used in the required Life Cycle Cost (LCC) calculation. The basic year for data will be 2005 throughout the study. Consumer expenditure base data for the product category television consists of product and use related costs over the life time of the device. For the purpose of the preparatory study we are investigating:

- Purchase costs
- Running costs for operation (i.e. electricity costs)
- Running costs for repair and maintenance
- Costs for disposal
- Costs due to inflation and interest rates (if applicable)

In general, it has to be stated that data on consumer expenditure is mostly only available with a technology-based differentiation (CRT, LCD, PDP and RP) as well as a differentiation of size or size categories. No consumer expenditure data was found differentiating between TV sets, TV component units or TV/video combos. Since in task 1.1 the scope of the study for lot 5 was narrowed down to two size classes as well as the differentiation between self-emissive and backlight displays, these categories were used as an orientation for the compilation of results in the following sub-task.

2.4.1. Introduction

There are two different approaches – top down and bottom-up – to compile and calculate consumer expenditure. The “top-down” approach is using official statistical data which are available on the level of European Union. The “bottom-up” approach consists of an own investigation based on open and commercial sources. In order to get a better overview and possibilities of comparison both approaches have been carried out.

2.4.1.1. Top-Down Approach

Generic economic data gathered and described in section 2.1 has also been used for evaluation of average costs. Eurostat, the statistical office of the European Communities, provides **PRODCOM Statistic** and the **EU-25 Trade Statistic**. The external trade database PRODCOM classifies the product category “television receivers” (Code 32.30.20) into ten subgroups. The EU-25 trade statistics, whose classification is based on the Combined Nomenclature, has even more subgroups. From these sources relevant data were drawn. However, it has to be said, that both statistics seem to have data gaps or inconsistencies that can not explained by the author at this point of time. Therefore the value of these data for the purpose of the study is limited.

2.4.1.2. Bottom-Up Approach

Several organizations gather market data concerning sales (in Euro and in unit volume) and prices of TV equipment. On EU level the European Information Technology Observatory (**EITO**) publishes the EITO Yearbook which provides applicable data for Western Europe. Unfortunately it was not possible to get access to any other publicly available data on European level. Neither **EICTA** (European Information, Communications and Consumer Electronics Industry Technology Association) nor consumer organizations (e.g. Bureau Européen des Unions de Consommateurs – **BEUC**) were able to make market data on TV equipment available. In Germany the **GfU** (Gesellschaft für Unterhaltungs- und Kommunikationselektronik) – being an association of actors within the CE and ICT industry – publishes quite a lot of data regarding TV equipment but only for the German market. This data has nevertheless been analysed and evaluated since it is very up to date and detailed. Both the EITO Yearbook and the GfU publications base their data on market surveys done by the **GfK** (Gesellschaft für Konsumforschung) being a private market research institute in Germany. GfK has more data than the one published in the EITO Yearbook but does only make it commercially available. The international organization "**DisplaySearch**" publishes a lot concerning TV equipment but no detailed market data is available to the public. Only few examples of prices per TV device can be found. Several company reports, press releases and newspaper articles contain market data on sales and prices. Nevertheless these only give a short insight and do not represent a solid data base. Considering the above described situation regarding TV market base data it was decided to carry out an online survey on consumer prices for TV devices. Several internet sites were checked: e.g. the German consumer organization association ("Bundesverband Verbraucherzentralen") makes a selection of TV devices with their respective prices available on the internet ("Onlinethek"). Additionally, several price comparison websites (inter alia www.guenstiger.de, www.geizhals.de, www.kelkoo.de and www.ciao.de) list numerous television devices with their respective prices. Some of these sites are available in selected European countries, others only have national sites. Furthermore, certain magazines regularly publish price lists of TV equipment available on the market.,

When looking at prices published in the EITO Yearbook it can be seen that there are not much price differences within Western EU Member States (cf. discussion of Table 38 below). Unfortunately, no general information or statement could be found on price levels of TVs in the new Member States. However, as it is the case for imaging equipment (cf. task report lot 4 at www.ecoimaging.org), it was assumed that the price structure would be the same across EU25.

Since there was a lot of up-to-date data available for Germany it was decided to evaluate data found on Germany exemplarily. Due to the extremely large amount of data available on the internet it was not possible to carry out such a bottom-up research for other EU countries.

In a first step data on 177 TV devices from the German consumers' association were evaluated and compared with the results of the top-down approach and other data available. The data includes prices for CRT, LCD, PDP and rear projection TVs.

2.4.1.3. Approach Other Costs

It is important to state that the running costs for operation of a TV device can only be calculated on the basis of an average time for the on-mode and an average time for the stand-by and/or off-mode[48]. The power consumption is different in the diverse modes. The total energy consumption can be calculated by multiplying the assumed time in which one mode is active with the power consumption of that mode. The thus resulting electricity consumption in kWh then needs to be multiplied with the electricity costs in order to determine the running costs for operation. Concerning **costs for maintenance and repair** no detailed data could be found. Statistics do not include such data. European and national associations and industry groups do not make such data publicly available. A market survey amongst media stores and consumers could possibly be more successful. Carrying out such a survey is nevertheless not feasible within the framework of this study.

Electricity rates for the EU25 Member States were gathered from Eurostat data publicly available on the internet. **Electricity costs** can be calculated via base data on daily or yearly operation time of a TV multiplied with electricity rates in EUR / kWh. **Costs for disposal** do not occur for private consumers any more since the EU Directive on waste electrical and electronic equipment (WEEE-Directive) is in force and includes the zero-disposal-cost requirement for private owners of electrical and electronic equipment. Nevertheless, recycling and disposing of a TV device does certainly create costs.

Costs for inflation and interest rates are required within the evaluation of consumer expenditure data. Concerning TV equipment it needs to be clarified in what context inflation and interest rates are relevant for consumers. A possible scenario can be the purchase of a TV which requires financing on the basis of a credit. Such a credit can be granted by a bank, the store and collaborating financial institution or via the current account. In the context of data gathering within

48 To be precise, the electricity consumption of a television depends on many different aspects. Thus, the "real" energy consumption can only be determined through measurement while the TV is in actual use. Since this is not a practicable approach within the framework of this study certain assumptions will have to be taken. E.g. it has to be determined what different modes (on-mode, stand-by active, stand-by passive, save mode, off mode…) will be considered for the calculation of the energy consumption.

this sub-task only national inflation rates available at the Eurostat website as well as general long-term ECB interest rates have been evaluated. However, it needs to be checked whether for this product group such rates are applicable at all and if so whether product-specific inflation rates for TV equipment can be gathered or whether specific interest rates granted for the special case of TV equipment purchase.

2.4.2. Purchase Costs

Table 28 gives an overview on available data concerning purchase costs. The average value per unit calculated on the basis of PRODCOM statistics belongs to the *top-down approach* while consumer prices collected via market research belong to the *bottom-up approach*).

Table 28: Overview on purchase costs / average prices (in Euro)

	CRT		PDP+LCD	LCD	PDP	Rear & Front Projection	
	Average value / unit, Prodcom 2004 (1)	Consumer price, market research 2005 (2)	Average value / unit , Prodcom 2004 (8)	Consumer price, market research 2005 (2)	Consumer price, market research 2005 (2)	Average value / unit Prodcom 2004 DLP(9)	Consumer price market research 2005 (2)
BE	22 (5)	281 (3)	150	985 (3)	2411 (3)	:	1459 (3)
CZ	21 (6)	:	204	:	:	:	:
DK	55 (6)	:	214	:	:	:	:
DE	173	350 (4)	:	1195 (4)	2578 (4)	555	1264 (4)
EE	191	:	-147	:	:	:	:
EL	154	:	555	:	:	-7189	:
ES	164 (6)	227	:	946	1.832	408	1.366
FR	31 (5)	250	:	:	2.751	:	1.674
IE	218	:	180	:	:	:	:
IT	154	198	:	908	2.381	844	1.243
CY	226	:	65	:	:	813	:
LV	149	:	0	:	:	521	:
LT	19 (5)	:	-8	:	:	882	:
LU	394	:	-	:	:	610	:
HU	162	:	:	:	:	1641	:
MT	151	:	188	:	:	167	:
NL	60 (6)	281 (3)	:	985 (3)	2411 (3)	459	1459 (3)
AT	183	281 (3)	566	985 (3)	2411 (3)	274	1459 (3)
PL	307	:	1.472	:	:	:	:
PT	147	:	7	:	:	578	:
SI	182	:	19	:	:	1118	:
SK	752	:	:	:	:	990	:
FI	223	:	22	:	:	701	:
SE	181	281 (3)	0	985 (3)	2411 (3)	1048	1459 (3)
UK	149	316	-	948	2.550	3293	1.428
EU 15	12 (5)	:	698	:	:	:	:
EU 25	169 (7)	:	628	:	:	:	:
WE (10)		281	:	985	2.411	434	1.459

(1) Categories evaluated: 32302030, 32302050, and 32302085
(2) Source: EITO Yearbook 2006, data for 2005; own calculation
(3) Values taken from data for Western Europe (WE)
(4) Source: CEMIX GfU/GfK first quarter 2006

(5) Only category 32302085
(6) Only category 32302030 and 32302085
(7) Only category 32302050 and 32302085
(8) Only category 32302060
(9) Only category 32302020
(10) WE = AT, BE, FR, DE, IT, NL, ES, SE, CH, UK
: Data not available
- Data "Not applicable" or "Real zero" or "Zero by default"

When comparing PRODCOM data to market research data concerning prices of TV equipment one can see that the PRODCOM data are inconsistent. For example, the average value per unit of a CRT television in EU-15 of 12 Euro is not explainable and seems to be to low. Concerning these not plausible figures it has to be pointed out that data is not always available for all TV-relevant categories. Where such data gaps exist regarding CRT TVs the corresponding category was left out of the calculation (see footnotes below the table). For some countries, it was not possible to calculate an average value per unit for flat panel TVs since data either data on production, import or export is not available in PRODCOM. For example, a negative value of apparent consumption in Denmark leads to a negative average value of a TV which again shows the limited reliability of statistical data. Nevertheless, statistical data for e.g. Austria, Italy and Spain shows approximation of the average values for CRT TVs with market data.

Furthermore the table above shows that the price variation of data gathered by market research between single EU countries is not very important: for CRT TVs the price is of around 300 €. Only few countries have lower prices (e.g. France and Spain with around 200 €). For LCD TVs the average price is around 1.000€ across all western EU countries. Concerning PDP TVs price variations are a bit more important: in most countries it cost around 2.500 € while Spain has a lower price of around 1.800 €. Rear Projection equipment has a price around 1.500 € except for Italy and Germany where it is a bit lower lying around 1.200 €. Table 29 below shows more data based on the top-down approach.

Table 29: Average Prices by Intra-EU Trade of EU25 totals in 2005 (in Euro)

		Import	Export
		average price (Euro)	average price (Euro)
Television projection equipment (85281210)		440	634
Colour TVs with video (85281220)		182	143
CRT colour TVs	**85281252**	136	88
	85281254	138	125
	85281256	205	155
	85281258	392	318
	85281262	213	181
	85281266	408	366
	85281270	375	1175
Flat panel TVs (85281281/85281289)		459	466
		734	769
B&w TVs		42	22

The average trade prices shown in the EU-25 trade statistic are in more realistic ranges. A CRT color television is traded between 100 and 1,000 Euro depending on the screen size and other product features. The majority of trade prices are between 200 and 400 Euro which is comparable to an average market price of around 300 Euro. Rear and front projection equipment shows an average trade price of about 500 Euro while the average retail price for rear projection is quite above 1,000 Euro. Flat panel televisions are traded between about 500 and 800 Euro. Retail prices are considerable higher at 1,000 and 5,000 Euro. The official European Union trade statistics provide only partially suitable data. Therefore the focus for compiling purchasing price data will be placed on other public and commercial sources.

The **price deterioration** in the flat panel television market from 2Q 2005 to 2Q 2006 was very dynamic (see Table 30 and Table 31 below[49]).

Table 30: Comparison of Worldwide Market Prices for LCD Televisions (in US Dollar)

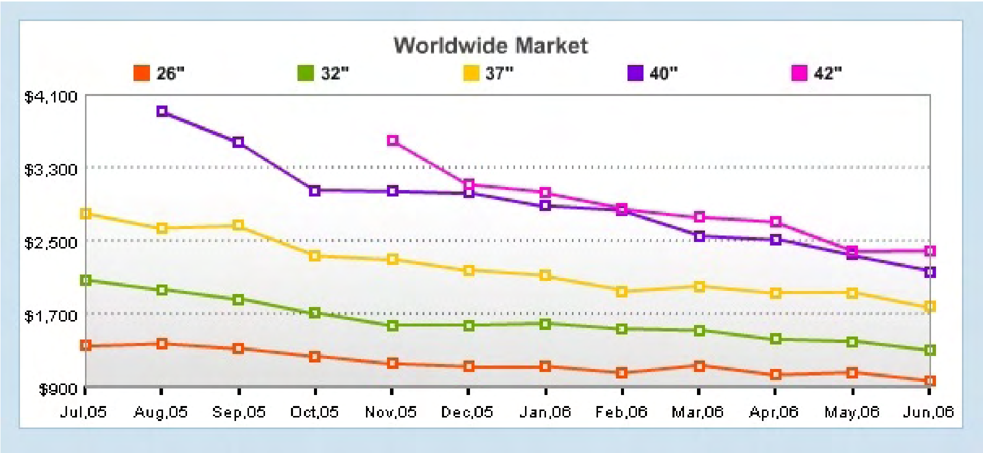
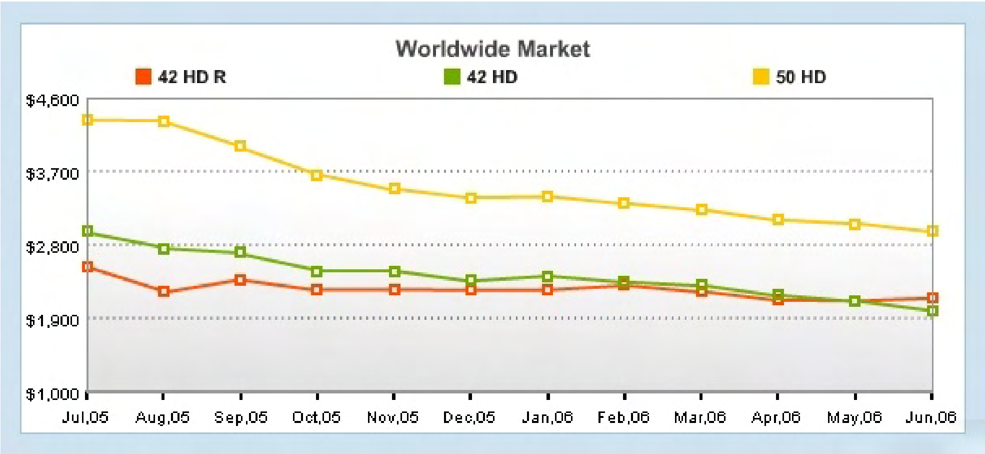


Table 31: Comparison of Worldwide Market Prices for PDP Televisions (in US Dollar)



[49] Source: Displaybank; on the Internet: http://www.computerpartner.de/consumerelectronics/displays_beamer/204461/index.html

The prices for medium screen size LCD televisions dropped by average 25 to 30 percent. Large screen LCD televisions over 40 Inch show an even stronger decline. A similar decline in prices – although not as prominent – can be asserted for the global PDP television market. It is very interesting to notice that particular in the range of 40 Inch and 42 Inch LCD as well as PDP televisions have reached a similar price level by June 2006. The current situation of a rapid change of in the price structure on the global market is reflected in the European market as well.

The Table 32 below shows the results obtained through a 2006 online research on a website from the German consumers' organization association[50] in comparison to other market data collected by market research institutes and published by manufacturers and their associations.

Table 32: Results of an online survey 2/2006 compared to other market data

Average price [€]	**DE Online Research 2/2006** (1)	**DE Market research 1/2006** (2)	**EU** (3)	**CH** (3)	**ES / IT** (3)
CRT	773	350	277	-	-
LCD	1.477	1.195	1.000	-	-
PDP	1.658	2.578	2.500	-	-
RP	938	1.264	-	-	-
Average weighted over technology (3)		517	544	1.000	< 500

(1) Source: www.verbraucherinfothek.de, April 2006
(2) Source: gfu 2006
(3) Loewe 2005

For LCD TVs, the average prices per technology calculated with the data of the online research more or less match the average prices calculated with the data published by the German association on consumer electronics (gfu) and with data based on market research and estimates: according to the online research an LCD TV costs in average around 1.500 € in Germany. According to data published by GfU the price is around 1.200 € and according to figures by the manufacturer Loewe for the EU an LCD TV costs around 1.000 € in average. Concerning CRT TVs there is quite an important difference between the results of the German online survey and other figures: the average purchase price of a CRT TV in Germany is around 800 € (resulring from online survey) while according to GfU the average purchase price would be 350 € (EU figures are also in the same range).

As regards PDP TVs the average price of such equipment in Germany is around 2.500 € (GfU) and at the same amount in the EU (Loewe). The online survey lead to a different result for the average purchase price in Germany of around 1.500 €. Rear Projection TVs result in more or less the same price range when comparing data from the online survey and GfU: around 1.000 €.

[50] Bundesverband Verbraucherzentrale; "Online Infothek" (www.verbraucherinfothek.de), for a total number of 177 devices data was collected in April 2006.

The average purchase price of a TV across all technologies differs between the EU and Switzerland: in the EU a TV costs around 500 € in average according to different data sources while it costs 1.000 € in average in Switzerland.

In the next step we analyzed the prices in particular according to screen size segments defined in task 1.1. The results are shown in Table 33. When compared to prices available for the world market it can be seen that price segments are close to each other – at least for PDP TVs and RP TVs: both according to the online survey as well as according to the world prices delivered by Displaysearch a PDP TV costs around 1.700 € and RP TVs cost around 1.000 €. Only for LCD TVs a difference can be seen between the prices delivered by the online research and the world prices by Displaysearch: in the first case a LCD TV costs approximately 1.500 € while in the second case it costs around 2.300 €. Compared to other data sources naming prices for 32" LCD TVs they also lye in the same range as the online research with between 1.500 € and 1.800 €. Same applies when comparing prices for CRT TVs between the results of the online survey and other sources with about 800 €. No significant results could be gathered with respect to price differences between the two size categories.
In this context it has to be stated that the basis for the online survey is a total number of 177 devices, meaning that in order to get reliable and representative data a much larger data base would be required. Hence, the results of the online survey can only serve as a rough approximation in order to get a first estimate on the price level.

Table 33: Results online survey 2/2006 possible categories base case

Online survey D 2/2006 [1]			World price 1/2006 [2]
Average price [€]	**Medium 14"- 35"**	**Large 36"- 65"**	**Large 36"- 65"**
CRT	773	-	-
LCD	1.411	1.473	2.313
PDP	-	1.658	1.674
RP	-	938	1.288
LCD 32" [2]	1.500		
LCD 32" [3]	1.800		
PDP [3]		3.400	
CRT 32" [4]	737		
LCD 32" [4]	1.769		

[1] Source: www.verbraucherinfothek.de, April 2006
[2] Loewe 2005
[3] Sharp 2005
[4] gfu 2005

In order to specify the data for the purpose of the preparatory study we have taken the product groups defined in task 1.1 and obtained purchasing prices for each subgroup through an online research. Table 34 shows the results of this survey aggregated in regards to different display technologies (RP, CRT, LCD, PDP) and small, medium and large screen sizes. The prices of 120 products on sale in large retail centers in Germany were obtained in January 2006 and rounded up.

Table 34: Average Sales Prices for Televisions in Germany (1/2006)

	Small			Medium			Large		
	14"-19"	20"-24"	25"-26"	27"-29"	30"-33"	34"-39"	40"-43"	44"-50"	51"-75"
RP								1.500	2.200
CRT	100	150	300	400	900				
LCD		500	750	1.000	1.700	2.100	2.800		
PDP						2.500	2.400	3.900	11.000

These prices should be the base for the assessments. Further investigation will have to confirm these preliminary findings.

2.4.3. Electricity rates

The following Table 35 shows the electricity rates for the EU25 as from 1 July 2005 and published by Eurostat.

Table 35: Electricity rates for EU25 July 2005(1)

Country	Electricity rate [Euro/100 kWh]	Country	Electricity rate [Euro/100 kWh]
BE	14,3	**LU**	15,0
CZ	8,2	**HU**	1,1
DK	23,3	**MT**	7,7
DE	18,0	**NL**	19,6
EE	7,1	**AT**	13,9
EL	6,9	**PL**	8,5
ES	11,0	**PT**	13,8
FR	11,9	**SI**	10,3
IE	14,4	**SK**	12,9
IT	20,1	**FI**	10,4
CY	12,1	**SE**	13,8
LV	8,6	**UK**	9,4
LT	7,2	**EU 25**	13,6

(1) Source: Eurostat electricity rates for households type Dc
(yearly consumption 3.500 kWh incl. 1.300 kWh night electricity part),
July 2005 incl. all taxes

It can be seen that Denmark has the highest rate with approximately 23 Euro for 100 kWh. In comparison Hungary has the lowest electricity rate with 1 Euro per 100 kWh. The average for EU25 countries is of nearly 14 Euro per 100 kWh. Belgium, Ireland, Luxemburg, Austria, Portugal, Slovakia and Sweden are all close to that average.

2.4.4. Repair and maintenance costs

The Methodology Study Eco-Design of Energy Using Products by Van Holsteijn en Kemna (VHK) named for the product case on televisions 50 Euro costs for repair and maintenance over lifetime but did not clarify on which data basis this assumption was done. In German national statistics it can be found that private households spend an average of 7 Euro per months for TV equipment, VCR and antennas. Assuming that 1/3 of these costs belong to repair and maintenance[51] and that from this third half of the costs[52] are due to the use of TV equipment, yearly costs could be of approximately 15 Euro. This is however just a very rough estimate based on uncertain assumptions. Assuming a lifetime of 10 years, total costs would be of 150 Euro and thus three times the costs assumed by VHK.

Nevertheless, it is just as much plausible that consumers will not spend much on repair & maintenance if they can buy new relatively cheap equipment. Maintenance costs for TVs do not occur and it is thus only non-costly repair costs that would occur over lifetime probably staying below 100 € (since costs over such an amount are considered not to be a valuable investment if new equipment only costs slightly more).

2.4.5. Interest and inflation rates

The following Table 36 shows inflation and interest rates for EU25 countries as published by Eurostat and the ECB. Both data categories only reflect national rates and are not product-specific.

Table 36: Interest and inflation rates for EU25 countries

Country	Inflation rates [%] (1)	Interest rates [%] (2)	Country	Inflation rates [%] (1)	Interest rates [%] (2)
BE	2,8	3,4	**LU**	3,4	:
CZ	1,9	:	**HU**	3,3	6,6
DK	2,2	3,4	**MT**	3,4	4,6
DE	2,1	3,4	**NL**	2,1	3,4
EE	3,6	-	**AT**	1,6	3,4
EL	3,5	3,6	**PL**	0,8	5,2
ES	3,7	3,4	**PT**	2,5	3,4
FR	1,8	3,4	**SI**	2,4	3,8
IE	2,2	3,3	**SK**	3,9	3,5
IT	2,1	3,6	**FI**	1,1	3,4
CY	1,4	5,2	**SE**	1,3	3,4
LV	7,1	3,5	**UK**	2,0	4,5
LT	3,0	3,7			
EU 15 (3)	2,2	3,4			
EU 25	2,1	3,9			

(1) Annual Inflation (%) in Dec 2005 Eurostat "Euro-Indicators", 7/2006 - 19 January 2006

[51] 1/3 because statistical data refers to three types of costs: TV, VCR and antennas.
[52] Half because it is assumed that the average spending stated in the statistics also include purchase costs broken down to monthly costs. Monthly costs are thus assumed to be due half to proportionate purchase costs and half to maintenance costs.

(2) Source: ECB long-term interest rates; 10-year government bond yields, secondary market. Annual average (%), 2005

(3) Euro-zone

2.4.6. Disposal costs

The UK Market Transformation Programme has evaluated the costs of disposal for consumer electronics equipment, presented in the Table 37 below.

Table 37: Overview on costs for disposal of TVs in the UK [www.mtprog.com]

	Cost for Disposal of TVs (1,000 £)							
	2004	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**Total**
CRT TVs	94,630	82,038	91,715	99,444	110,663	116,090	123,652	**718,231**
LCD TVs	?	?	?	?	?	?	?	
VCRs	6,534	6,736	6,900	6,435	6,230	8,222	7,901	**48,956**
DVDs	48	147	181	405	1,037	2,319	2,413	**6,550**
								773,737

Apparently data is not available concerning costs for disposal of LCD TVs. Costs for the disposal of CRT TVs have been increasing over the years. In 2006 these costs are of approximately 92 Million Pounds which corresponds to approximately 140 Million Euro. They are estimated to grow up to 124 Million Pounds (188 Million Euro) in 2010. This is nearly 16 times the costs for the recycling of a VCR. Key assumptions of the Market Transformation Program were that the average cost of disposal of a CRT television set is 10.05 Pounds per unit.

Literature task 2

- Huenges Wajer et al. 1998a Huenges Wajer, B.P.F. ; Siderius, P.J.S. et al.. Analysis of energy consumption ans effieciency potential for TVs in on-mode. Contract EC-DGXVII 4.1031/D/97-023. Final Report. November 1998
- Huenges Wajer et al. 1998b Huenges Wajer, B.P.F. ; Siderius, P.J.S. et al.. Analysis of energy consumption ans effieciency potential for TVs in on-mode. Contract EC-DGXVII 4.1031/D/97-023. Final Annexes. November 1998
- EU 2003 Cinema, TV and radio in the EU. Statistics on audiovisual services. Data 1980 - 2002. Theme 4: industry, trade and services. European Commission 2003
- Eurostat 2003 Eurostat. Trends in households in the Eurpoean Union: 1995-2025. Theme 3 24/2003, Baseline Scenario (BS)
- MTP 2006a Market Transformation Program. BNTV01: Televisions: Future Stock and Energy Trends. Briefing Note Version 2.0. 2006
- NAEEC 2004 Minimum Energy Performance Standards - Televisions.NAEEEC. Report No: 2004/11. Australia. 2004
- Rosen and Meier 1999 Rosen, K. B.; Meier, A.K.. Energy Use of Televisions and Videocassette Recorders in the U.S.. LBNL-42393. Environmental Energy Technologies Division, Lawrence Berkeley National Laboratory, University of California. Berkeley, California. March 1999 This report is available online at: http://eetd.lbl.gov/ea/reports/42393/
- Roth et al. 2002 Roth, Kurt W.; Larocque, Gerald R.; Kleinman, Jonathan. Energy Consumption by Office and Telecommunications Equipment in Commercial Buildings Vol. I: Energy Consumption Baseline. Arthur D. Little Inc. Cambridge, MA. 2002
- Strubel et al. 1999 Strubel, V.; Gensch, C.-O.; Buchert, M.; Bunke, D.; Ebinger, F.; Heber, E.; Hochfeld, C.; Grießhammer, R.; Quack, D.; Reichart, I.; Viereck, H.-G.. Cooperation project: Contributions to the development of a cyclical materials economy, formulated for the exemplary case of a complex mass-produced product the TV set; Sub-project 1: Ecological and economic in-process research. Freiburg/Darmstadt 1999
- White et al. 2006 White, P.; Armishaw, M.; Dolley, P.;Harrison, R.; Graziano, T.; Lindblom, J.. Environmental, Technical and Market Analysis concerning the Eco-design of Television. Technical Report EUR 22212 EN. 2006

EuP Preparatory Studies "Televisions" (Lot 5)

Final Report on Task 3
"Consumer Behaviour and Local Infrastructure"

Compiled by Deutsche Umwelthilfe and Fraunhofer IZM

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Berlin, 2nd August 2007

Content

Introduction

This is the final report on Task 3 “Consumer Behavior and Local Infrastructure” for the EuP Preparatory Studies on televisions (lot 5). The findings presented in this report are results of the research conducted by the IZM consortium and the continuous feedback from a wide range of stakeholders. The statements and recommendations presented in the final report however are not to be perceived as the opinion of the European Commission.

We like to acknowledge the fruitful collaboration and trustful working relationship with various industry partners, non-industry stakeholders, and the European Commission throughout the study. We like to thank all stakeholders for their contributions and critical reviews of our reports.

2nd August 2007

CONSUMER BEHAVIOR AND LOCAL INFRASTRUCTURE

3.1. Real Life Efficiency

The consumer behaviour has a considerable influence on the overall environmental impact of a television. Although the environmental impact of a TV is predetermined by the products design (related material content, technology and manufacturing processes) and products performance characteristics (power consumption in various modes), the consumer's choice of a product and the actual use of the product play an important role. In today's highly developed markets the consumer can choose from very different products. The decision is influenced by technical trends and the information a consumer receives on certain product features. It is necessary to pay attention to the information and particularly the environmentally relevant information given to the consumer. It is also important to investigate the means by which such information is provided. After sales the consumer determines the overall amount of power consumption by his use patterns. We already noticed an increase in the functionality of TVs particular through digitalization, new broadcasting methods, network interaction regarding the recording/reviewing of programs/videos etc. Variety of use patterns is increasing. Through that it is very difficult to determine the average time a TV is actively (watching) or passively (recording, downloads) used. In our assessment we will focus on the home use of TVs and not on the growing commercial use of larger screen TVs. Finally, the consumer determines the effective lifetime of a TV. As indicated in the market analysis the amount of a second device in households are increasing. This second hand use in the children's or sleeping room prolongs the lifetime of a TV although the use patterns are different from the primary devices, which is usually situated in the living room.

In the present section we investigate user defined parameters that determine "**real life efficiency**" of the TVs in an average EU-25 household. This includes:

- Product features and information that influence the buying decision in today's TV sales.
- The frequency of single TV utilisation in households with regard to average use hours per day (on-time) and the duration in other modes (passive and active standby or off-time).
- The characteristics of TV use as primary and secondary device in households including the use for different media (VCR, DVD, videogames, etc.), programming and recording behaviour.

The main elements of this task derive from a systematic analysis of available market surveys, statistics, and information collected from the industry via a questionnaire (see annex).

3.1.1. Buying decision

With the decision to buy a certain TV the consumer constitutes to some extent the environmental impact of the device in the use phase. If a large screen TV consumes twice as much of power than a medium size TV then the customer's choice is an influencing factor. But which aspects are influencing actually the buying decision and how transparent are the environmental implications of a buying decision to a customer? Such questions were posed in a questionnaire sent out to leading manufacturers of TVs. Figure 1 is showing the overview of the responses.

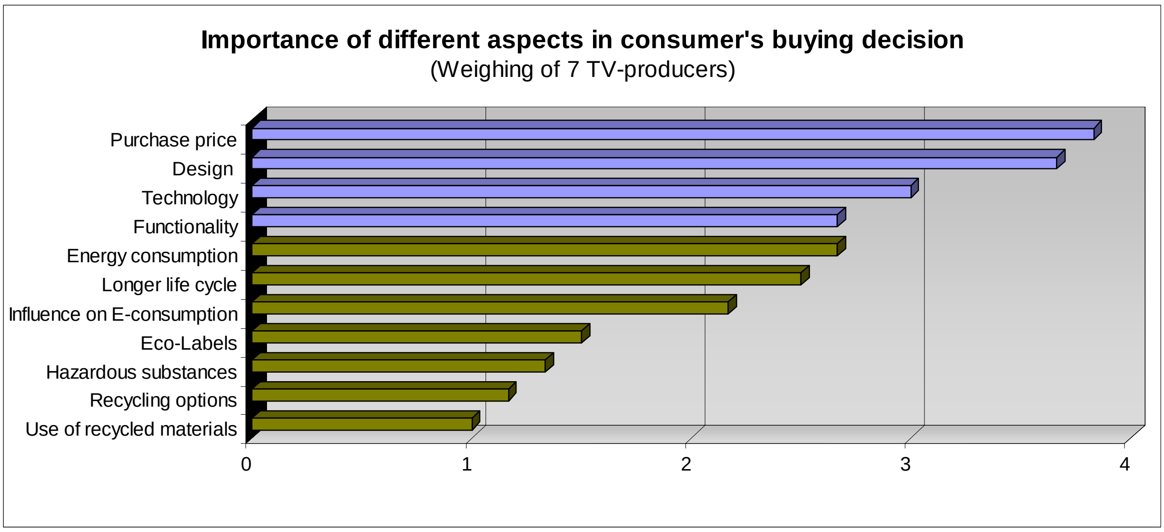


Figure 1: Importance of aspects in the buying decision (Source: answered questionnaires)

It can be observed that price is currently the most important issue of concern for the consumer. One manufacturer, in response to the question, "which are the most important factors influencing the buying decision?" even answered: "The first priority is the price, the second priority is the price, and the third priority is price." The same manufacturer gave three differently answered questionnaires from Germany, Netherlands and Czech Republic. Especially from the Czech market is reported that it is a "price oriented market with all related aspects". But we can also conclude from the answers that the recent market trends towards larger flat screen TVs weighs more than the single price for a TV. The term "design" reflects this aspect in the questionnaire. Although CRT TVs are considerably cheaper larger flat panel devices are increasingly appeal to the costumer and are influencing the buying decision today.

According to the questionnaire responses, technical aspects such as display technology and related picture quality (e.g. contrast, moving picture resolution, viewing angle, color reproduction), high definition ready and hard disk recording capability are also important factors influencing the

consumer’s buying decision in addition (correlation) to the product price. This was confirmed by additional interviews with manufacturers which stress the importance of high picture quality.
Energy consumption is evaluated as important as functionality and a little less important as technology. Asked on that issue several manufacturers said, that even the consumers are aware on environmental issues – that’s why the questionnaires where answered like that – the consumers almost don’t ask for concrete environmental aspects when buying a new device.
Concerning eco labels for TV devices the statements show that they don’t influence consumer’s choice significantly. To our knowledge, at present there is only one TV manufacturing company (Sharp) which has been awarded EU flower eco-label and one (Philips) for Nordic Swan, thus the penetration eco-labels in the TV-market is not deep. Further, eco labels are more encouraged in the professional sector or in public procurement where TVs are the products of less significance. It is difficult to predict if wide use of eco-labels would influence consumers’ buying decision. However clear presented information concerning energy consumption and active communication on that could have a significant impact on the buying decision as well as a positive impact on innovations and competition in the television market and it could raise consumers’ awareness on the issue of energy efficiency.

Another study, ISOE[1] socio-scientific market analysis, confirms the results of our questionnaire analysis, “Price and screen size are considered the most important criteria, followed by display quality, design, brand, and technology. Labels are unknown in this context and therefore, like other environmental criteria, do not form a part of the buying decision. Features such as use of materials, the recycling, or hazardous substances are only of little interest to consumers.”

In conclusion, the buying decision is influenced by the growing market choice which is driven by technical development. The price, picture size and quality are the most important decision factors. With the trend towards larger flat panel TV it seems that qualitative aspects are gaining in importance (over price) which opens the door to introduce power consumption as qualitative buying criteria to the consumer. The clear declaration of product specific energy consumption characteristics (see differences between self-emissive [CRT, PDP] and non-self emissive displays [LCD]) in advertisement and point of sales should become an established product distinction factor in TV market. When power consumption becomes a feature of product quality than the market forces will promote sustained improvement and related consumer demand.

[1] ISOE GmbH (2006) „Eco Top Ten Television“ Presentation

3.1.2. Frequency and characteristics of use

3.1.2.1. Influencing factors

Emerging new transmission technologies such as digital TV broadcasting, digital video media, and Internet TV as well as technical features (larger flat panels and high definition) affect the manner in which the consumer uses a television. Also, new leisure activities in both indoors/outdoors and demographic characteristics influence user behaviour. A report 'Media Consumption in EU 25[2] identifies following trends:

- In the past, television was about sharing time and space with the family. Families used to sit together in front of it and agree what program to watch amongst a restricted list of options. This is changing and members of the family are increasingly watching different programs according to individual wishes. The trend of "individualism" is also increasing number of TV sets in the households.
- Television still dominates the overall media consumption but watching television is being squeezed by many other activities though wide variations are observed among different countries.
- Single persons spend less time at home compared to a family. Further, an ageing population most likely boosts television viewing.
- People are increasingly 'multi-tasking' with different media, e.g. searching data in the internet while watching television. This has consequences for 'attention to content'. It also increases the watching time, as the TV may be on even if nobody is watching.

Such changes are leading to new use patterns and should be seen in conjunction with certain technical aspects of modern digital television. The digitalisation in computing, communication, and consumer electronics result in a further convergence of devices and media. However, it has become very clear that use patterns related to audio, video and TV will further change. The current trend towards digital program updates, program-on-demand or programmed recording which affect the directly related active standby usage. The apparently higher power consumption in active standby as well as the unknown frequency and duration of digital program updates in conjunction with energy efficiency affects the overall power consumption of television. However, the customer may be the weakest link in this correlation, due to the assumption, that he might be interested in or aware of such a service or not. In any case, the example active standby requiring digital program updates shows how the environmental impacts can be reduced through technical development in conjunction to customer perception.

[2] nVision/Future Foundation (2006) Media Consumption in the EU 25 – How new media is affecting television, radio and newspapers (Free extract).

3.1.2.2. On-mode time per day

Many studies estimate an average on-mode (use) time of 4 hours per day for a single TV in a regular household environment in Europe. Similar average use duration has been the basis for many energy efficiency calculations in the world. Some data from the literature are presented in the following paragraphs. It is important to notice differences in terminology (e.g. on-time, use-time, watching time) as well as differences in the allocation of such terms to products in households. Some studies investigate TV consumption in households where it is unclear how many devices are covered and what kind of use patterns. For the purpose of this study we are only focusing on average daily on-mode time, passive and active standby (as of IEC 62087) for a single TV. The GEEA Working Group on Consumer Electronics considers an active operating time of 4 hours per day as reference. The times of standby and off mode depend on whether auto power off function (APO) and/or a digital decoder is differentiated. The different estimates indicate the possible difference in time duration per mode as discussed above.

Table 1: TV watching time (Source: GEEA)

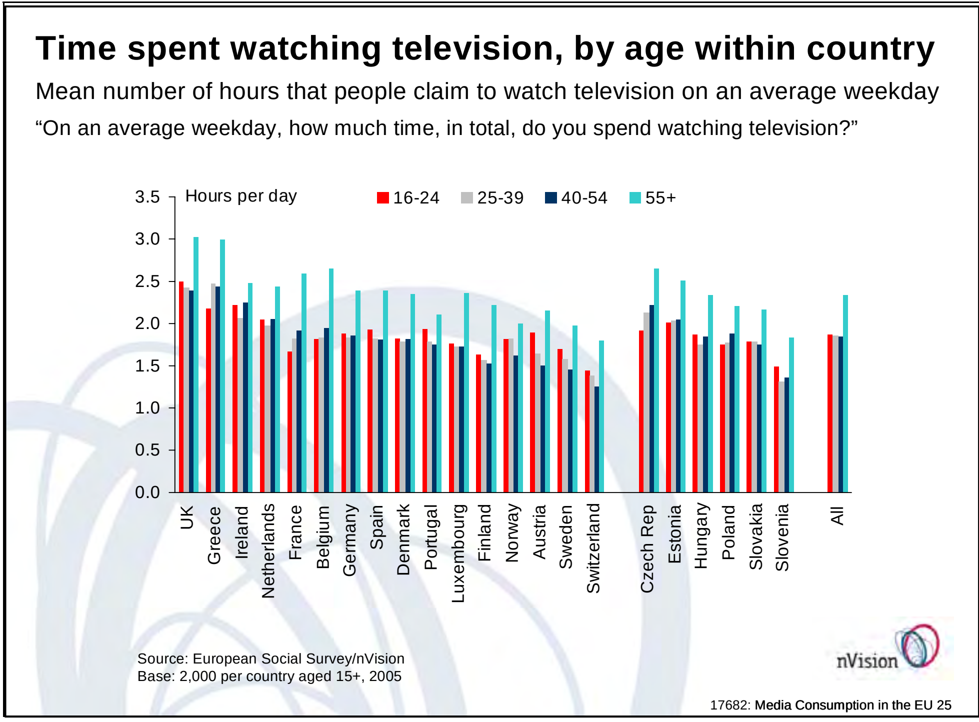
Mode	TV without APO (hrs/day)		TV with APO (hrs/day)	
	TV without digital decoder	TV with digital decoder	TV without digital decoder	TV with digital decoder
On	4	4	4	4
Standby active	0	10	0	2
Standby passive	20	10	4	2
Off	0	0	16	16

A German study of Buhl DataService GmbH indicates that use of digital TV reduces the watching time from 3.5 hours daily in average to 2.2 hours (not including the DVD watching time) i.e. a reduction of around 28 %. But it is assumed that at the same time the DVD watching time is increasing with the availability of digital TV. As soon as people don’t like a program anymore they either go on the internet, watch a DVD, or move to another device. But in the latter case, about 32 % of the people don’t switch off the TV. Thus, it can be assumed that the total TV on-mode time is not reduced compared with the watching behaviour without digital TV. Anyhow no exact figures on the time in on-mode while nobody is watching were provided in this study. The ISI/CEPE[3] study solves this problem of watching time and time in on-mode by calculating for the actual operating time of a TV device the viewing time multiplied with factor 1.3. To this, 120 hours

[3] Cremer C. et al. (2003) Der Einfluss moderner Gerätegenerationen der Informations- und Kommunikationstechnik auf den Energieverbrauch in Deutschland bis zum Jahr 2010. ISI & CEPE for the German Federal Ministry of Economy and Labour.

per year (32 minutes per day) were added for the use of video and games. On this basis, the study assumes for 2005: 4.7 hours per day total operating time (on-mode), 12.1 h/d in standby mode, 3.6 h/d in off-mode, and 3.6 h/d switch off at the mains. For 2010, an estimate was given regarding on-mode (5 h/d), standby (16.8 h/d), off-mode (1.1 h/d) and total off (1.1 h/d). In conclusion this study indicates an increase in on-mode time to 5h/d which should be considered in scenarios to estimate total power consumption of TVs. In contrary to the ISE/CEPE study, a recent Jupiter Research survey[4] of more than 5000 people in the UK, France, Germany, Italy and Spain indicates a relatively short daily TV use time, which is surprising. According to the study that television viewing time has risen from 10 hours (1.4 h/d) to 12 hours per week (1.7 h/d) over the last two years. Here only the watching time is declared, not the total time in on-mode. The European Communities documentation "Consumers in Europe - facts and figures 1999-2004" highlights the importance of demographics. The consumers tend to watch more television with increasing age. As shown in the following Table 2 the +55 years age group watch significantly more TV (about 2.4 h/d compared to nearly 1.9 h/d for other age groups). As the proportion of this age group of the population is constantly growing in the EU, overall increasing television watching time can be presumed.

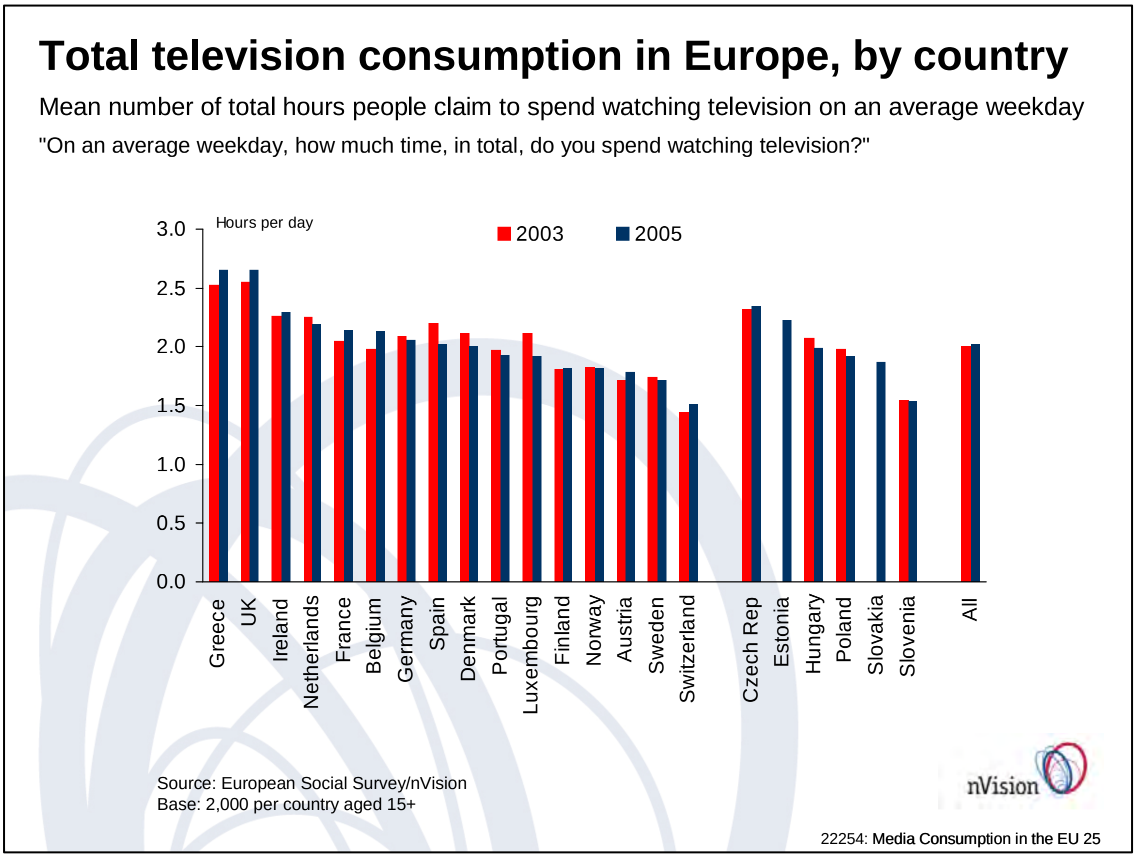
Table 2: Time spent watching television (Source: nVision/Future Foundation)



[4] Survey covered in Financial Times http://www.ft.com/cms/s/eb9509dc-5700-11db-9110-0000779e2340.html 0ctober 8, 2006 (viewed 11/10/2006)

According to the nVision/Future Foundation Study "Media Consumption in the EU 25"[5] an average European (+15 years age) spends nearly two hours a day watching television. The study remarks that data from audience monitoring organisations provide slightly higher estimates because they count the total active running time of a device and not only just the actual viewing time. Table 3 shows the national differences in television consumption in the EU: While in Greece and Britain people spend more than 2.5 hours per day watching TV, Austrians, Swedes and Swiss consume less than two hours a day. Even if internet use has increased substantially in recent years, television continues to be the dominant media for most people, with Europeans still spending three times as much time watching programmes as going online.[6] Similar results have been obtained in studies in the USA.

Table 3: Total television consumption in Europe by country (Source: nVision/Future Foundation)



The German study of Buhl DataService GmbH suggests that during recent years, people tend to watch more and more TV in their sleeping rooms. While people watch about 3.5 hours a day in the living room they meanwhile (in 2005) watch almost 1.3 hours on average in the sleeping room

[5] nVision/Future Foundation (2006), Media Consumption in the EU 25 – How new media is affecting television, radio and newspapers, London.
[6] Survey covered in Financial Times http://www.ft.com/cms/s/eb9509dc-5700-11db-9110-0000779e2340.html 0ctober 8, 2006 (viewed 11/10/2006)

compared to 1 hour in 2003. The longest watching time in sleeping rooms was noticed at single person households with 3 hours, while in families it was about 1 hour. But it is to add that only 8.8 % of the households have a TV-set in the sleeping room. Further, 3 % have additional TV-sets in kitchen or dining room.

A *forsa*, RWI study[7] underlines the influence of the size of the households on TV operating time. For Germany, the study assumes an average operating time of 4.8 hours per day. While the operating time in single person households is only 4.4 hours, it increases to 5.5 hours in household with five or more persons. Whereas 97% of all European households are equipped with at least one TV-set[8], it also needs to be taken into account that there are households with 2 TV-sets, e.g. 46.6 % of households in Germany own two or more TVs[9].

The current ENERGY STAR TV Specification Revision Update (January 3, 2007) give a new perspective to the overall on-time hours per day. According to NMR (Nielsen Media Research), for the September 2004 – September 2005 viewing season, the average U.S. household was tuned into television and average of 8 hours and 11 minutes per day. And this does not take into account additional hours that a TV is due to peripheral devices such as game consoles, digital video recorders, and increased availability of cable/satellite programming. In conclusion EPA is recognizing the importance of on-mode power consumption in comparison to the previews focus on standby power alone. We strongly support this opinion (see tasks 4 and 5). However, the 8 hours per day "tuned into television" needs does not indicate the average daily on-mode time of a single TV. This figure could mean that in a household multiple TVs are running at different time or in parallel (e.g. the children watch in the afternoon, the parents at night).

Studies that provide data on watching time do not provide relevant information for the purpose of the EuP study which is focussing on the daily duration a TV is in on-mode and consumes power. Based on existing data we should conclude that the primary TV in a European household is 4 hours on per day. With growing functionality it can be assumed that this average daily on-time duration may increase in the future and that power consumption scenarios should consider a 5 hours on-mode a future case.

[7] Frondel M. et al. (2003) Erhebung des Energieverbrauchs der privaten Haushalte für das Jahr 2003. RWI & forsa for the Geman Federal Ministry for Economy and Technology
[8] European Communities (2004) study
[9] Schlomann B. et al. (2004): Energieverbrauch der privaten Haushalte und des Sektors Gewerbe, Handel, Dienstleistungen. Abschlussbericht an das Bundesministerium für Wirtschaft und Arbeit

3.1.2.3. Standby-mode / off-mode time per day

After watching a TV program, video or other active use of the TV the consumer turns the TV off by pressing a button on the remote control, the TV-set or even unplugs the device. Depending on the technical options provided as well as the user behaviour the TV is transferred in an off-mode (hard-off with no power draw, soft-off with some power draw) or standby-mode (passive standby, active standby). The power consumption in these modes has to be considered in regards to the overall energy efficiency of a TV.

There is an ongoing discussion between the TV manufacturer and consumer/environmental organization (e.g. Eco-label) regarding the topic of reducing standby power consumption and the necessity of a hard-off switch. In this discussion a hard-off switch is argued to be necessary with respect of resulting "standby and off-mode losses" (see lot 6). International studies actually show that consumers are making still extensive use of off-switches when provided[10]. The consumers expect their devices to have a total off switch. Some industry representatives are replying to these arguments that it is difficult to facilitate a hard-off switch on the front site of a flat panel TV and that a hard-off switch is not necessary due to the very low power consumption an optimized TVs can achieve in passive standby (0.5 to 0.3 Watts). They also argue that new functionalities such as network capability for program downloads (active standby) are market trends that are not only influenced by the TV manufacturers but also by the broadcast companies. The provision of digital program downloads for television is increasing. The product can only provide this service when the device is kept in standby mode. For downloading some components are activated and draw power over a certain period of time[11]. There are two aspects to consider: firstly, it is unknown neither to the TV manufacturer nor to the broadcast provider if the customer demands this service or how vital the service is for him and secondly, the customer does not know how often this activation occurs while he is not using the TV and what consequence a disconnection might have.

As this discussion indicates there are many pro and cons to the aspect of standby and off-mode and the related power consumption. In task 4 we will make some calculation regarding the amount of

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[10] Concerning the aspect of setting a TV in off-mode after use the previously mentioned forsa study (2003) assessed that 30 % of all German households use the standby mode and 70 % switch off their TV while not using it (although it is not differentiated between using the hard or soft switch). A recent household survey in Australia shows that about 41% of TVs (mostly CRT) were found to be in passive standby mode (use of remote control), 40% were found in off-mode (hard or soft switch used to turn unit off) and about 19% were found to be unplugged or off at the mains. About 95% of units had a hard off switch, about 4% were found to have a soft off switch or standby switch. But about 69% of units only were found to have remote control.

[11] TV Manufacturer gave different answers ranging from 15 to 30 Watts on average over a period of 20 to 30 minutes per download.

power consumption related to active and passive standby modes and off. We will investigate the following four scenarios for various TVs (different technologies and screen sizes):

- Annual power consumption of TVs (4h on-mode / 20h passive standby at 3 Watt)
- Annual power consumption of TVs (4h on-mode / 20h passive standby at 1 Watt)
- Annual power consumption of TVs (4h on-mode / 18,5h passive standby at 3 Watt / 1,5h active standby high at 20 Watts)
- Annual power consumption of TVs (4h on-mode / 19,5h passive standby at 1 Watt / 0,5h active standby high at 20 Watts)

Further scenarios regarding higher or lower power consumption as well as time durations in different modes might be added, depending on the results of task 4 and 5.

3.1.2.4. Conclusion

Table 4 is summarising the data regarding average times per mode from different sources.

Table 4: Overview on time estimates regarding on, standby and off duration for TV

Study/Source	Year	Countries	On-Mode (h/d)	Standby (h/d)	Off-Mode (h/d)	Main off (h/d)
DOE	1998	US	4	20	-	-
Jupiter Research	2006	UK, France, Germany, Italy, Spain	1.7*	-	-	-
Buhl data	2006	Germany	2.2 digital* 3.8 all*	-	-	-
nVision/Future Foundation	2006	EU	2*	-	-	-
AGF / GfK	2006	Germany	3.5*			
ISI, CEPE	2003	Germany	2005: 4.7 2010: 5	12.1 16.8	3.6 1.1	3.6 1.1
forsa, RWI	2003	Germany	4.8	-	-	-
Meyer, Schaltegger	1999	Switzerland	2.3	9.7	12	-
EICTA CoC	2003	EU	4	16	(12 if APO)	-
GEEA	2001	GEEA framework	4	0-20	0-16	-
European Communities	2003	EU	3.5*	-	-	-
Nielsen Media Research	2006	USA	8*	-	-	-

* Average watching time, not over all operating time

The existing results from studies on TV use patterns indicate a typical on-mode time duration per TV per day in European households of 2.5 to 5 hours. This range reflects the increasing use of a second TV in households (see market analysis Task 2.2). For the purpose of this study we will calculate annual power consumption for all TV on stock in EU-25 in on-mode based on an average of 4 hours per day and 5 hours per day for a future scenario. Regarding standby and off-mode time duration no clear figures could be obtained. Therefore we suggest calculating the environmental impact from power consumption in standby and off-mode based on various scenarios that have been outlined above.

3.2. End-of-Life behaviour

3.2.1. Technical lifetime of a TV

The technical lifetime of equipment depends on the reliability of the most expensive and/or the most intensively utilised component which is the display unit in the case of a TV. The display of a TV is the single most expensive component with the highest added value for the manufacturer. Industry sources indicated that modern flat panel displays such as LCD or PDP may achieve a 60000 hours running time before failure, and that they are more stable than conventional CRT. However, due to the novelty of the flat panel displays there are no long-term data available on the actual lifetime of these displays. It is known from public sources that LCD and PDP had at the time of their first market introduction still qualitative problems regarding blind spots or burn-in. In interviews with leading manufacturers, we were assured that such problems are mostly overcome by the current mature technology. This means that the technical lifetime of the latest devices is at least comparable to CRT devices.

Regarding other components that might influence the overall lifetime of TVs, it is reasonable to assess the growing complexity of electronics in modern devices. With the shift towards advanced digital data processing, the amount of electronic components is increasing rapidly. At the same time, system integration technology is improving leading to more reliable assemblies and the quality of electronic components and the system packaging is a key to longer lifetime of TVs.

At the present time the average use duration of TVs in European households is 10 to 15 years depending on the quality of the devices and aspects of second hand use. In the next five to ten years we assume to see a rapid exchange of the primary devices in most households due to the market introduction of new larger screen flat panel TVs. The tremendous change in technology (see task 2) has consequences regarding the time a TVs remains in use. It is reasonable to assume that with the growing maturity and improved quality of new flat panel technology, the introduction of high definition video, and digital broadcasting, a faster turn-over in sales will occur. This means that consumer will by more frequently a new TVs or peripheral devices. Particular the consumers of the first generations of a LCD or PDP might buy a new TV within a short period of time. Similar effects have been observed in the field of Information and Communication Technology (ICT) in the past two decades. In consequence we could expect a somewhat shorter duration a TV actually remains in the market. Manufacturers from Japan indicated that the average turn-over regarding

TVs in Japan is currently in a range of 8 to 6 years only. As for future scenarios we propose average use duration of 8 years (first use) and 4 years (second use).

3.2.2. Repair and Maintenance

Over the past fifty years the repair of CRTs was a common practice. With the advances in technology and the increase in product reliability this practice seems to decline but no exact data are available at this point of time. According to the responses to our questionnaire, manufacturers pointed to the fact that the price for repairs is increasing and it is more likely that consumers buy a new device instead of getting the old TV repaired. We assume that repair is less of an issue in the years to come for LCD and PDP devices although still a considerable business.

Regarding some rear projection TVs, which have a lamp (projection) system, the situation might be different. In this case, one manufacturer acknowledged that the lifetime of the lamps is considerably shorter and replacement of the lamp system might be necessary every five years depending on the actual use pattern. For these products, a replacement of lamp is more common although the lamps are a premium cost factor. Rear projection TVs seem to be an exemption from multiple perspectives. Although they provide a large screen picture, they have much lower power consumption in comparison to LCD and PDP. The aspect that the lamp system is more fragile increases the lifecycle costs for rear projection TVs. The trade-off between reduced power consumption over lifetime and the (most commonly) necessary exchange of the lamps system has to be analysed in the product case assessments conducted in task 4.

3.2.3. Discarded Devices and Recycling Issues

With the national implementation of the WEEE Directive in EU-25 we are in the situation that TVs can be given back for reuse, recycling, or final disposal with no fee for the consumer. In consequence more devices are expected to be discarded and accumulate for recycling. Through that the recycling market for consumer electronics is increasing however with qualitative differences. The eco-efficiency of the current WEEE take-back and recycling of consumer electronics including TVs has been questioned by experts.[12] HUISMAN (2006) argues that the initial intention of the WEEE (ten years ago) the control over toxic substances by means of smart Design for Recycling (DfR) and manual disassembly of hazardous components in the recycling phase itself is outdated. In order to improve the eco-efficiency of consumer electronics recycling a more practical categorization of products and treatment requirements is necessary. It is correct that Huisman

[12] Huisman, Jaco; Stevels, Ab (Delft University of Technology); Marinelli, Thomas; Magalini, Frederico (Philips Consumer Electronics): Where did WEEE go wrong in Europe?, in Proceedings of the 2006 IEEE International Symposium on Electronics and the Envoironment, 8-11 May 2006, San Francisco, CA, USA.

points to the fact that significant technical developments in shredding and separation provide today the necessity of a “recycling destination” oriented dismantling strategy. Today “the recovery of valuable materials (prevention of new material extraction also decreases emissions) and energy preservation becomes much more important”[13]. In consequence a more practical categorization of material streams with similar content in (precious) metal, glass and plastic dominated products occurs naturally, instead of a division by origin as in Annex I of the WEEE Directive.[14]

As a matter of fact, the effectiveness of TV (display) recycling is not sufficient. Most display technologies feature substances that are currently still under exemptions of RoHS regulation (cp. chapter 1.3.1.1). There is mercury in the backlight system of LCD, the liquid crystals in itself, and lead in the glass structures of PDP and CRT. In a recycling process these substances (components) have to be separated and specially treated. It is known that the average percentage of CRT glass recycling (replacing new glass) is lower that 20% and that most re-application occurs in replacing Feldspar in ceramics industry and sand in the building industry. In the case of LCD, the manual removal of the backlight system has to be done very careful in order to avoid health hazards to the worker from breaking lamps. In a similar way is the shredding insufficient due to the uncontrolled Hg emissions. It remains to be assessed what the most effective recycling/materials streams are in regards to various TV display technologies, sizes, etc.

Design for Recycling (DfR) has to address the requirements of selective component pre-treatment (e.g. Hg lamps, batteries, printed circuit boards, plastics with poly-bromide flame retardants) and common material streams. Manufacturers have indicated that there are missing incentives for such a DfR due to the many different take-back (collective character of product collection) and recycling schemes (costs and level of recycling technology) on national level in Europe. As long as there is no economic pressure fostering an eco-efficient application of recycled materials, Design for Recycling can not be focused and is of less relevance in ecodesign.

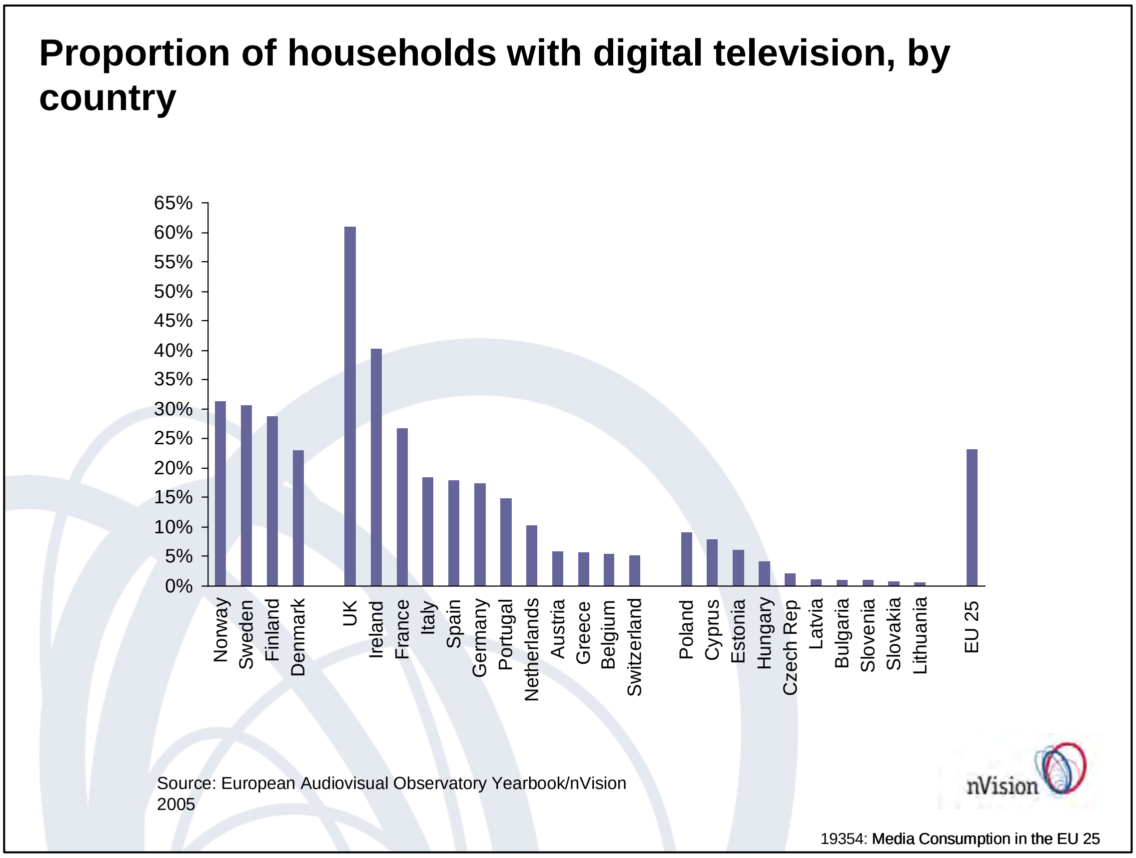
[13] Ibidem, page 83.
[14] Ibidem, page 83.

3.3. Local infrastructure

3.3.1. TV broadcast and access infrastructure

The most influencing factor concerning the infrastructure seems to be the availability of digital video signals. As outlined already in the market analysis all European countries are switching from analogue to digital transmissions. Digitalisation greatly increases the choice of channels, which will very likely lead to a more fragmented audience scenario. Digital technology also opens the window to interactivity. The transition to digital television in Europe proceeds at very different speeds. The nVision/Future Foundation study clarifies the proportions of households with digital television by country (see Table 5). It shows that in most of the EU 15 countries 15-30 % of all households are equipped with digital TV, the UK with 60 % and Ireland with 40 % are far above average, while the adoption of this new technology in Central and Eastern Europe is much lower.

Table 5: Proportion of households with digital TV (Source: nVision/Future Foundation)



Digital TV will influence the consumer behaviour. On one hand, the consumer has usually a greater choice and freedom on what and when he watches a program or recorded program. On the other hand, digital TV could eventually lead to prolonged (always on) active standby of the main devices. It is estimated that the programs have duration of 30 up to 90 minutes daily and draw 20-30 Watts power in that time. In the subsequent tasks it will be examined, if this transmission has a significant influence on the energy consumption.

One further consequence of digital TV is the increasing of peripheral devices such as set-top-boxes, HD/DVD recorder, and separate powered room antenna. The effect on the system infrastructure is manifold. We encounter already an increase in broadcasting and telecommunication infrastructure with parallel developments. The customer can choose between various broadcast access systems (cp. chapter 2.3.3). The dynamic of this development is fast and not always transparent. We have to assume that the provision of multiple TV access infrastructures will increase the overall amount of resource and power consumption. We suggest that the eco-efficiency of the extended TV broadcasting and access infrastructure in conjunction with end-user devises should be investigated in a separate study.

3.4. Conclusion of Task 3

The first aim of this task is to analyze user-parameters that determine the environmental impact of a TV in the use phase. Of particular importance seems to be the on-mode time per day due to the growing power consumption of larger flat panel TVs which enter the market. The time duration of daily on-mode and standby/off-mode correlates with the overall energy consumption of televisions.

We suggest defining a general scenario for all TVs (stock) with an on-mode time of 4 hours per day. This 4 hours scenario considers the actual trend of longer on-mode time of the primary TV in a household, the expected penetration rate of 2.0 TVs in each EU household in 2010 and the shorter on-mode time of a second TV in the household. In order to identify the significance of power consumption in correlation to standby and off-modes we have suggested two scenarios for 20 hours passive standby with 3 and 1 Watts, two scenarios for 20 Watts active standby, one with a half an hour duration and another with 1.5 hours. Further scenarios regarding higher or lower power consumption as well as time durations in different modes might be added, depending on the results of task 4 and 5. A total off scenario is easily down and can in comparison to the results of the other scenarios indicate the importance of standby and hard-off. In order to calculate the overall environmental impact TVs throughout the full product life we suggest defining a current scenario with 10 years in primary use and some 5 years in secondary use and a future scenario (past 2010) with 8 years primary use and 4 years secondary use duration. From our analysis we also conclude that repair is decreasing but the exchange of the lamp system is an issue for rear projection TVs and will be reflected in the lifecycle costing analysis. Most of the time a TV remains in the household for secondary use, however, a second hand market exists.

Finally, we also analyzed influencing factors concerning the buying decision. It was concluded that the price is the dominating aspect. However, due to the tremendous technological changes that currently occur the consumer is considering more and more the picture size and quality as well as the functional spectrum of new TVs. Energy consumption – which is related to these technical aspects – is not yet considered as a really important decision factor. There are very strong indications that power consumption in on-mode is an important environmental impact. It is therefore necessary to provide the consumer with information on power consumption.

EuP Preparatory Studies “Televisions” (Lot 5)

Final Report on Task 4 “Technical Analysis”

Compiled by Fraunhofer IZM and PE Europe

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Berlin, 2nd August 2007

Content

Introduction

This is the final report on Task 4 "technical analysis of existing products" for the EuP Preparatory Studies on televisions (lot 5). The findings presented in this report are results of the research conducted by the IZM consortium and the continuous feedback from a wide range of stakeholders. The statements and recommendations presented in the final report however are not to be perceived as the opinion of the European Commission.

We like to acknowledge the fruitful collaboration and trustful working relationship with various industry partners, non-industry stakeholders, and the European Commission throughout the study. We like to thank all stakeholders for their contributions and critical reviews of our reports.

2nd August 2007

Technical Analysis

General Approach to Technical Analysis

Task 4 is dedicated to the technical analysis of existing products on the EU-market. Bill of materials (BOM) and resources consumption data during product life have been compiled for various products. Following the VHK methodology (MEEuP) these data will provide the general input for the definition of the Base Cases in Task 5. In view of Task 5 we selected products for the analysis with following intentions:

- Products of different display technologies
- Products of different screen sizes
- Products that represent strong market segments in the near future (2010)[1]
- Products with expected technical improvement potential

With these aspects in mind we made a selection of desired products and asked manufactures at the beginning of the study to provide particular data for such products. Based on the results of our market analyses (Task 2) we selected four primary product cases:

- 26” CRT-TV
- 32” LCD-TV
- 42” PDP-TV
- 50” RP-TV

In the following paragraph we will discuss the data input for the technical analysis.

Available Product Cases for Technical Analysis

A total of 15 product examples were provided from individual companies. It has to be said that all product examples were provided from ten brand-name manufactures[2]. Data sets for the selected 26” CRT-TV could not be obtained. However, we received two data sets for 29” and 32” CRT-TV which will serve the purpose for analyzing CRT. In this conjunction we would like to point your

[1] This aspect reflects the assumption that the product analysis and the base cases should focus on the market situation when the EuP directive takes effect.

[2] A stakeholder comment from Mr. Siderius (SeneterNovem) indicated possible limitations to this choice of only brand-name products. His question, if the conclusions from the analysis will also be valid for no-name products is relevant, however has to be answered with yes. The analysis will show that the products even in the same segments are quite different and that an assessment is only on a highly aggregated level possible. On this level we can not detect individual difference in material composition of the utilization of particular electronics components. Take the example of the LCD displays, the assessment with VHK EcoReport does not allow a distinction of different LCD panel types (specifications of functional layers, etc.) or backlight systems because VHK uses only one default data set for the complete assessment of the LCD. This is the true limitation.

attention to the fact that the industry is not expecting further technological development in the field of CRT. CRT is a very mature display technology with – to our knowledge – no known technological improvement potential. It is of cause always possible to improve the technical properties of a CRT-TV such as the efficiency of power conversion, standby power draw, or material related issues. However, there is no indication for a major technology jump in CRT display technology. As indicated in Task 2, the CRT market is expected to shrink in the next years. The market prognosis for 2010 is still forecasting a significant sales volume of almost 5 million units in the European Union, although it seems that a phase out could occur faster. From this situation we conclude that CRT-TV will be of less significance by the year 2010. The technical analysis will thus be based on just two products in the case of CRT.

With respect to LCD-TV we received three data sets for 32” screen size. For comparison purposes we also analyzed a 26”, 37”, and 42” LCD-TV. These secondary product cases are intended to provide control data regarding the magnitude of changes in the environmental impacts for products of different technologies or screen sizes. As an example we will compare products of the same screen size segment but of different display technologies (e.g. 42” LCD to 42” PDP) or of same display technology but different screen size segments (e.g. 32” LCD to 42” LCD).

Regarding PDP-TV we will analyze two 42” and two 43” and aggregate them to a 42” PDP product case. For secondary product case we received three 50” PDP-TV and a 50” RP-TV. The following Table 1 shows the structure of the technical analysis of existing products.

Table 1: Overview of product cases

	26“	29“	32 “	37“	42“	43“	50“
CRT		1x 29” CRT	1x 32” CRT				
LCD	1x 26“ LCD		3x 32” LCD	1x 37” LCD	1x 42” LCD		
PDP					2x 42” PDP	2x 43“ PDP	2x 50“ PDP
RP							1x 50“ RP

It is very unfortunate that we do not have the opportunity to analyze more RP-TVs of different technologies (e.g. DLP, 3LCD, LCoS[3]) for the purpose of this study. The technical differences in rear projection technologies have to be considered as significant. On the other hand it is difficult to predict if such differences are visible in an environmental assessment applying VHK EcoReport. It is matter of fact that RP-TVs have in the large screen size segment comparatively low on-mode power consumption. This aspect is very interesting from an environmental point of view. But we also have to consider the current market development which seems to focus on flat panel display TVs. Furthermore, picture quality (contrast, color reproduction, side viewing) and convenience (instant on/off without cooling fans, long life component reliability) are important sales aspects. Such issues has been known as weaknesses of RP-TVs and it is a question of time if improved technologies can compete with currently more dominant flat panel display TVs. These aspects are reflected by market forecasts which predict a rather moderate market potential for RP-TVs in the next years. Nevertheless, we will consider RP-TVs throughout the study regarding their current technical advantage of low power consumption. We would appreciate further stakeholder support for the analysis for PR-TVs, their technical development and market potential.

Aspects of Data Input for Technical Analysis

The following technical analysis of product cases has been done with the EcoReport tool developed by VHK for the purpose of the EuP preparatory studies. In preparation of this analysis we provided the contributing industry partners with a guideline document (Guidance for Product Case Assessment Lot 5, 9th August 2006). With this document we tried to enable a coherent completion of the VHK EcoReport spread sheet (EuP_EcoReport_v5.xls) for the product case assessments.

To enable the identification of technical and environmental improvement potential the link between material/component and function/functionality is needed (at least on a confidential basis). Therefore we ask the contributing industry partner to complete one VHK input table for the following main product modules (sub-assemblies):

- **Chassis, c**abinet, stand, speaker unit, control keys, small parts (especially screws)
- **Display** module including drivers, backlighting, front glass and frames
- **Power supply** unit including PCB and cord
- **Remote control** including batteries
- **Electronics Boards** including populated printed circuit boards, sensors, connectors, heat sinks and cooling elements, other electro mechanics
- **Packaging** materials, paper manuals etc.

[3] See Task 6 report for technical specifications and current developments.

- **Others** (e.g. internal cables), all materials/components relevant for your product but not being part of the above mentioned six groups should be stated under others.

The basic concept is to break down the data input according to main product modules. This allows us to assess the environmental impact of these sub-assemblies separately and to make a consistency check of the entries. As a result we should be able to correlate certain environmental impacts more precisely to a particular functional module of the product. In the following report only the required aggregated product data will be presented for the:

- Production phase
- Distribution phase
- Use phase (product)
- Use phase (system)
- End-of-life phase

In the production phase the material composition of a product and related manufacturing processes will be analyzed. The focus of this analysis will be put on the determination of the relationship between the amounts of certain materials/components and their technical function. The modular approach is supporting this task and leads to a better understanding of material usage in a particular product. What will be noticeable are the considerable differences of material composition within the same or similar product segments.

The VHK EcoReport does not provide a data set for Plasma Display Panels in comparison to LCD and CRT for which a data set is given. To allow a proper consideration of PDP in the frame of the preparatory study on televisions a data set is needed, which is comparable to the LCD and CRT data sets in terms of detail, system boundaries and impact categories. In order to overcome this problem we have contacted the only five PDP manufacturers (LG, Samsung, Pioneer, Panasonic, Hitachi) in order to obtain a similar data set. The following request was send to the five PDP manufacturers on August 9th 2006:

- Provide data for the latest generation of PDP manufacturing (describe very briefly the data source, e.g. technology generation, substrate sizes, fab).
- Reference is the display panel only (no frames etc.) in terms of weight (1 kg output of panel, yield losses excluded). Additionally, please provide a factor to allow for area (1m²) based calculations: Specific weight in kg / m².
- Provide data on a cradle-to-gate basis (from raw materials extraction to plasma display panels). If you have only gate-to-gate data (data for the PDP plant itself, plant considered as “black box”), please state additionally to the data requested below the main input flows

for the plant in terms of energy (state whether it is fossil fuel, electricity…) and main raw materials (e.g. water, …)

- Regarding the PDP fab, include the manufacturing processes and the direct infrastructure (HVAC, gas farm etc.). If possible, please exclude office buildings, dormitories etc. Please, explain briefly the “system boundaries” of your PDP fab data.

The data should be provided based on the following inventory.

Table 2: PDP manufacturing data request

Data for the following inventory and impact categories:			(per kg panel)
Other Resources & Waste			
	Total Energy (GER)	MJ	
	of which, electricity (in primary MJ)	MJ	
	Water (process)	ltr	
	Water (cooling)	ltr	
	Waste, non-haz./ landfill	g	
	Waste, hazardous/ incinerated	g	
Emissions (Air)			
	Greenhouse Gases in GWP100	kg CO2 eq.	
	Acidification, emissions	g SO2 eq.	
	Volatile Organic Compounds (VOC)	g	
	Persistent Organic Pollutants (POP)	ng i-Teq	
	Heavy Metals	mg Ni eq.	
	PAHs	mg Ni eq.	
	(PAH alternatively in	mg Benzo(a)pyrene eq.)	
	Particulate Matter (PM, dust)	g	
Emissions (Water)			
	Heavy Metals	mg Hg/20 eq	
	Eutrophication	g PO4 eq.	
	Persistent Organic Pollutants (POP)	ng i-Teq	

We received very different data regarding PDP manufacturing from four companies. For example, the data on energy consumption largely differs between individual manufacturers by a maximum factor of 14 (from below 600 MJ to close to 8000 MJ electricity per square-meter panel).

Comment: After publishing the interim report further discussion with LG Electronics, Panasonic, Hitachi, and Pioneer regarding the extreme dissimilarity in PDP manufacturing data (total energy) uncovered two reasons for this situation. First of all, one manufacturer that had given a total energy consumption of 600 MJ did not include all production steps into the assessment. Secondly, the manufacturer with the highest amount (8000 MJ) had taken data from the first manufacturing generation which is considerably less efficient than the nowadays applied second and third generation. According to statements from the industry average total energy consumption for plasma panel manufacturing (in MJ per m² PDP) is today approximately 3500 MJ. This data are however comparable to the averages with which the calculation was done initially.

The initial averages for secondary energy per m² plasma display panel are:

- 2.940 MJ electricity (secondary energy)
- 645 MJ natural gas
- 2.160 liter water for manufacturing processes

The data on energy consumption, which actually have been provided as secondary energy, not primary energy, and on water consumption, have been multiplied by the factors given in the EuP EcoReport spreadsheet for the base case assessments (task 5). However, the huge variation among the different manufacturers is remarkable. On a bilateral basis clarifications where requested and received to ensure a coherent data acquisition among the different manufacturers, but this did not unveil any indications, that these variations might result from inadequate data quality. Obviously there is indeed a large difference among the different manufacturers. Reasons could be the different generations of panel fabs (different efficiencies and panel sizes), differences in yield, and overhead (office buildings etc.). Consequently, all assessments undertaken for PDP TVs with this averaged data set have to be interpreted with caution when it comes to the manufacturing phase.

4.1. Production Phase

4.1.1. LCD-TV

4.1.1.1. Introduction to LCD-TV Technology

Liquid Crystal Displays (LCD) are the most mature and commercially successful flat panel display technology today. More light weight than conventional CRTs and with an increasing picture quality the LCD technology has the capability of realizing the full range of screen sizes for a reasonable price. LCD and other FPDs are incorporating fixed matrix technologies, but create the images using different methods. LCD – in contrast to PDP or SED – is a non-emissive technology using a backlight (CCFL[4] or LED[5]) as a light source. LCD is made up of any number of pixels consisting of materials (liquid crystals) that can alter their crystalline structure or orientation when voltage is applied. The transparency is changing through this principle. The light from the light source first passes through a polarization filter, gets than modulated by the liquid crystals, and creates a blue, red or green pixel after passing through another polarization and color filter. Thin Film Transistor (TFT) technology on glass is used to drive or control the orientation of the liquid crystals (pixels). The display is protected on the front side with an antireflective hard coating. LCD technology is continuously improving. This improvement revolves around the miniaturization and optimization of the functional layers by keeping transparency of the layers very high. The Figure 1 shows the principle design of a liquid crystal display.

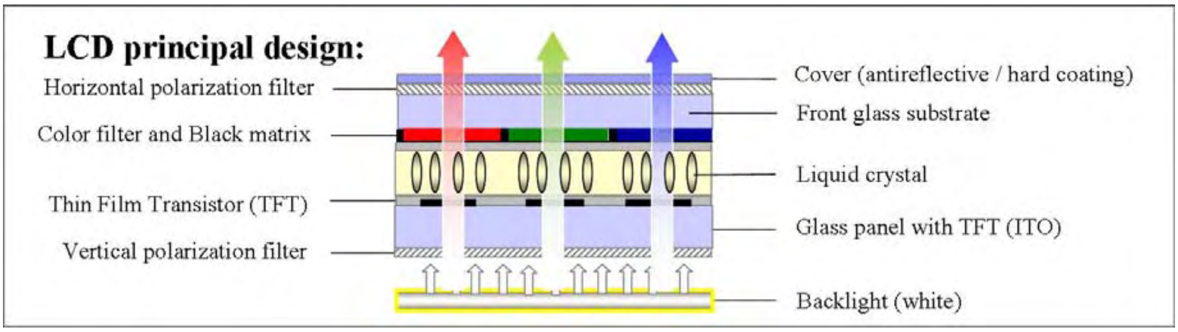

Figure 1: Principle Design of a Liquid Crystal Display

Figure 2 shows the principle design of a LCD-TV in exploded view.

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[4] CCFL, cold-cathode florescent lamps
[5] LED, light emitting diode

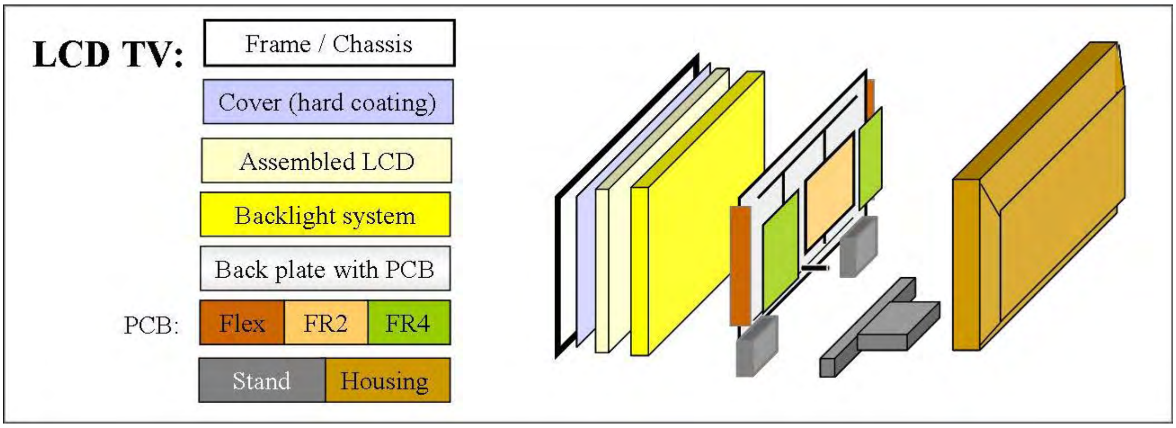

Figure 2: Principle Design of a LCD-TV

The manufacturing of a LCD-panel is characterized by multiple process steps for fine structuring and distribution of functional layers. Similar to microelectronics manufacturing LCD-panel processing demands clean environments, fine chemical processes and constant quality control. Front and back glass panels will be coated with ITO metal oxide film which acts as an electrode. Afterwards a polymer alignment layers is applied on the glass substrate. This layer is structured to support the later alignment of the liquid crystal molecules. After preparation of both panel sides the front and back glass substrates will be fixed in the right position, than assembled under pressure, and heated in order to temper the sealing. Finally the panels are cut and the liquid crystals can be filled into the cells. After sealing, the polarization filters are applied and the display interconnected.

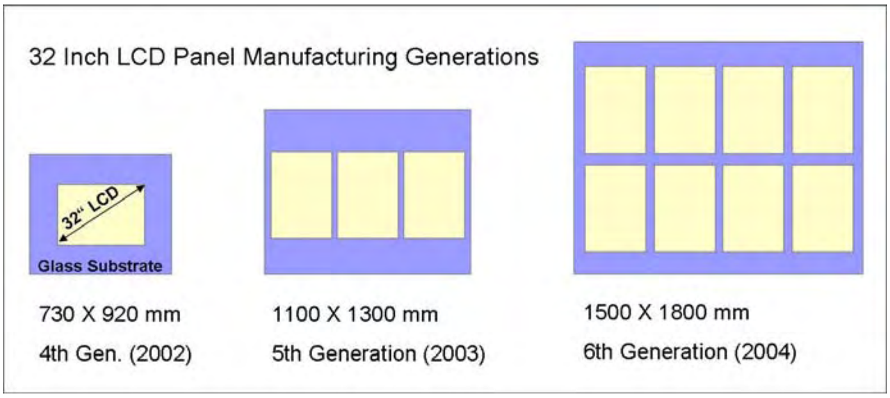

Figure 3: 32" LCD panel manufacturing

Materials and technologies for mass manufacturing are improving constantly resulting in higher yield and overall productivity (resource efficiency). Figure above is illustrating the 4th to 6th manufacturing generation for 32" LCD panels. The 8th generation LCD manufacturing is currently under way. EE Times reports, that Sharp will use its Kameyama plant in Japan to produce 8th generation substrates, which at 2200 x 2400 mm in size are suited to 45- to 50-inch LCD TV panels. Samsung and Sony (S-LCD Corp.) have also the intention to establish an 8th generation amorphous

TFT LCD panel production line (2200mm x 2500mm) at the Tangjung plant in South Korea. Japan's largest glassmaker, Asahi Glass Co, plans to begin producing 8th generation glass substrates at its Takasago plant in Japan as soon as October 2006, being among the first to market with panels for the largest wide-screen TVs, the Nihon Keizai Shimbun reported without sources in June 2005. The 8th generation glass substrates will measure about 2400 x 2600 mm, allowing more or larger panels to be produced. The industry expects demand for LCD glass substrates to grow about 30 percent a year, however experiencing currently an overcapacity in LCD panels, whereas PDP is driving production capacity by building also new factories.

4.1.1.2. Bill of Material of 32" LCD-TV (primary product case)

For the primary product case two 32" LCD-TVs from different manufacturers have been considered. For assessing the characteristics of the TVs the Bill of Materials (BOM) of all modules (chassis, display, PSU, etc.) have been considered separately. For the primary product case data of all modules have been aggregated by the arithmetic average of the used materials by keeping the modular structure. Assumptions have been made for the speakers in the chassis module and the batteries in the remote control module, due to the fact that there are mainly total masses given in the BOMs. Therefore the speakers and battery assemblies have been allocated to the input category "electronics: 44-big caps & coils" in the VHK spreadsheet. Table 3 presents the mass proportions of the considered TVs modules. Mass proportions that are between 15 and 50 % of the total mass are highlighted yellow and mass proportions that are higher than 50% of the total mass are highlighted red. This color coding eases the identification of significant modules or materials by mass related to the total TV. When reading the following tables it should be kept in mind that this coding is only related to mass and does not identify the environmental significance of the modules and materials. The environmental assessment of the modules is discussed in Task 5.

Table 3: Total Mass Proportion of 32" LCD-TV

	LCD-TV 1	**LCD-TV 2**
	Proportion of total mass	
Chassis	45,55%	39,06%
Display	31,84%	30,72%
Power supply unit	3,02%	4,15%
Remote	0,39%	0,47%
Electronic boards	1,47%	4,21%
Packaging	16,83%	19,71%
Other	0,90%	1,69%
Total	**100,00%**	**100,00%**

As it is presented in Table 3 the chassis, display and packaging are the predominant modules related to mass. There are no significant differences in between the two 32" LCD-TVs identifiable. The exemption is the module electronic boards, which total model mass varies between 300g and 1020g per product model. As discussed before, this mass difference is due to the different layouts of the PWBs, allocation of PWBs to other modules, and possibly to additional functions per product, e.g. digital tuner – analogue tuner, surround sound – stereo etc. Therefore the arithmetic average to calculate the base case is chosen for all modules including the electronic boards. The application of this calculation provides a representative material mix relating to the LCD technology for 32" with average electronic features. The resulting bill of materials for the primary product case for the 32"LCD-TV is shown in the following Table 4.

Table 4: EcoReport Input Table for 32" LCD-TV

Version 5 VHK for European Commission 28 Nov. 2005			Document subject to a legal notice (see below)		
	ECO-DESIGN OF ENERGY-USING PRODUCTS		EuP EcoReport: INPUTS Assessment of Environmental Impact		
Nr	Product name		Date	Author	
	Primary case 32" LCD TV				
Pos	**MATERIALS Extraction & Production**	**Weight**	**Category**	**Material or Process**	
nr	**Description of component**	**in g**	**Click &select**	**select Category first !**	
1	CHASSIS				
2	Housing, plastic parts	3284,5	1-BlkPlastics	**10-ABS**	
3	Metal frame	5052,0	3-Ferro	**21-St sheet galv.**	
4	Speakers	251,8	6-Electronics	**44-big caps & coils**	
5	Stand, Metal parts	321,5	3-Ferro	**23-Cast iron**	
6	Stand, Metal parts	205,0	4-Non-ferro	**26-Al sheet/extrusion**	
7	Stand, Plastic parts	246,0	1-BlkPlastics	**10-ABS**	
8	Stand, Plastic parts	195,0	1-BlkPlastics	**5-PS**	
9	Screws	124,5	3-Ferro	**25-Stainless 18/8 coil**	
10					
11	DISPLAY				
12	LCD Module	282,3	6-Electronics	**42-LCD per m2 scrn**	
13	LCD Module, mass dummy	6707,7			
14	Electronic module	216,0	6-Electronics	**44-big caps & coils**	
15	Electronic module	2,0	6-Electronics	**45-slots / ext. ports**	
16	Electronic module	2,0	6-Electronics	**46-IC's avg., 5% Si, Au**	
17	Electronic module	3,0	6-Electronics	**48-SMD/ LED's avg.**	
18	Electronic module	154,0	6-Electronics	**50-PWB 6 lay 4.5 kg/m2**	
19					
20	POWER SUPPLY UNIT				
21	Heatsink	84,5	4-Non-ferro	**26-Al sheet/extrusion**	

22	Electronic module	477,6	6-Electronics	44-big caps & coils	
23	Electronic module	22,9	6-Electronics	47-IC's avg., 1% Si	
24	Electronic module	0,1	6-Electronics	46-IC's avg., 5% Si, Au	
25	Electronic module	14,5	6-Electronics	52-Solder SnAg4Cu0.5	
26	Label	0,1	7-Misc.	57-Office paper	
27	Power Cord PVC part	17,3	1-BlkPlastics	8-PVC	
28	Power Cord Copper part	22,4	4-Non-ferro	29-Cu wire	
29	Connectors	22,9	6-Electronics	45-slots / ext. ports	
30	Electronic module	0,5	6-Electronics	48-SMD/ LED's avg.	
31	Electronic module	10,2	3-Ferro	21-St sheet galv.	
32	Electronic module	0,4	4-Non-ferro	30-Cu tube/sheet	
33	Electronic module	156,4	6-Electronics	49-PWB 1/2 lay 3.75kg/m2	
Pos nr	**MATERIALS Extraction & Production Description of component**	**Weight in g**	**Category Click &select**	**Material or Process select Category first !**	
42	REMOTE CONTROL				
43	Electronic module	14,1	6-Electronics	50-PWB 6 lay 4.5 kg/m2	
44	Electronic module	0,5	6-Electronics	44-big caps & coils	
45	Electronic module	0,5	6-Electronics	45-slots / ext. ports	
46	Electronic module	0,5	6-Electronics	46-IC's avg., 5% Si, Au	
47	Electronic module	0,4	6-Electronics	47-IC's avg., 1% Si	
48	Rubber	11,9	2-TecPlastics	16-Flex PUR	
49	Housing	22,0	1-BlkPlastics	7-HI-PS	
50	Housing	32,4	1-BlkPlastics	10-ABS	
51	Screw	0,1	3-Ferro	21-St sheet galv.	
52	Terminal	0,8	3-Ferro	25-Stainless 18/8 coil	
53	Battery	17,9	6-Electronics	44-big caps & coils	
54					
55	ELECTRONIC BOARDS				
56	Shielding	27,7	3-Ferro	21-St sheet galv.	
57	Electronic module	0,3	3-Ferro	24-Ferrite	
58	Heatsink	20,0	4-Non-ferro	26-Al sheet/extrusion	
59	Electronic module	1,0	4-Non-ferro	30-Cu tube/sheet	
60	Electronic module	29,0	6-Electronics	44-big caps & coils	
61	Electronic module	56,9	6-Electronics	45-slots / ext. ports	
62	Electronic module	12,5	6-Electronics	46-IC's avg., 5% Si, Au	
63	Electronic module	0,6	6-Electronics	47-IC's avg., 1% Si	
64	Electronic module	65,0	6-Electronics	48-SMD/ LED's avg.	
65	Electronic module	360,0	6-Electronics	50-PWB 6 lay 4.5 kg/m2	
66	Electronic module	94,5	6-Electronics	50-PWB 6 lay 4.5 kg/m2	
67	Electronic module	0,2	6-Electronics	52-Solder SnAg4Cu0.5	
68					
69					
70	PACKAGING				
71	Cardboard box	2438,5	7-Misc.	56-Cardboard	
72	Plastic bag	121,7	1-BlkPlastics	1-LDPE	
73	Polystyrene Foam	706,0	1-BlkPlastics	6-EPS	
74	Manual	946,7	7-Misc.	57-Office paper	

75					
76	OTHERS				
77	Internal/ external cables	123,3	4-Non-ferro	**29-Cu wire**	
78	Internal/ external cables	49,5	1-BlkPlastics	**8-PVC**	
79	Internal/ external cables	1,7	2-TecPlastics	**11-PA 6**	
80	Internal/ external cables	0,6	2-TecPlastics	**13-PMMA**	
81	Internal/ external cables	1,6	2-TecPlastics	**16-Flex PUR**	
82	Internal/ external cables	71,9	3-Ferro	**21-St sheet galv.**	
83	Internal/ external cables	20,5	3-Ferro	**24-Ferrite**	
84	Internal/ external cables	2,7	3-Ferro	**25-Stainless 18/8 coil**	
85	Internal/ external cables	2,6	4-Non-ferro	**30-Cu tube/sheet**	
86	Internal/ external cables	27,5	6-Electronics	**45-slots / ext. ports**	

Table 5 shows the total material use for the 32” LCD-TV primary product case according to VHK EcoReport aggregation.

Table 5: Total Material Use of 32” LCD-TV

Life Cycle Impact (per unit) of Primary case 32" LCD TV

Nr	Life cycle Impact per product:	Date	Author
0	Primary case 32" LCD TV	0	vhk

	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	**Total**	**BUTION**		Disposal	Recycl.	**Total**	
	Materials	**unit**									
1	Bulk Plastics	g			**4674**			4207	467	**4674**	**0**
2	TecPlastics	g			**16**			14	2	**16**	**0**
3	Ferro	g			**5632**			282	5351	**5632**	**0**
4	Non-ferro	g			**459**			23	436	**459**	**0**
5	Coating	g			**0**			0	0	**0**	**0**
6	Electronics	g			**2286**			1296	990	**2286**	**0**
7	Misc.	g			**10093**			505	9588	**10093**	**0**
	Total weight	g			**23160**			6326	16834	**23160**	**0**

The LCD panel (misc.) is dominating the amount of totally used materials for the 32” LCD-TV followed by ferro metals, bulk plastics, cardboard and electronics. The significance to environmental impacts caused by material from these groups is discussed in the base case impact assessment (Task 5).

4.1.1.3. Bill of Material of 26”, 37”, 42” LCD-TVs (secondary product cases)

For the purpose of comparing the 32” LCD-TV product case with LCD-TV of larger and smaller screen size an analysis of a 26”, 37” and 42” LCD-TV follows. For the secondary product cases of LCD-TVs all modules have been averaged by the mass proportions of materials and components as described for the primary product case. The latter are already averaged to a single column.

Comparing the mass proportion of the modules from the primary product case and the secondary product cases we see that there are only minor differences. These can be explained by the different TV dimensions and respective designs as the comparison by module below shows. Table 6 compares the primary and secondary product cases related to the mass proportion of their modules.

Table 6: Primary and Secondary LCD-TV Product Cases

	Primary case	Secondary case		
	32" LCD-TV	26" LCD-TV	37" LCD-TV	42" LCD-TV
	Proportion of TV mass			
Chassis	41,80%	38,09%	44,28%	39,35%
Display	31,81%	27,43%	37,54%	37,68%
Power supply unit	3,58%	5,01%	3,18%	3,43%
Electronic boards	2,88%	5,31%	2,04%	2,89%
Remote	0,43%	0,59%	0,40%	0,27%
Packaging	18,19%	21,38%	12,21%	15,88%
Other	1,30%	2,18%	0,35%	0,49%
Total	**100 %**	**100%**	**100%**	**100%**

The following tables present the material mass proportions of the considered TV modules.

Chassis:

There are minor differences in material mass proportions which are due to the different screen sizes and therefore design variations of the considered TVs. The main materials used for the chassis skin are steel sheet for the frame and ABS or Hi- PS for the plastic skin. The predominant plastic used for the housing skin is ABS. The differences in the caused environmental impacts of the two plastics are discussed in Task 5.

Table 7: Comparison of Chassis mass proportion for LCD-TV product cases

	Primary case 32" TV	26" LCD TV	37" LCD TV	42" LCD TV
	proportion of module mass/ *TV mass*			
Chassis				
Plastic parts	38,49%	35,76%	33,64%	38,07%
Metal parts	58,91%	59,79%	63,59%	59,44%
Speakers	2,60%	4,45%	2,77%	2,49%
Total	**100 %**	**100%**	**100%**	**100%**

Display:

For the display the most data were given by total mass of the whole LCD module. Additional information for controller board of the backlight assembly is available for the 32" and 42" LCD TVs. The populated PWB for the display has been added to the primary product case to achieve more representative data.

Table 8: Comparison of Display mass proportion for LCD-TV product cases

	Primary case 32" TV	26" LCD TV	37" LCD TV	42" LCD TV
	proportion of module mass/ *TV mass*			
Display				
LCD module, mass	94,88%	100,00%	100,00%	97,94%
Populated PWB	5,12%	0,00%	0,00%	2,06%
Total	**100 %**	**100%**	**100%**	**100%**

For Comparison: LG Philips Environmental Product Declaration for LCD (display module)

Data for composition and environmental impacts of LCD-TV display modules for three screen sizes (32“, 37“, 42“) have been published by LG-Philips in 2005 as an environmental product declaration (EPD), referring to production in 2004. The composition of the modules according to LG.Philips is as listed in Table 9 below.

Table 9: Material Composition of LCD Modules according to LG-Philips

Content (%)	**32“ module**		**37“ module**		**42“ module**	
Metals	*47.58%*	*4 329 g*	*46.87%*	*6 984 g*	*43.37%*	*6 896 g*
Steel	47.25%	*4 300 g*	46.52%	*6 931 g*	42.96%	*6 831 g*
Copper	0.33%	*30 g*	0.35%	*52 g*	0.42%	*67 g*
Plastics	*28.30%*	*2575 g*	*30.23%*	*4 504 g*	*34.19%*	*5 436 g*
EPS	6.17%	*561 g*	10.40%	*1 550 g*	13.19%	*2 097 g*
PMMA	7.63%	*694 g*	6.80%	*1 013 g*	7.09%	*1 127 g*
PET	7.40%	*673 g*	6.56%	*977 g*	6.89%	*1 096 g*
PC	6.35%	*577 g*	5.83%	*869 g*	6.12%	*973 g*
PE	0.70%	*64 g*	0.61%	*91 g*	0.85%	*135 g*
Others	0.04%	*4 g*	0.04%	*6 g*	0.05%	*8 g*
Glass	14.52%	*1321 g*	13.86%	*2 065 g*	14.91%	*2 371 g*
Paper	8.69%	*791 g*	8.07%	*1 202 g*	6.58%	*1 046 g*
Electronics	0.92%	*84 g*	0.97%	*145 g*	0.94%	*149 g*
Total	**100%**		**100%**		**100%**	
product weight	**7 200 g**		**11 500 g**		**11 800 g**	
packaging weight	**1 900 g**		**3 400 g**		**4 100 g**	

The module consists of TFT board, colour filter board, BLU (back light unit), polarizer, printed circuit board cases (PCB). This data includes also the packaging of the module, which is removed at final assembly of the TV set.

Power Supply Unit and Electronic Board:

For the "Power Supply Unit" and the "Electronic board" there are generally identified differences in the use of electronic components. This is because for electronic components in the VHK spreadsheet is no option to select components specifically. Electronic components can only be chosen by groups like "44-caps and coils" or "45-slots / ext. ports". Therefore the spreadsheets from the different TVs have been completed by the manufacturers with many assumptions, which defined and selected from the VHK options electronics differently.

For the PSU modules there are differences for the mass proportions of the cords. The range is from 0% - 13%. This is due to the different PSU layouts and that there no exact limitation for the PSU if only electronic components belong to the module or electronic and electro mechanic components. So it is possible that the missing cords for the PSU are considered in the "electronic boards" module or in the "others" module.

Table 10: Comparison of PSU mass proportion for LCD-TV product cases

	Primary case 32" TV	**26" LCD TV**	**37" LCD TV**	**42" LCD TV**
	proportion of module mass/ *TV mass*			
Power supply unit				
Heat Sink	10,18%	13,12%	16,49%	16,34%
PWB	18,85%	17,85%	14,21%	20,46%
ICs	2,77%	2,07%	4,61%	1,01%
Connectors	2,76%	0,81%	0,00%	0,57%
Caps and Coils	57,56%	63,04%	52,37%	44,71%
SMD Components	0,06%	0,11%	0,80%	3,98%
SOLDER	1,75%	3,00%	0,00%	0,00%
LABEL	0,01%	0,01%	0,00%	0,00%
Cord	4,78%	0,00%	11,53%	12,93%
Other metal parts	1,23%	0,00%	0,00%	0,00%
Other copper parts	0,05%	0,00%	0,00%	0,00%
Total	**100 %**	**100%**	**100%**	**100%**

For the electronic boards the main difference in the modules is the shielding mass of the 42" LCD-TV and the heat sink for the 37" LCD-TV which functionality might be integrated in the PWB mass of the other product examples.

Table 11: Comparison of PWB mass proportion for LCD-TV product cases

	Primary case 32" TV	26" LCD TV	37" LCD TV	42" LCD TV
	proportion of module mass/ *TV mass*			
Electronic boards				
Shielding	4,15%	2,28%	3,55%	37,51%
Inductor	0,04%	0,06%	0,00%	0,00%
Heat sink	3,00%	0,00%	15,28%	4,06%
Earth plate	0,15%	0,19%	0,00%	0,00%
passive components	4,34%	1,16%	10,66%	6,48%
connectors	8,51%	12,32%	12,43%	12,95%
IC	1,88%	0,95%	8,88%	2,13%
IC	0,09%	0,12%	0,00%	0,81%
SMD Components	9,74%	12,70%	5,33%	1,93%
PWB	68,07%	70,18%	43,87%	34,13%
solder	0,02%	0,03%	0,00%	0,00%
Total	**100 %**	**100%**	**100%**	**100%**

In summary all electronic component groups show minor differences regarding the mass proportions of electronic components, but the composition differs, which does not allow a representative environmental assessment in details of the module electronics for Task 5, but allows an aggregated consideration related to the contribution of this module as part of the entire TV-set.

Remote Control:

For the remote control the predominant material is the plastic, mainly ABS and PS, used for the housing, followed by the battery and the printed wiring board. There are no significant differences in the material use of the different remote controls. Only the battery mass of the 26" LCD-TV differs form the other product cases. Due to its low weight, it has no significance for the environmental impacts of the TV.

Table 12: Comparison of Remote Control mass proportion for LCD-TV product cases

	Primary case 32" TV	26" LCD TV	37" LCD TV	42" LCD TV
	proportion of module mass/ *TV mass*			
Remote				
Housing, plastic parts	54,28%	56,67%	57,66%	54,42%
Capacitors	0,45%	0,79%	0,00%	0,48%
IC	0,90%	0,70%	1,80%	1,19%
Connector	0,50%	0,00%	0,00%	0,00%
PWB	14,07%	14,17%	22,52%	21,00%
SMD Components	0,00%	0,00%	1,80%	0,95%
Rubber parts	11,87%	19,06%	0,00%	0,00%
Screws	0,10%	0,09%	0,00%	0,95%
Battery	17,83%	8,53%	16,22%	21,00%
Total	**100 %**	**100%**	**100%**	**100%**

Packaging:

For the packaging there are differences in the mass proportion of the manuals and polystyrene foam. These are due to missing entries for manuals and caution papers given for the 37” and 42” TVs. Therefore there is a shift in the mass proportions of the other used materials, but related to the total mass of the packaging this difference is negligible.

Table 13: Comparison of Packaging mass proportion for LCD-TV product cases

	Primary case 32" TV	26" LCD TV	37" LCD TV	42" LCD TV
	proportion of module mass/ *TV mass*			
Packaging				
Plastic bag	2,89%	0,52%	2,96%	1,32%
Polystyrene Foam	16,76%	14,93%	0,00%	12,08%
Cardboard	57,88%	47,03%	94,85%	85,20%
Manual	22,47%	35,93%	1,22%	1,14%
Other plastic parts	0,00%	1,60%	0,97%	0,27%
Total	**100 %**	**100%**	**100%**	**100%**

Others:

All parts that can not be allocated to another module are summarized in this module. These are mainly internal and external cables including connectors and cable funnel. Due its low mass compared to the total TV mass the “others” module are assumed to not have significant influence to the total environmental impact.

Table 14: Comparison of Others mass proportion for LCD-TV product cases

	Primary case 32" TV	26" LCD TV	37" LCD TV	42" LCD TV
	proportion of module mass/ *TV mass*			
Other				
Wire / Cord, copper	40,86%	33,95%	50,00%	50,00%
Wire / Cord, plastic	0,00%	0,00%	50,00%	50,00%
Other plastic parts	17,66%	1,83%	0,00%	0,00%
Other metal parts	31,50%	50,05%	0,00%	0,00%
Other copper parts	0,86%	1,14%	0,00%	0,00%
Port	9,11%	13,04%	0,00%	0,00%

Conclusion:

The comparison of the different product cases show, that the selection of the primary product case of 32” TV is also representative for a wider range of LCD TVs, because of a similar proportional weight allocation amongst and between the defined modules. Occurring differences in total however are explainable respectively relate to technical reasons in regard to different screen sizes. More significant differences relate to minor important modules – except the electronic boards – will not have major influence on environmental impacts in Task 5.

4.1.2. PDP-TV

4.1.2.1. Introduction to PDP-TV Technology

Although the technological principle was invented already in 1964 by Donald L. Bitzer and H. Gene Slottow of University of Illinois, the first color PDP television was sold in 1997 by Pioneer. Today only five plasma display panel manufacturers are competing in the market. These are LG and Samsung of Korea, and Panasonic, Pioneer and Fujitsu-Hitachi-Plasma of Japan. Plasma television's high brightness, high-speed response, and wide viewing angle show some advantages for motion pictures and large screens. However, LCD and other technologies (SED) are closing in and competition is harsh. PDP is currently competing in screen size segment of 37 Inch and larger. Plasma Display Panel (PDP) is a self-emissive flat panel display where light is created in a cell by phosphors excited by a plasma discharge between two flat panels of glass. Each cell is filled with a gas and sandwiched between layers of electrodes. The illuminant effectiveness (brightness) is reduced if cell size is smaller as gas volume is also reduced. A voltage of 100 to 200V is required to ignite the plasma for individual pixels, and display heating as well as radio frequency emission has to be carefully controlled. The following Figure 4 and Figure 5 show the principle PDP design.

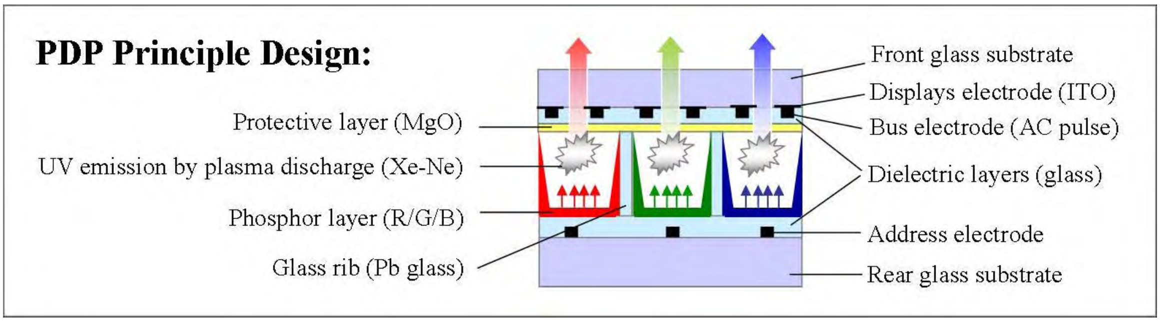

Figure 4: Principle Design of Plasma Display Panel (PDP)

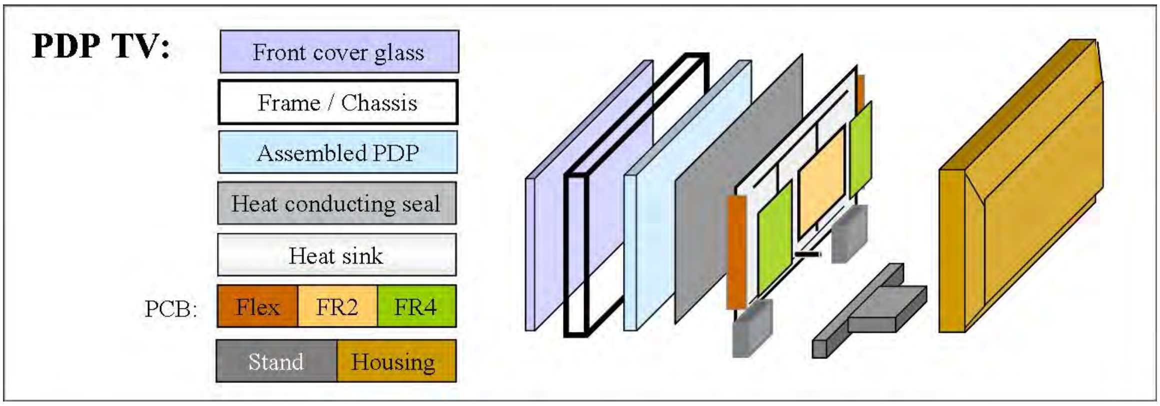

Figure 5: Principle Design of a PDP-TV

PDP manufacturing is complex and requires a series of precision lamination and bonding processes on regular glass substrates (front and back panel). The glass thickness and properties differ to some extent from manufacturer to manufacturer as will be seen in the substitute material analysis. There are multiple material (ITO, Cr/Cu) distribution processes (sputtering, etching) necessary to apply the scan and address electrode on the glass substrate. The insulating layer and glass rib (barrier) formation includes fine glass frit coating and high temperature firing processes. The first generations of PDP used lead-oxide glass ribs for structuring the cells. By November 2006 the Panasonic Corporation announced that they have eliminated all of the roughly 70 grams of lead used in a 37” plasma display panel[6]. Following the glass formation the color phosphor layers are produced by different deposition and fixing processes. After the structuring of the front and back panels the glass panels will be cut and prepared for assembly. The assembled glass panels are than sealed, evacuated and filled with usually neon and xenon gas[7]. The PDP front and back glass panels are relatively heavy due to their thickness of 2 to 3 mm. Some manufacturers process a color filter/anti reflection/electromagnetic shielding layer directly on the plasma display panel whereas others add a further cover glass with similar functionality to the panel. The assembled display is than fixed together with a heat plate in a heavy steel frame and connected with the circuit boards.

The five plasma display panel manufacturers which hold main patents are extending their production capacities expecting to lead the market in large screen televisions. The panel production is located in Japan and South Korea. Depending on the manufacturing generation more than one front or rear glass panel can be processed on a single glass module (core substrate panel). The resource efficiency of the manufacturing process is directly related to this aspect.

4.1.2.2. Bill of Material of 42” PDP-TV (primary product case)

In the interim report the PDP-TV primary product case was based on three PDP-TVs, two 42” and one 43” PDP TVs with data from different manufacturers. Following the publication of the interim report in February 2007, some data gaps explaining the obvious differences in total masses (30kg to 53kg), the false allocation of components to modules (display integrated in chassis data set), and considerable differences in production (depending on the assumed manufacturing generation) were discovered and discussed with industry partners. In this discussion the conclusion was reached, that due to the averaging of all three data sets, the apparent inconsistency of product data have been counterbalanced. This averaging of material data of three existing products therefore results in a

[6] New Release of Panasonic Corporation of North America from November 27, 2006, in the internet: http://www.greensupplyline.com.
[7] Some manufacturer use helium in the gas.

representative data set for an average 42” PDP-TV of the year 2006. What the abstraction shows is that the overall material mass in relation to the display panel size is the most significant factor in the assessments. Smaller differences for instance related to power consumption efficiency such as in the panel design (high luminescence efficiency) or on component level (e.g. advanced electrical efficient circuitries and components on printed wiring boards) are unfortunately not detectible when applying VHK EcoReport. As a result of these considerations it was agreed that the following aggregated data set for a 42” PDP-TV is feasible for the purpose of this study. In closing the involved PDP manufacturers emphasized again that the plasma display technology, related product design, and manufacturing processes have not yet reached a maturity comparable to LCD. Considerable improvements will occur in the next years. They might change material and design characteristics of PDP-TVs to an extent that the following data for an average 42” PDP-TV are not valid anymore.

Against that background and in agreement with the data providing industry partners no changes were made concerning the previous version of the interim report. It would have been of cause favorable to make a completely new assessment of the 42” PDP-TV, but the time schedule of the study did not allow such complete revision. And it should be again emphasized that due to the high aggregation level only small changes in the results are expected. Some inconstancies therefore still remain in the following text.

The resulting bill of materials for the primary product case for PDP-TVs is shown in the following Table 15.

Table 15: EcoReport Input Table for 42” PDP

Version 5 VHK for European Commission 28 Nov. 2005			Document subject to a legal notice (see below)		
	ECO-DESIGN OF ENERGY-USING PRODUCTS		EuP EcoReport: INPUTS Assessment of Environmental Impact		
Nr	Product name		Date	Author	
	Primary case 42" PDP TV				
Pos	**MATERIALS Extraction & Production**	**Weight**	**Category**	**Material or Process**	
nr	**Description of component**	**in g**	**Click &select**	**select Category first !**	
1	CHASSIS				
2	Plastic parts	5,5	1-BlkPlastics	**2-HDPE**	
3	Plastic parts	0,5	1-BlkPlastics	**3-LLDPE**	
4	Plastic parts	13,9	1-BlkPlastics	**4-PP**	
5	Housing	502,8	1-BlkPlastics	**5-PS**	
6	Plastic parts	4,3	1-BlkPlastics	**6-EPS**	
7	Plastic parts	50,7	1-BlkPlastics	**8-PVC**	

8	Housing	1429,8	1-BlkPlastics	**10-ABS**	
9	Plastic parts	11,5	2-TecPlastics	**11-PA 6**	
10	Plastic parts	728,0	2-TecPlastics	**12-PC**	
11	Frame	13177,1	3-Ferro	**21-St sheet galv.**	
12	Metal parts	13,3	3-Ferro	**22-St tube/profile**	
13	Metal parts	142,3	3-Ferro	**23-Cast iron**	
14	Metal parts	109,0	3-Ferro	**24-Ferrite**	
15	Metal parts	735,0	4-Non-ferro	**26-Al sheet/extrusion**	
16	Cable	14,3	4-Non-ferro	**28-Cu winding wire**	
17	Front glass	2866,7	7-Misc.	**54-Glass for lamps**	
18	Labels	111,5	7-Misc.	**57-Office paper**	
19	Plastic parts	80,0	2-TecPlastics	**15-Rigid PUR**	
20					
21	DISPLAY				
22	Plastic parts	54,0	1-BlkPlastics	**10-ABS**	
23	Plastic parts	290,0	2-TecPlastics	**12-PC**	
24	Plastic parts	304,5	2-TecPlastics	**13-PMMA**	
25	Metal parts	40,0	3-Ferro	**24-Ferrite**	
26	Metal parts	236,0	3-Ferro	**25-Stainless 18/8 coil**	
27	Frame	3408,9	4-Non-ferro	**26-Al sheet/extrusion**	
28	Metal parts	171,0	4-Non-ferro	**27-Al diecast**	
29	Cable	5,5	4-Non-ferro	**29-Cu wire**	
30	Electronic module	127,0	6-Electronics	**44-big caps & coils**	
31	Electronic module	32,0	6-Electronics	**45-slots / ext. ports**	
32	Electronic module	19,5	6-Electronics	**46-IC's avg., 5% Si, Au**	
33	Electronic module	117,5	6-Electronics	**48-SMD/ LED's avg.**	
34	Electronic module	303,0	6-Electronics	**49-PWB 1/2 lay 3.75kg/m2**	
35	Electronic module	6,0	6-Electronics	**52-Solder SnAg4Cu0.5**	
36	Panel glass	9109,0	7-Misc.	**54-Glass for lamps**	
37	Labels	28,6	7-Misc.	**57-Office paper**	
38	Metal parts	239,0	3-Ferro	**21-St sheet galv.**	
39					
40					
41					
Pos	**MATERIALS Extraction & Production**	**Weight**	**Category**	**Material or Process**	
nr	**Description of component**	**in g**	**Click &select**	**select Category first !**	
42	POWER SUPPLY UNIT				
43	Cable insulation, other parts	50,0	1-BlkPlastics	**8-PVC**	
44	Plastic parts	4,3	2-TecPlastics	**12-PC**	
45	Plastic parts	10,0	2-TecPlastics	**14-Epoxy**	
46	Metal parts	27,0	3-Ferro	**21-St sheet galv.**	
47	Metal parts	14,7	3-Ferro	**24-Ferrite**	
48	Heatsink	355,7	4-Non-ferro	**26-Al sheet/extrusion**	
49	Cable	23,7	4-Non-ferro	**29-Cu wire**	
50	Metal parts	5,8	4-Non-ferro	**31-CuZn38 cast**	
51	Electronic board	440,0	6-Electronics	**44-big caps & coils**	
52	Electronic board	18,3	6-Electronics	**45-slots / ext. ports**	
53	Electronic board	10,0	6-Electronics	**46-IC's avg., 5% Si, Au**	

54	Electronic board	21,7	6-Electronics	**47-IC's avg., 1% Si**	
55	Electronic board	292,0	6-Electronics	**48-SMD/ LED's avg.**	
56	Electronic board	214,3	6-Electronics	**49-PWB 1/2 lay 3.75kg/m2**	
57	Electronic board	63,8	6-Electronics	**52-Solder SnAg4Cu0.5**	
58					
59	REMOTE CONTROL				
60	Housing	55,0	1-BlkPlastics	**10-ABS**	
61	Frame	41,5	3-Ferro	**21-St sheet galv.**	
62	Metal parts	1,5	3-Ferro	**23-Cast iron**	
63	Electronic board	1,0	6-Electronics	**45-slots / ext. ports**	
64	Electronic board	1,0	6-Electronics	**46-IC's avg., 5% Si, Au**	
65	Electronic board	1,0	6-Electronics	**47-IC's avg., 1% Si**	
66	Electronic board	1,5	6-Electronics	**48-SMD/ LED's avg.**	
67	Electronic board	15,0	6-Electronics	**49-PWB 1/2 lay 3.75kg/m2**	
68	Electronic board	2,5	6-Electronics	52-Solder SnAg4Cu0.5	
69	Rubber parts	15,0	2-TecPlastics	**16-Flex PUR**	
70					
71	ELECTRONIC BOARD				
72	Metal parts	33,3	3-Ferro	**21-St sheet galv.**	
73	Heatsink	181,7	4-Non-ferro	**26-Al sheet/extrusion**	
74	Electronic board	17,3	6-Electronics	**44-big caps & coils**	
75	Metal parts	37,3	3-Ferro	**24-Ferrite**	
76	Electronic board	170,1	6-Electronics	**45-slots / ext. ports**	
77	Electronic board	21,7	6-Electronics	**46-IC's avg., 5% Si, Au**	
78	Electronic board	84,4	6-Electronics	**47-IC's avg., 1% Si**	
79	Electronic board	2,7	4-Non-ferro	**31-CuZn38 cast**	
80	Electronic board	231,6	6-Electronics	**48-SMD/ LED's avg.**	
81	Electronic board	457,8	6-Electronics	**49-PWB 1/2 lay 3.75kg/m2**	
82	Electronic board	262,7	6-Electronics	**50-PWB 6 lay 4.5 kg/m2**	
83	Electronic board	182,6	6-Electronics	**52-Solder SnAg4Cu0.5**	
84	Electronic board	6,7	6-Electronics	**44-caps and coils**	
85	Cable	10,7	4-Non-ferro	**29-Cu wire**	
86					
87	PACKAGING				
88	Plastic bag	32,9	1-BlkPlastics	**2-HDPE**	
89	Plastic parts	44,0	1-BlkPlastics	**4-PP**	
90	Bumpers	940,3	1-BlkPlastics	**6-EPS**	
91	Metal parts	8,0	3-Ferro	**21-St sheet galv.**	
92	Cardboard packaging	3939,1	7-Misc.	**56-Cardboard**	
93	Manual/ packaging	2707,6	7-Misc.	**57-Office paper**	
94					
95	OTHER				
96	Cable	130,0	1-BlkPlastics	**8-PVC**	
97	Cable	127,5	4-Non-ferro	**29-Cu wire**	
98	Metal parts	104,9	3-Ferro	**21-St sheet galv.**	

Table 16 shows the total material use for the primary product base case according to VHK aggregation.

Table 16: Total Material Use of 42" PDP-TV

Version 5 VHK for European Commission 28 Nov. 2005 Document subject to a legal notice (see below))

ECO-DESIGN OF ENERGY-USING PRODUCTS

EuP EcoReport: RESULTS
Assessment of Environmental Impact

Table . Life Cycle Impact (per unit) of Primary case 42" PDP TV

Nr	Life cycle Impact per product:	Date	Author
0	Primary case 42" PDP TV	0	0

	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	Total	BUTION		Disposal	Recycl.	Total	
	Materials	**unit**									
1	Bulk Plastics	g			**3314**			2982	331	**3314**	**0**
2	TecPlastics	g			**1443**			1299	144	**1443**	**0**
3	Ferro	g			**14225**			711	13514	**14225**	**0**
4	Non-ferro	g			**5043**			252	4790	**5043**	**0**
5	Coating	g			**0**			0	0	**0**	**0**
6	Electronics	g			**3122**			1618	1504	**3122**	**0**
7	Misc.	g			**18762**			938	17824	**18762**	**0**
	Total weight	g			**45909**			7801	38108	**45909**	**0**

As shown in Table 16 the predominantly used materials are glass (Misc.) in the plasma display panel and cover glass as well as ferro-metals used for the steel frame. The significance to environmental impacts caused by material from these groups is discussed in Task 5.

Table 17 presents the mass proportions of the considered TVs modules for the primary product case. The 42" PDP-TV1 has the display module integrated in the chassis module. This explains the high mass proportion of the chassis module and the packaging. The Display masses of the considered TVs are between 14 and 15kg. The high mass proportion of the 43" PDP-TV1 display module is because of the low total weight (31 kg)[8] compared the 42" PDP TV2 (53 kg).

These mass differences might be also due to the different technologies of the PDP displays. There are no detailed specifications on subassemblies of modules for all TV types available. Therefore the consideration of material mass proportions is done by the total amount of used materials per module, according to the VHK spread sheet.

[8] The weight of the receiver is missing

Table 17: Total Mass Proportion of 42”/43” PDP-TV

	Primary product case PDP-TVs		
	43” PDP-TV 1	**42” PDP-TV 1**	**42” PDP-TV 2**
Chassis	22,50%	70,16%	49,10%
Display	47,01%	0,00%	26,91%
Others	0,67%	0,00%	2,29%
Packaging	17,46%	22,42%	16,88
PSU	5,16%	4,53%	2,45%
Electronic board	7,20%	2,52%	3,43%
Remote	0,00%	0,36%	0,97%
Total	**100%**	**100%**	**100%**

Chassis:

The predominant used materials are from the Ferro group, which are used for the steel frame, followed by the TV front glass (Misc.). Following table shows that glass is not used for the chassis of the 43” PDP TV1, possibly because there are no data in the BOM available. For all other modules there are only minor differences in the mass proportions of the considered TVs.

Table 18: Comparison of chassis mass proportion for PDP-TV primary product case

	Primary product case PDP-TVs		
	43” PDP-TV 1	**42” PDP-TV 1**	**42” PDP-TV 2**
Chassis			
Materials			
Bulk Plastics	14,8%	6,4%	12,5%
TecPlastics	3,4%	7,2%	1,1%
Ferro	77,1%	66,5%	65,3%
Non-ferro	4,7%	4,7%	3,8%
Coating	0,0%	0,0%	0,0%
Electronics	0,0%	0,0%	0,0%
Misc. (Glass)	0,0%	15,2%	17,3%
Total weight	**100%**	**100%**	**100%**

Display:

Due to the fact that there is no PDP Panel in the VHK spreadsheet available the panels are represented by its steel frame and panel glass. The following table shows the mass proportions of the glass panels and the steel frames. For the 42” PDP-TV2 there are no data for the display available. Therefore the data for the primary product case is averaged by the display data from the 43” PDP-TV1 and 42” PDP-TV2.

Table 19: Comparison of Display mass proportion for PDP-TV primary product case

	Primary product case PDP-TVs		
	43” PDP TV 1	**42” PDP TV 1**	**42” PDP TV 2**
Display			
Materials			
Bulk Plastics	0,7%		0,0%
TecPlastics	2,1%		6,1%
Ferro	3,2%		3,9%
Non-ferro	29,2%		20,2%
Coating	0,0%		0,0%
Electronics	0,0%		8,5%
Misc. (glass)	64,7%		61,4%
Total weight	**100,0%**		**100,0%**

Power supply unit and electronic board:

Table 20 and Table 21 show the material mass proportion of the power supply unit and the electronic boards. It shows that the predominant materials are from the populated PWB, which is summarized in the “Electronics” group. The table of the electronic board also shows that there is a difference in the mass proportion of the ferro and non-ferro group of the TVs. These materials are mainly used for heat sinks and shielding. In addition the selection and allocation of electronic components is very different. Finally it has to be mentioned that the module electronic boards have a relative high absolute mass (about 2,5% – 7,2% of about 31kg-53kg) which might lead to super proportional consideration at the environmental impact assessment in Task 5.

This high mass ratio of the electronic boards has to be put into perspective of the PDP technology. The PDP requires a high voltage (AC) pulse from the electrode in order to produce the plasma discharge. Power conversion within the PDP-TV is therefore very complex with requirements for various high and low voltages. The relatively high mass of electronic components (PWB) can be explained through the existence of power electronics which are related to signal electronic of VHK spreadsheet.

Table 20: Comparison of PSU mass proportion for PDP-TV primary product case

	Primary product case PDP-TVs		
	43" PDP-TV 1	**42" PDP-TV 1**	**42" PDP-TV 2**
Power Supply Unit			
Materials			
Bulk Plastics	0,0%	9,4%	0,0%
TecPlastics	0,0%	1,7%	0,0%
Ferro	0,0%	3,9%	0,0%
Non-ferro	31,5%	17,4%	30,8%
Coating	0,0%	0,0%	0,0%
Electronics	68,5%	67,6%	69,2%
Misc.	0,0%	0,0%	0,0%
Total weight	**100,0%**	**100,0%**	**100,0%**

Table 21: Comparison of PWB mass proportion for PDP-TV primary product case

	Primary product case PDP-TVs		
	43" PDP-TV 1	**42" PDP-TV 1**	**42" PDP-TV 2**
Electronic board			
Materials			
Bulk Plastics	0,0%	0,0%	0,0%
TecPlastics	0,0%	0,0%	0,0%
Ferro	0,0%	35,2%	11,6%
Non-ferro	22,2%	4,1%	0,0%
Coating	0,0%	0,0%	0,0%
Electronics	77,8%	60,7%	88,4%
Misc.	0,0%	0,0%	0,0%
Total weight	**100,0%**	**100,0%**	**100,0%**

Remote control:

The data sheets of the considered TVs do only contain two data for two remote control units. Therefore the averaging is done by the arithmetic average of the two datasets.

Table 22: Comparison of Remote Control mass proportion for PDP-TV primary product case

	Primary product case PDP-TVs		
	43" PDP-TV 1	**42" PDP-TV 1**	**42" PDP-TV 2**
Remote			
Materials			
Bulk Plastics		42,9%	50,0%
TecPlastics		0,0%	0,0%
Ferro		0,0%	6,0%
Non-ferro		0,0%	0,0%
Coating		0,0%	0,0%
Electronics		57,1%	44,0%
Misc.		0,0%	0,0%
Total weight		**100,0%**	**100,0%**

Packaging:

Table 23 shows the data for the packaging. It shows that there are only minor differences in the mass proportion of used materials. The main mass proportion is for the cardboard and office paper for the manuals, which are summarized in the Misc. group.

Table 23: Comparison of Packaging mass proportion for PDP-TV primary product case

	Primary product case PDP-TVs		
	43" PDP-TV 1	**42" PDP-TV 1**	**42" PDP-TV 2**
Packaging			
Materials			
Bulk Plastics	12,0%	13,7%	14,7%
TecPlastics	0,0%	0,0%	0,0%
Ferro	0,0%	0,0%	0,3%
Non-ferro	0,0%	0,0%	0,0%
Coating	0,0%	0,0%	0,0%
Electronics	0,0%	0,0%	0,0%
Misc.(Paper/Cardboard)	88,0%	86,3%	86,1
Total weight	**100,0%**	**100,0%**	**100,0%**

Others:

The module "others" contains different metal parts and cables that could not have been allocated to any of the other modules. Due to the fact that the mass proportion of this module is only 0,97% of the total mass the impacts of this module are negligible.

Table 24: Comparison of others mass proportion for PDP-TV primary product case

	Primary product case PDP- TVs		
	43" PDP TV 1	**42" PDP TV 1**	**42" PDP TV 2**
Others			
Materials			
Bulk Plastics	0,0%		0,0%
TecPlastics	0,0%		0,0%
Ferro	100,0%		0,0%
Non-ferro	0,0%		21,0%
Coating	0,0%		0,0%
Electronics	0,0%		0,0%
Misc. (Office paper)	0,0%		0,0%
Total weight	**100,0%**		**100,0%**

Conclusion:

The tables show that there are differences in the material mass proportions of any TV modules due to different technologies, designs and possibly missing input data. Generally the procedure for averaging the products for the base case covers different technologies but leads related to its composition not to a realistic product.

4.1.2.3. Bill of Material of 50" PDP-TV (secondary product cases)

For the secondary product cases of PDP-TVs all modules have been averaged by the mass proportions of materials and components as described for the primary product case. Data base for the secondary product cases are four 50" PDP-TVs form different manufacturers. The comparison of the different PDP-TVs shows the same problematic as discussed for the 42" PDP-TV primary product case. There is no homogenous allocation to identify.

Table 25: Primary and Secondary PDP-TV Product Case

	Primary product case	**Secondary product case for 50" PDP TVs**			
		Type 1	**Type 2**	**Type 3**	**Type 4**
Chassis	43,58%	22,50%	70,16%	49,10%	22,50%
Display	31,58%	47,01%	0,00%	26,91%	47,01%
others	0,79%	0,67%	0,00%	0,97%	0,67%
Packaging	16,72%	17,46%	22,42%	16,88%	17,46%
PSU	3,38%	5,16%	4,53%	2,45%	5,16%
PWB	3,66%	7,20%	2,52%	3,43%	7,20%
Remote	0,29%	0,00%	0,36%	0,25%	0,00%
Total	**100%**	**100%**	**100%**	**100,00%**	**100%**

The following tables provide the mass proportions for the different modules of the 50" PDP-TV product cases in comparison to the 42" PDP-TV primary product case.

Table 26: Comparison of Chassis mass proportion for primary and secondary product cases

	Primary product case	**Secondary product case for 50" PDP TVs**			
		Type 1	**Type 2**	**Type 3**	**Type 4**
Chassis					
Materials					
Bulk Plastics	11,2%	13,83%	14,88%	8,33%	5,28%
TecPlastics	3,9%	2,79%	0,63%	0,00%	11,00%
Ferro	69,6%	79,47%	53,98%	79,09%	41,54%
Non-ferro	4,4%	3,91%	30,35%	12,58%	10,60%
Coating	0,0%	0,00%	0,00%	0,00%	0,00%
Electronics	0,0%	0,00%	0,06%	0,00%	0,000%
Misc.	10,8%	0,00%	0,10%	0,00%	31,57%
Total weight	**100,0%**	**100,00%**	**100,00%**	**100,00%**	**100,00%**

Table 27: Comparison of Display mass proportion for primary and secondary product cases

	Primary product case	Secondary product case			
		Type 1	Type 2	Type 3	Type 4
Display					
Materials					
Bulk Plastics	0,4%	0,71%	0,00%		
TecPlastics	4,1%	1,98%	0,00%		
Ferro	3,6%	2,49%	0,00%		
Non-ferro	24,7%	29,75%	0,00%		
Coating	0,0%	0,00%	0,00%		
Electronics	4,2%	0,00%	0,00%		
Misc.	63,0%	65,07%	100,00%		
Total weight	**100,0%**	**100,00%**	**100,00%**		

Table 28: Comparison of PSU mass proportion for primary and secondary product cases

	Primary product case	Secondary product case			
		Type 1	Type 2	Type 3	Type 4
Power Supply Unit					
Materials					
Bulk Plastics	3,1%	0,00%	4,92%	0,00%	7,13%
TecPlastics	0,6%	0,00%	0,26%	0,00%	1,31%
Ferro	1,3%	0,00%	0,68%	0,00%	1,93%
Non-ferro	26,6%	31,52%	9,84%	24,55%	28,71%
Coating	0,0%	0,00%	0,00%	0,00%	0,00%
Electronics	68,4%	68,48%	84,29%	75,45%	60,91%
Misc.	0,0%	0,00%	0,00%	0,00%	0,00%
Total weight	**100,0%**	**100,00%**	**100,00%**	**100,00%**	**100,00%**

Table 29: Comparison of PWB mass proportion for primary and secondary product cases

	Primary product case	Secondary product case			
		Type 1	Type 2	Type 3	Type 4
Electronic board					
Materials					
Bulk Plastics	0,0%	0,00%	3,06%	0,00%	0,00%
TecPlastics	0,0%	0,00%	5,32%	4,42%	0,00%
Ferro	15,6%	0,00%	3,11%	26,93%	42,43%
Non-ferro	8,8%	23,45%	19,91%	0,00%	5,22%
Coating	0,0%	0,00%	0,00%	0,00%	0,00%
Electronics	75,6%	76,55%	68,60%	68,64%	52,35%
Misc.	0,0%	0,00%	0,01%	0,00%	0,00%
Total weight	**100,0%**	**100,00%**	**100,00%**	**100,00%**	**100,00%**

Table 30: Comparison of Remote Control mass proportion for primary and secondary product cases

	Primary product case	Secondary product case			
		Type 1	Type 2	Type 3	Type 4
Remote					
Materials					
Bulk Plastics	46,4%		41,69%	53,41%	42,86%
TecPlastics	0,0%		15,45%	0,16%	0,00%
Ferro	3,0%		0,24%	22,92%	0,00%
Non-ferro	0,0%		0,00%	13,45%	0,00%
Coating	0,0%		0,00%	0,00%	0,00%
Electronics	50,6%		15,19%	10,06%	57,14%
Misc.	0,0%		27,43%	0,00%	0,00%
Total weight	**100,0%**		**100,00%**	**100,00%**	**100,00%**

Table 31: Comparison of Packaging mass proportion for primary and secondary product cases

	Primary product case	Secondary product case			
		Type 1	**Type 2**	**Type 3**	**Type 4**
Packaging					
Materials					
Bulk Plastics	13,5%	12,38%	19,91%	5,68%	9,62%
TecPlastics	0,0%	0,00%	0,00%	0,00%	0,00%
Ferro	0,1%	0,00%	0,00%	1,84%	0,00%
Non-ferro	0,0%	0,00%	0,00%	0,00%	0,00%
Coating	0,0%	0,00%	0,00%	0,00%	0,00%
Electronics	0,0%	0,00%	0,00%	0,00%	0,00%
Misc.	86,4%	87,62%	80,09%	92,48%	90,38%
Total weight	**100,0%**	**100,00%**	**100,00%**	**100,00%**	**100,00%**

Table 32: Comparison of Others mass proportion for primary and secondary product cases

	Primary product case	Secondary product case			
		Type 1	**Type 2**	**Type 3**	**Type 4**
Others					
Materials					
Bulk Plastics	10,7%	0,00%	0,00%	0,00%	
TecPlastics	0,0%	0,00%	0,00%	0,00%	
Ferro	50,0%	100,00%	0,00%	100,00%	
Non-ferro	10,5%	0,00%	0,00%	0,00%	
Coating	0,0%	0,00%	0,00%	0,00%	
Electronics	0,0%	0,00%	100,00%	0,00%	
Misc.	28,8%	0,00%	0,00%	0,00%	
Total weight	**100,0%**	**100,00%**	**100,00%**	**100,00%**	

4.1.3. CRT-TV

4.1.3.1. Introduction to CRT-TV Technology

The cathode ray tube (CRT) uses heat to create light by striking large numbers of electrons against glass. Once the light hits the glass, extra electrodes deflect the light beams onto the television screen. An image is produced by modulating the intensity of the electron beam with a received video signal (or another signal derived from it). Cathode rays exist in the form of streams of high speed electrons emitted from the heating of a cathode inside a vacuum tube, at its rear end. The emitted electrons form a beam within the tube due to the voltage difference applied across the two electrodes (the CRT screen typically forms the anode). The beam is then perturbed (deflected), either by a magnetic or an electric field (magnetic yoke), to scan systematically in a fixed pattern (raster) the inside surface of the screen (anode). The screen is covered with a phosphorescent coating (often transition metals or rare earth elements), which emits visible light when excited by the electrons. The outer glass allows the light generated by the phosphor out of the monitor, but (for color tubes) it must block dangerous X-rays generated by high energy electrons impacting the inside of the CRT face. For this reason, the glass is leaded (sometimes called "lead crystal"). Color tubes require significantly higher anode voltages than monochrome tubes (as high as 32,000 volts in large tubes), partly to compensate for the blockage of some electrons by the aperture mask or grille; the amount of X-rays produced increases with voltage. Because of leaded glass, other shielding, and protective circuits designed to prevent the anode voltage from rising too high in case of malfunction, the X-ray emission of modern CRTs is well within approved safety limits[9].

4.1.3.2. Bill of Material of 29” CRT-TV (primary product case)

The data for the CRT-TV primary product case derives from two rather large 29” and 32” CRT-TVs, for which data were provided. Somewhat more representative would have been smaller 23” or 26” CRT-TV, but they are not available. Table 33 presents the primary case data for the CRT-TV.

[9] The description was partially taken from Wikipedia.

Table 33: EcoReport Input Table for 29" CRT-TV

Version 5 VHK for European Commission 28 Nov. 2005

Document subject to a legal notice (see below)

ECO-DESIGN OF ENERGY-USING PRODUCTS

EuP EcoReport: INPUTS
Assessment of Environmental Impact

Nr	Product name	Date	Author
	Primary case 29" CRT TV		

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !
1	CHASSIS			
2	Housing	4600,0	1-BlkPlastics	5-PS
3	SCREWS	60,0	3-Ferro	22-St tube/profile
4	Antenna connector	7,0	4-Non-ferro	31-CuZn38 cast
5	Speakers	673,0	6-Electronics	44-big caps & coils
6				
7	DISPLAY			
8	CRT panel (Aspect ratio) 4:3	260,4	6-Electronics	43-CRT per m2 scrn
9	CRT panel (mass dummy)	27100,0	7-Misc.	0
10	Rubber Part	21,0	2-TecPlastics	16-Flex PUR
11	Resin	35,0	1-BlkPlastics	1-LDPE
12	Plastic part	162,0	1-BlkPlastics	5-PS
13	Cable	140,0	1-BlkPlastics	8-PVC
14	Plastic parts	13,0	1-BlkPlastics	8-PVC
15	Plastic parts	50,0	2-TecPlastics	11-PA 6
16	Steel parts	3471,0	3-Ferro	21-St sheet galv.
17	Ferrite core	575,0	3-Ferro	24-Ferrite
18	Copper part	485,0	4-Non-ferro	28-Cu winding wire
19	Cable	1260,0	4-Non-ferro	28-Cu winding wire
20	Coils	93,0	6-Electronics	44-big caps & coils
21	Connector	3,0	6-Electronics	45-slots / ext. ports
22	PWB	28,0	6-Electronics	49-PWB 1/2 lay 3.75kg/m2
23				
24				
25	POWER SUPPLY UNIT			
26	Electronic board	370,0	6-Electronics	44-big caps & coils
27	Electronic board	2,0	6-Electronics	45-slots / ext. ports
28	Electronic board	38,0	6-Electronics	49-PWB 1/2 lay 3.75kg/m2
29	Electronic board	2,7	6-Electronics	52-Solder SnAg4Cu0.5
30				
31	REMOTE			
32	Housing	69,0	1-BlkPlastics	5-PS
33	Plastic part	3,0	1-BlkPlastics	10-ABS

34	Screws	2,0	3-Ferro	**22-St tube/profile**	
35	Electronic board	0,2	6-Electronics	**48-SMD/ LED's avg.**	
36	Electronic board	14,0	6-Electronics	**49-PWB 1/2 lay 3.75kg/m2**	
37	Electronic board	0,2	6-Electronics	**52-Solder SnAg4Cu0.5**	
38	Rubber sheet	17,0	2-TecPlastics	**16-Flex PUR**	
39	Batteries	36,0	6-Electronics	**44-big caps & coils**	
40					
41					
Pos	**MATERIALS Extraction & Production**	**Weight**	**Category**	**Material or Process**	
nr	**Description of component**	**in g**	**Click &select**	**select Category first !**	
42	ELECTRONIC BOARD				
43	Plastic part	2,0	1-BlkPlastics	**5-PS**	
44	Frame	56,0	3-Ferro	**21-St sheet galv.**	
45	Screws	4,0	3-Ferro	**22-St tube/profile**	
46	Ferrite core	6,0	3-Ferro	**24-Ferrite**	
47	Heat sink	321,0	4-Non-ferro	**26-Al sheet/extrusion**	
48	Elecronic board	864,0	6-Electronics	**44-big caps & coils**	
49	Elecronic board	87,0	6-Electronics	**45-slots / ext. ports**	
50	Elecronic board	5,0	6-Electronics	**46-IC's avg., 5% Si, Au**	
51	Elecronic board	10,0	6-Electronics	**47-IC's avg., 1% Si**	
52	Elecronic board	262,0	6-Electronics	**49-PWB 1/2 lay 3.75kg/m2**	
53	Elecronic board	72,0	6-Electronics	**50-PWB 6 lay 4.5 kg/m2**	
54	Elecronic board	22,8	6-Electronics	**52-Solder SnAg4Cu0.5**	
55	Electronic board	11,0	6-Electronics	**98-controller board**	
56					
57	PACKAGING				
58	Plastic bag	116,0	1-BlkPlastics	**1-LDPE**	
59	Cushion	447,0	1-BlkPlastics	**6-EPS**	
60	Cardboard	2847,0	7-Misc.	**56-Cardboard**	
61	Manual	611,0	7-Misc.	**57-Office paper**	
62					
63	OTHERS				
64	Cable	53,0	1-BlkPlastics	**8-PVC**	
65	Plastic part	13,0	1-BlkPlastics	**8-PVC**	
66	Plastic part	9,0	2-TecPlastics	**11-PA 6**	
67	Antenna plug	1,0	3-Ferro	**21-St sheet galv.**	
68	Ferrite core	57,0	3-Ferro	**24-Ferrite**	
69	Cable	53,0	4-Non-ferro	**29-Cu wire**	
70	Antenna plug	1,0	4-Non-ferro	**31-CuZn38 cast**	
71	Connectors	17,0	6-Electronics	**45-slots / ext. ports**	
72	Solder	1,0	6-Electronics	**52-Solder SnAg4Cu0.5**	
73					

Table 34 shows the total material use for the 29” CRT-TV primary product case according to VHK aggregation. Proportional to screen size is the total mass of CRT-TV significantly higher than the LCD-TV or PDP-TV resulting mainly from the mass of glass (display) of total weight. The environment impacts caused by this high material fraction are discussed in Task 5.

Table 34: Total Material Use of 29” CRT-TV

Version 5 VHK for European Commission 28 Nov. 2005 Document subject to a legal notice (see below))

ECO-DESIGN OF ENERGY-USING PRODUCTS

EuP EcoReport: RESULTS
Assessment of Environmental Impact

Table . Life Cycle Impact (per unit) of Primary case 29" CRT TV

Nr	Life cycle Impact per product:	Date	Author
0	Primary case 29" CRT TV	0	

	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	**Total**	**BUTION**		Disposal	Recycl.	**Total**	
	Materials	**unit**									
1	Bulk Plastics	g			**5653**			5088	565	**5653**	**0**
2	TecPlastics	g			**97**			87	10	**97**	**0**
3	Ferro	g			**4232**			212	4020	**4232**	**0**
4	Non-ferro	g			**2127**			106	2021	**2127**	**0**
5	Coating	g			**0**			0	0	**0**	**0**
6	Electronics	g			**2872**			1577	1295	**2872**	**0**
7	Misc.	g			**30558**			1528	29030	**30558**	**0**
	Total weight	g			**45539**			8598	36942	**45539**	**0**

4.2. Distribution Phase

The distribution phase of a product is considered in the VHK spreadsheet by product type and packaging volume. To select the product type, there is the possibility to select an ICT product with a weight that is less than 15 kg, an installed appliance or none of them. Specific distribution distance is not specified in the VHK spreadsheet. The used materials and masses for the packaging are not mentioned in this table, but is mentioned in “materials extraction & production” table. The data for the packaging used in the “materials extraction & production” table and assumed packaging volumes are summarized in Table 35. Packaging volumes of the primary product cases are assumed over typical dimensions of the TV types and extra five percent of the total volume for packaging cushions etc. Table 36, Table 37, and Table 38 present the data input in the VHK EcoReport spreadsheet for the primary product cases.

Table 35: Total mass of packaging for primary product cases

	Primary product cases		
	32” LCD TV	**42” PDP TV**	**29” CRT TV**
Packaging volume [m^3]	**0,14**	**0,17**	**0,25**
W [cm]	**92**	**111**	**78**
H [cm]	**75**	**75**	**61**
D [cm]	**21**	**20**	**51**
Packaging mass [g]			
Cardboard	2438,5	3939,1	2847
Plastic bags	121,7	33	116
Cushion	706,0	940	447
Other Plastics		44	
Metal parts		8	
Total mass	**3266,2**	**4964**	**3410**

Table 36: EcoReport Input Table Distribution of 32” LCD-TV

Pos	DISTRIBUTION (incl. Final Assembly)		Answer	Category index (fixed)	
nr	Description				
208	Is it an ICT or Consumer Electronics product <15 kg ?		NO	59	0
209	Is it an installed appliance (e.g. boiler)?		NO	60	1
				62	1
210	Volume of packaged final product in m^3	in m3	0,14	63	0
				64	1

Table 37: EcoReport Input Table Distribution of 42" PDP-TV

Pos	DISTRIBUTION (incl. Final Assembly)		Answer	Category index (fixed)	
nr	Description				
208	Is it an ICT or Consumer Electronics product <15 kg ?		NO	59	0
209	Is it an installed appliance (e.g. boiler)?		NO	60	1
				62	1
210	Volume of packaged final product in m^3	in m3	0,17	63	0
				64	1

Table 38: EcoReport Input Table Distribution of 29" CRT-TV

Pos	DISTRIBUTION (incl. Final Assembly)		Answer	Category index (fixed)	
nr	Description				
208	Is it an ICT or Consumer Electronics product <15 kg ?		NO	59	0
209	Is it an installed appliance (e.g. boiler)?		NO	60	1
				62	1
210	Volume of packaged final product in m^3	in m3	0,25	63	0

4.3. Use Phase (Product)

VHK EcoReport considers the use phase of the products by calculation of total annual power consumption (including off-, standby- and on-mode of the TVs), the amount of spare parts used for maintenance over the product use phase, the product life in years and the number of km for services. The amount for spare parts is fixed in the VHK spreadsheet to 1% of the total product materials and manufacturing. Data for power consumption of the TVs product cases (different modes) have been averaged from the actual power consumption values of the product examples. For the calculation of annual power consumption the assumption of daily 4 hours on-mode / 20 hours standby (no off-mode) has been taken from Task 3 user behavior assessment. The product life time is set to 10 years for all TV types reflecting the primary product life. Table 39 summarized the power consumption data for the primary product cases.

Table 39: Power consumption data for primary product cases

	Primary product case		
	32" LCD TV	**42" PDP TV**	**29" CRT TV**
Power consumption [kWh]			
On-mode	0,15	0,33	0,13
Off-mode	0	0	0
Standby-mode	0,002	0,003	0,003
Working hours per year [h]			
On-mode (4 hour per day)	4	4	4
Off-mode	0	0	0
Standby-mode (20 hours per day)	20	20	20
Total power consumption per year [MWh]	**0,23**	**0,50**	**0,21**

The following tables present the use phase data form the VHK EcoReport spreadsheet for the primary product cases 32” LCD-TV, 42” PDP-TV, and 29” CRT-TV. The environmental impacts caused by the use phase (power consumption) are highly significant. Power consumption is largely related to the display technology and the screen size. The on-mode power consumption in comparison to standby is the source of primary environmental impact. A detailed discussion of the total impacts will be provided in Task 5.

Table 40: EcoReport Input Table for Use Phase of 32" LCD-TV

Pos	USE PHASE		unit	Subtotals	
nr	Description				
211	Product Life in years	10	years		
	Electricity				
212	On-mode: Consumption per hour, cycle, setting, etc.	0,15	kWh	219	
213	On-mode: No. Of hours, cycles, settings, etc. / year	1460	#		
214	Standby-mode: Consumption per hour	0,002	kWh	14,6	
215	Standby-mode: No. Of hours / year	7300	#		
216	Off-mode: Consumption per hour	0	kWh	0	
217	Off-mode: No. Of hours / year	0	#		
	TOTAL over Product Life	2,34	MWh (=000 kWh)	65	
	Heat				
218	Avg. Heat Power Output	0	kW		
219	No. Of hours / year	0	hrs.		
220	Type and efficiency (Click & select)			85-not applicable	
	TOTAL over Product Life	0,00	GJ		
	Consumables (excl. spare parts)			material	
221	Water	0	m^3/year	83-Water per m3	
222	Auxilliary material 1 (Click & select)	0	kg/ year	85-None	
223	Auxilliary material 2 (Click & select)	0	kg/ year	85-None	
224	Auxilliary material 3 (Click & select)	0	kg/ year	85-None	
	Maintenance, Repairs, Service				
225	No. of km over Product-Life	0	km / Product Life	86	
226	Spare parts (fixed, 1% of product materials & manuf.)	232	g		

Table 41: EcoReport Input Table for Use Phase of 42" PDP-TV

Pos	USE PHASE		unit	Subtotals	
nr	Description				
211	Product Life in years	10	years		
	Electricity				
212	On-mode: Consumption per hour, cycle, setting, etc.	0,33	kWh	481,8	
213	On-mode: No. Of hours, cycles, settings, etc. / year	1460	#		
214	Standby-mode: Consumption per hour	0,003	kWh	21,9	
215	Standby-mode: No. Of hours / year	7300	#		
216	Off-mode: Consumption per hour	0	kWh	0	
217	Off-mode: No. Of hours / year	0	#		
	TOTAL over Product Life	5,04	MWh (=000 kWh)	65	
	Heat				
218	Avg. Heat Power Output		kW		
219	No. Of hours / year	0	hrs.		
220	Type and efficiency (Click & select)			85-not applicable	
	TOTAL over Product Life	0,00	GJ		
	Consumables (excl. spare parts)			material	
221	Water	0	m^3/year	83-Water per m3	
222	Auxilliary material 1 (Click & select)	0	kg/ year	85-None	
223	Auxilliary material 2 (Click & select)	0	kg/ year	85-None	
224	Auxilliary material 3 (Click & select)	0	kg/ year	85-None	
	Maintenance, Repairs, Service				
225	No. of km over Product-Life	0	km / Product Life	86	
226	Spare parts (fixed, 1% of product materials & manuf.)	459	g		

Table 42: EcoReport Input Table for Use Phase of 29" CRT-TV

Pos	USE PHASE		unit	Subtotals
nr	Description			
211	Product Life in years	10	years	
	Electricity			
212	On-mode: Consumption per hour, cycle, setting,	0,13	kWh	189,8
213	On-mode: No. Of hours, cycles, settings, etc. / ye	1460	#	
214	Standby-mode: Consumption per hour	0,003	kWh	21,9
215	Standby-mode: No. Of hours / year	7300	#	
216	Off-mode: Consumption per hour	0	kWh	0
217	Off-mode: No. Of hours / year	0	#	
	TOTAL over Product Life	2,12	MWh (=000 kWh)	65
	Heat			
218	Avg. Heat Power Output	0	kW	
219	No. Of hours / year	0	hrs.	
220	Type and efficiency (Click & select)			85-not applicable
	TOTAL over Product Life	0,00	GJ	
	Consumables (excl. spare parts)			material
221	Water	0	m^3/year	83-Water per m3
222	Auxilliary material 1 (Click & select)	0	kg/ year	85-None
223	Auxilliary material 2 (Click & select)	0	kg/ year	85-None
224	Auxilliary material 3 (Click & select)	0	kg/ year	85-None
	Maintenance, Repairs, Service			
225	No. of km over Product-Life	0	km / Product Life	86
226	Spare parts (fixed, 1% of product materials & mar	455	g	

4.4. Use Phase (System)

The scope of "system" in relation to TVs is unclear. For the purpose of the EuP preparatory study we will focus on the end-user peripheral devices which are used in support of watching TV (e.g. STB, surround speaker systems) or in conjunction with recording/replay of videos/images (e.g. VCR, DVD, Cameras). In the case of separate devices an interface (wired/wireless connection) with the TV is necessary for operation. For proper interoperability such interfaces have specific hardware and software requirements. Power consumption is always related to peripheral devices. Particular data on material composition and average power consumption could not be obtained in the framework of this study. However, it should be recognized that power consumption of TV peripheral devices will contribute increasingly to the overall power consumption in European households is as much as the daily use time duration of the first and second TV will increase, a full distribution of digital television broadcasting will be achieved, and new or improved video media (e.g. HD / blu-ray DVD) will enter the market. The utilization of large screen TVs in public viewing areas or in business context (e.g. for videoconferencing) can not be analyzed in the study.

4.5. End-of-Life Phase

The end of life phase for the TV product cases are defined by the disposal, incineration and re-use/ recycling for the base materials form the manufacturing data of the product cases. The end of life data for each product case is presented in the following tables. The preset data for landfill proportion and re-use/ recycling benefits from the VHK EcoReport spreadsheet are used for the end of life phases.

Table 43: EcoReport Input Table for End of life phase of 32" LCD-TV

Pos	DISPOSAL & RECYCLING		unit	Subtotals
nr	Description			
	Substances released during Product Life and Landfill			
227	Refrigerant in the product (Click & select)	0	g	1-none
228	Percentage of fugitive & dumped refrigerant	0%		
229	Mercury (Hg) in the product	0	g Hg	
230	Percentage of fugitive & dumped mercury	0%		
	Disposal: Environmental Costs perkg final product			
231	Landfill (fraction products not recovered) in g en %	1158	5%	88-fixed
232	Incineration (plastics & PWB not re-used/recycled)	5211	g	91-fixed
233	Plastics: Re-use & Recycling ("cost"-side)	469	g	92-fixed
	Re-use, Recycling Benefit	in g	% of plastics fraction	
234	Plastics: Re-use, Closed Loop Recycling (please edit%)	47	1%	4
235	Plastics: Materials Recycling (please edit% only)	422	9%	4
236	Plastics: Thermal Recycling (please edit% only)	4221	90%	72
237	Electronics: PWB Easy to Disassemble ? (Click&select)	990	YES	98
238	Metals & TV Glass & Misc. (95% Recycling)	15666		fixed

Table 44: EcoReport Input Table for End of life phase of 42" PDP-TV

Pos	DISPOSAL & RECYCLING		unit	Subtotals
nr	Description			
	Substances released during Product Life and Landfill			
227	Refrigerant in the product (Click & select)	0	g	1-none
228	Percentage of fugitive & dumped refrigerant	0%		
229	Mercury (Hg) in the product	0	g Hg	
230	Percentage of fugitive & dumped mercury	0%		
	Disposal: Environmental Costs perkg final product			
231	Landfill (fraction products not recovered) in g en %	2295	5%	88-fixed
232	Incineration (plastics & PWB not re-used/recycled)	5785	g	91-fixed
233	Plastics: Re-use & Recycling ("cost"-side)	476	g	92-fixed
	Re-use, Recycling Benefit	in g	% of plastics fraction	
234	Plastics: Re-use, Closed Loop Recycling (please edit%)	48	1%	4
235	Plastics: Materials Recycling (please edit% only)	428	9%	4
236	Plastics: Thermal Recycling (please edit% only)	4281	90%	72
237	Electronics: PWB Easy to Disassemble ? (Click&select)	1504	YES	98
238	Metals & TV Glass & Misc. (95% Recycling)	36237		fixed

Table 45: EcoReport Input Table for End of life phase of 29” CRT-TV

Pos nr	DISPOSAL & RECYCLING Description		unit	Subtotals	
	Substances released during Product Life and Landfill				
227	Refrigerant in the product (Click & select)	0	g	1-none	
228	Percentage of fugitive & dumped refrigerant	0%			
229	Mercury (Hg) in the product	0	g Hg		
230	Percentage of fugitive & dumped mercury	0%			
	Disposal: Environmental Costs perkg final product				
231	Landfill (fraction products not recovered) in g en	2277	5%	88-fixed	
232	Incineration (plastics & PWB not re-used/recyclec	6470	g	91-fixed	
233	Plastics: Re-use & Recycling ("cost"-side)	575	g	92-fixed	
	Re-use, Recycling Benefit	in g	% of plastics fraction		
234	Plastics: Re-use, Closed Loop Recycling (please	58	1%	4	
235	Plastics: Materials Recycling (please edit% only)	518	9%	4	
236	Plastics: Thermal Recycling (please edit% only)	5175	90%	72	
237	Electronics: PWB Easy to Disassemble ? (Click&	1295	YES	98	
238	Metals & TV Glass & Misc. (95% Recycling)	35339		fixed	

4.6. Conclusion Task 4

An aggregated data-set (see EcoReport input tables) was compiled for the 32” LCD-TV primary product case. The provided data show only minor differences in the BOM for various 32” LCD-TV and a proportional distribution of material mass when compared to different screen sizes 26”, 37”, and 42” LCD-TV. Generally for all product cases there are main differences in the compositions of electronic components for electronic boards and power supply units.

Regarding the PDP-TV product cases there are considerable differences in composition and masses of used materials and BOMs. PDP-TVs show particular differences in the amount of glass (panel) steel (frame) non-ferro metals (heat plate) and electronics (PWB) even for the different 42” PDP-TV primary product case. These differences have to be seen in conjunction with existing differences in plasma panel technology and set making. We can not rule out that some differences also result from missing data of different allocation of data in the EcoReport.

The CRT-TV product case shows in comparison to LCD and PDP a relative high total mass. This is due to the high glass weight of the CRT tube. The electronic components are more comparable to PDP-TV because of the similar necessity to provide high voltage power input for generating the electron beam.

Unfortunately Rear Projection TVs could not be analyzed due to missing product samples for various RP technologies.

EuP Preparatory Studies "Televisions" (Lot 5)

Final Report on Task 5 "Definition of Base Cases"

Compiled by Fraunhofer IZM and PE Europe

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Berlin, 2nd August 2007

Content

Introduction

This is the final report on Task 5 “Definition of Base-Cases” for the EuP Preparatory Studies on televisions (lot 5). The findings presented in this report are results of the research conducted by the IZM consortium and the continuous feedback from a wide range of stakeholders. The statements and recommendations presented in the final report however are not to be perceived as the opinion of the European Commission.

We like to acknowledge the fruitful collaboration and trustful working relationship with various industry partners, non-industry stakeholders, and the European Commission throughout the study. We like to thank all stakeholders for their contributions and critical reviews of our reports.

2nd August 2007

5. Definition of Base-Case

5.1. Product-specific Inputs

5.1.1. Two Base Cases: 32” LCD-TV and 42” PDP-TV

By selecting the 32” LCD-TV and 42” PDP-TV as main product cases for the technical analysis in Task 4 a quasi-definition of base cases has been made already. This selection reflects the expected large market penetration of 32” LCD-TVs and 42” PDP-TVs in the coming years. With these two base cases we cover the most prominent flat panel display technologies in respective screen size segments. Both are representative products with significant market share in the European Union. It is important to understand that the products that were selected as base case represent a significant market in terms of future sales. It would be misleading to focus the base cases on products which dominate the stock today, meaning the products that are already in the market. Although the environmental impact from televisions over the next ten years will derive from these (stock) products they can not be influenced by future implementing measures under the EuP framework Directive. Therefore we have focused our assessments on products that will present a growing market in the next years meaning LCD-TVs and PDP-TVs. In consequence, this means that CRT-TVs and RP-TVs are of less importance for the base case assessments although CRTs will still dominate the stock of televisions in European household for at least the next five to ten years and RP-TVs still has a considerable market potential due to continuous technical development.

Table 1: Base Case 32” LCD-TV

Table . Life Cycle Impact (per unit) of Primary case 32" LCD TV

Nr	Life cycle Impact per product:	Date	Author
0	Primary case 32" LCD TV	0	

	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	Total	BUTION		Disposal	Recycl.	Total	
	Materials	**unit**									
1	Bulk Plastics	g			**4674**			4207	467	**4674**	**0**
2	TecPlastics	g			**16**			14	2	**16**	**0**
3	Ferro	g			**5632**			282	5351	**5632**	**0**
4	Non-ferro	g			**459**			23	436	**459**	**0**
5	Coating	g			**0**			0	0	**0**	**0**
6	Electronics	g			**2286**			1296	990	**2286**	**0**
7	Misc.	g			**10093**			505	9588	**10093**	**0**
	Total weight	g			**23160**			6326	16834	**23160**	**0**

Table 2: Base Case 42” PDP-TV

Table . Life Cycle Impact (per unit) of Primary case 42" PDP TV

Nr	Life cycle Impact per product:	Date	Author
0	Primary case 42" PDP TV	0	0

	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	Total	BUTION		Disposal	Recycl.	Total	
	Materials	unit									
1	Bulk Plastics	g			3314			2982	331	3314	0
2	TecPlastics	g			1443			1299	144	1443	0
3	Ferro	g			14225			711	13514	14225	0
4	Non-ferro	g			5043			252	4790	5043	0
5	Coating	g			0			0	0	0	0
6	Electronics	g			3122			1618	1504	3122	0
7	Misc.	g			18762			938	17824	18762	0
	Total weight	g			45909			7801	38108	45909	0

5.1.2. Reference Product Case: 29” CRT-TV

In order to have a reference product case we will also provide an environmental impact assessment for the 29” CRT-TV. CRTs are still important when assessing the current status of environmental impacts that originate form the stock and use of televisions in European households (task 5.4). The 29” CRT-TV is however not so representative from the market penetration. A smaller size 26” CRT-TV would have been the better option. Nevertheless, the available CRT will allow making an environmental impact assessment. Regarding upcoming tasks of determining best available technologies (BAT) and the actual improvement potential a CRT base case would poses some trouble. From our knowledge we have to conclude that the high maturity of CRT technology and the strong market competition with flat panel technologies will reduce further technical development in CRT to a very minimum. Against this background we assume that the improvement potential in the field of CRTs is limited.

Table 3: Product Case 29” CRT-TV

Table . Life Cycle Impact (per unit) of Primary case 29" CRT TV

Nr	Life cycle Impact per product:	Date	Author
0	Primary case 29" CRT TV	0	

	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	Total	BUTION		Disposal	Recycl.	Total	
	Materials	unit									
1	Bulk Plastics	g			5653			5088	565	5653	0
2	TecPlastics	g			97			87	10	97	0
3	Ferro	g			4232			212	4020	4232	0
4	Non-ferro	g			2127			106	2021	2127	0
5	Coating	g			0			0	0	0	0
6	Electronics	g			2872			1577	1295	2872	0
7	Misc.	g			30558			1528	29030	30558	0
	Total weight	g			45539			8598	36942	45539	0

5.1.3. Reference Product Case: 50” RP-TVs

In the introduction of the Task 4 report we already indicated some constraints regarding the assessment of RP-TVs. In terms of current market size, the known good energy performance of the devices, and continuous technical development in the field of rear projection technology, it seems necessary to include RP-TVs in the scope of the assessment. But this is a difficult task. First of all, there is not a single rear projection technology but multiple technologies in the market. We only received one product case using Liquid Crystal on Silicon technology for the technical analysis. Secondly, the available market data are not distinguishing these different rear projection technologies. Market data are however necessary for an impact assessment. Thirdly, the known market forecasts are predicting a decline of the already relatively small market at least for the European Union (cp. task 2.2). Many RP-TVs don't perform as well in lit rooms, or rooms with a lot of ambient light, and they can't match LCDs for brightness or PDPs for black levels. On the other hand continues the technical development in rear projection TVs. Large screen rear projection TVs based on DLP, LCD polysilicon, or LCoS technologies have entered the market, competing with LCD and PDP by driving prices down even lower. This surely indicates future market potentials for RP-TVs. As a trend, very large RP-TVs are entering not only households but professional application environments such as in military or traffic command and control facilities as well as public viewing areas. The use patterns in these markets can not be covered within the scope of our study. Despite these difficulties for defining a RP-TV base case we will cover power consumption, life cycle costs, and best available technology (BAT) for a 50” RP-TV reference product case throughout the study.

5.2. Base-Case Environmental Impact Assessment

In the following chapters the results of the environmental impact assessments for the 32” LCD-TV and 42” PDP-TV base cases as well as the 29” CRT reference product case are presented. The environmental impact assessments are based on the results of the VHK EcoReport. A critical interpretation of the assessment results follows. For the purpose of comparison we analyze primary energy consumption and other environmental impact categories in all life cycle phases and for main product modules. For a more detailed assessment of the environmental profiles comparisons of different TV sizes within the same display category and between different display technologies has been done.

As we have indicated in the preceding chapters the specific product data that we have received from industry partners as input for the assessments are not fully transparent. There have been problems in allocating components to the input categories of the VHK EcoReport input table. In the assessments of the displays and electronic boards of the LCD-TVs we will see this difficulty in particular. During the course of the assessments we started noticing discrepancies, which have been discussed with industry partners in the review process. Changes will occur for the assessment of the PDP manufacturing process in particular. In a similar way we notice that the LCD panel manufacturing process (based on the VHK EcoReport figures) does not show such a high impact as we would have expected form our experience in assessing electronics manufacturing processes. The special requirements for lowest contamination levels of modern LCD clean room production lines in order to assure high yield, the heat-treatment, annealing, and curing process of large glass panels seems more energy intensive form our point of view. Up to now we could not obtain other reference data for LCD panel manufacturing from manufacturers except the environmental product declarations from LG.Philips. However, the assumed underestimation of the environmental impact from LCD panel production was addressed in talks with major LCD panel manufacturers again.

The shortcomings of a precise data allocation to the VHK EcoReport categories, the possible overestimation or underestimation of environmental impacts from materials and components manufacturing are still limiting the quality of the following assessments.

5.2.1. Base Case 32” LCD-TV

5.2.1.1. Overview of Assessment Results

Table 4 shows the environmental impact assessment results for the 32” LCD-TV base case from the VHK EcoReport result table. If we take the total energy consumption (GER) as primary reference for the environmental impact the results indicate that the use phase contributes most significantly to the overall environmental impact followed by the production phase. For an assumed ten use life (4h on-mode, 20h standby per day) the GER proportion of the use phase in comparison to the production phase is 7:1. All other life cycle phase have only minor impact.

Table 4: Environmental assessment results from VHK EcoReport for 32” LCD-TV base case

Version 5 VHK for European Commission 28 Nov. 2005 — Document subject to a legal notice (see below))

ECO-DESIGN OF ENERGY-USING PRODUCTS

EuP EcoReport: **RESULTS**
Assessment of Environmental Impact

Table . Life Cycle Impact (per unit) of Primary case 32" LCD TV

Nr	Life cycle Impact per product:	Date	Author
0	Primary case 32" LCD TV	0	

Nr	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	Total	BUTION		Disposal	Recycl.	Total	
	Materials	**unit**									
1	Bulk Plastics	g			**4674**			4207	467	**4674**	**0**
2	TecPlastics	g			**16**			14	2	**16**	**0**
3	Ferro	g			**5632**			282	5351	**5632**	**0**
4	Non-ferro	g			**459**			23	436	**459**	**0**
5	Coating	g			**0**			0	0	**0**	**0**
6	Electronics	g			**2286**			1296	990	**2286**	**0**
7	Misc.	g			**10093**			505	9588	**10093**	**0**
	Total weight	g			**23160**			6326	16834	**23160**	**0**
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	MJ	2793	549	**3341**	**499**	**24561**	433	437	**-4**	**28398**
9	of which, electricity (in primary MJ)	MJ	1114	180	**1294**	**1**	**24541**	0	117	**-117**	**25720**
10	Water (process)	ltr	679	26	**705**	**0**	**1642**	0	105	**-105**	**2243**
11	Water (cooling)	ltr	1101	150	**1251**	**0**	**65421**	0	31	**-31**	**66640**
12	Waste, non-haz./ landfill	g	17808	1334	**19141**	**267**	**28630**	1421	339	**1082**	**49121**
13	Waste, hazardous/ incinerated	g	1537	8	**1545**	**5**	**581**	5211	130	**5081**	**7212**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	kg CO2 eq.	143	33	**176**	**31**	**1072**	32	30	**2**	**1281**
15	Ozone Depletion, emissions	mg R-11 eq					negligible				
16	Acidification, emissions	g SO2 eq.	832	168	**1000**	**94**	**6326**	65	112	**-48**	**7372**
17	Volatile Organic Compounds (VOC)	g	4	6	**10**	**7**	**9**	1	2	**0**	**26**
18	Persistent Organic Pollutants (POP)	ng i-Teq	148	15	**163**	**2**	**162**	10	1	**9**	**336**
19	Heavy Metals	mg Ni eq.	150	37	**187**	**14**	**423**	118	15	**103**	**726**
	PAHs	mg Ni eq.	315	5	**320**	**17**	**52**	0	12	**-12**	**376**
20	Particulate Matter (PM, dust)	g	105	41	**146**	**1129**	**136**	559	5	**554**	**1964**
	Emissions (Water)										
21	Heavy Metals	mg Hg/20	277	1	**278**	**0**	**161**	36	66	**-30**	**410**
22	Eutrophication	g PO4	12	2	**13**	**0**	**1**	2	1	**1**	**15**
23	Persistent Organic Pollutants (POP)	ng i-Teq					negligible				

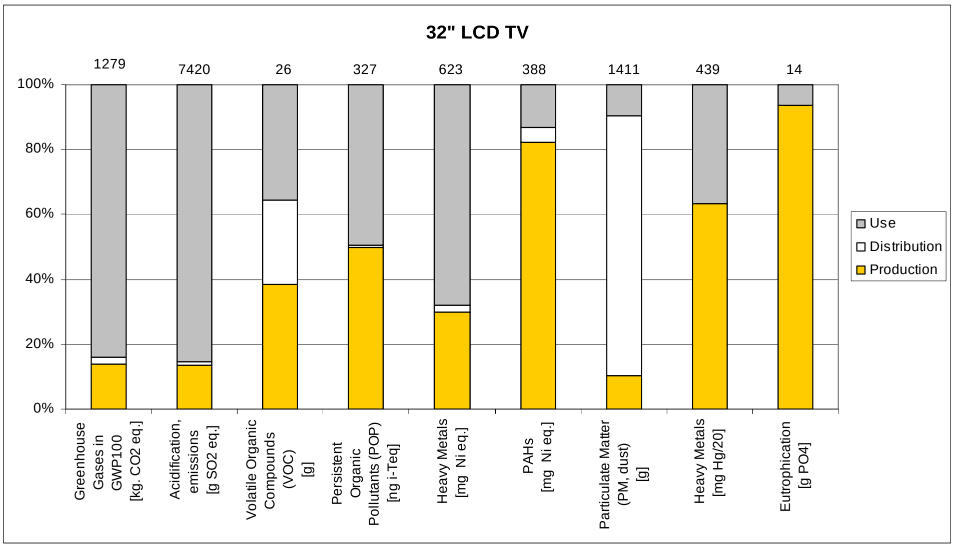


Figure 1: 32" LCD-TV base case assessment by environmental impact categories for life cycle phases

A graphic comparison of the total energy consumption (GER) for the different life cycle phases is given in the Figure 2 below. As indicated before the use phase with 24.561 MJ is by far the most dominating phase, production (materials) with 3341 MJ is second. Regarding greenhouse gas emissions (GWP) a similar impact correlation of the use phase (1072 kg/CO_2 eq.) in comparison to the production phase (176 kg/CO_2 eq.) is directly linked to the energy consumption. In terms of other emission related environmental impact categories (VOC, POP, Heavy Metals, etc.) a more diverse result has to be recognized. These impact categories are stronger related to the materials and manufacturing processes. They are proportionally larger for the production phase and end-of-life phase. Regarding Particulate Matters (dust) the distribution and end-of-life phase (disposal) have the strongest impact. For exact figures check again Table 4.

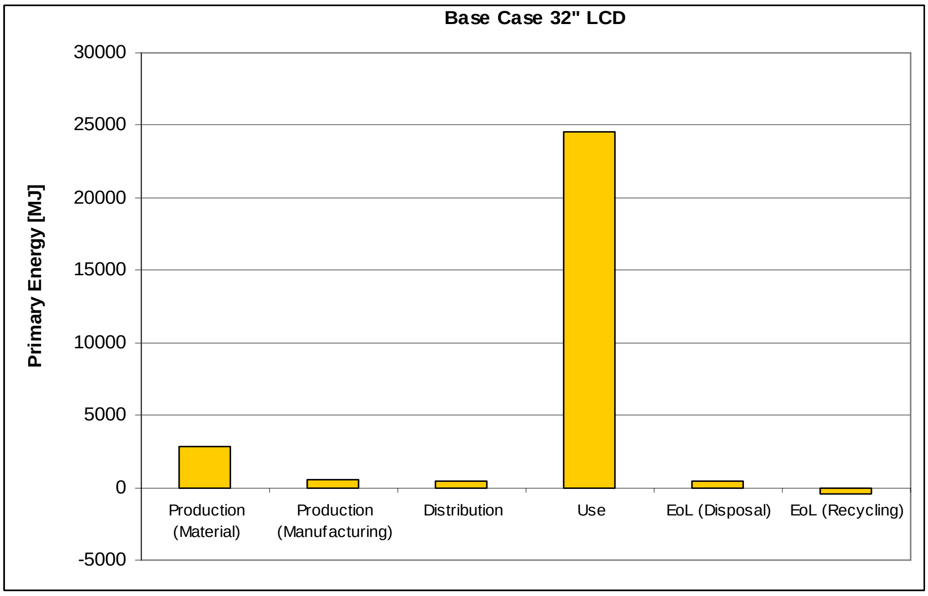


Figure 2: Total energy consumption of 32" LCD-TV base case over all life cycle phases

5.2.1.2. Raw Material and Manufacturing (Production Phase)

Figure 3 shows exemplarily the significance of each module (chassis, display, others, packaging, power supply unit, electronics boards and remote control) in relation to total energy consumption (GER) of the production phase for the 32" LCD-TV base case. Despite the LCD panel production (which is discussed later) does the chassis, PWB, and PSU show a considerable impact related to their mass proportion (of applied materials and components) in the product.

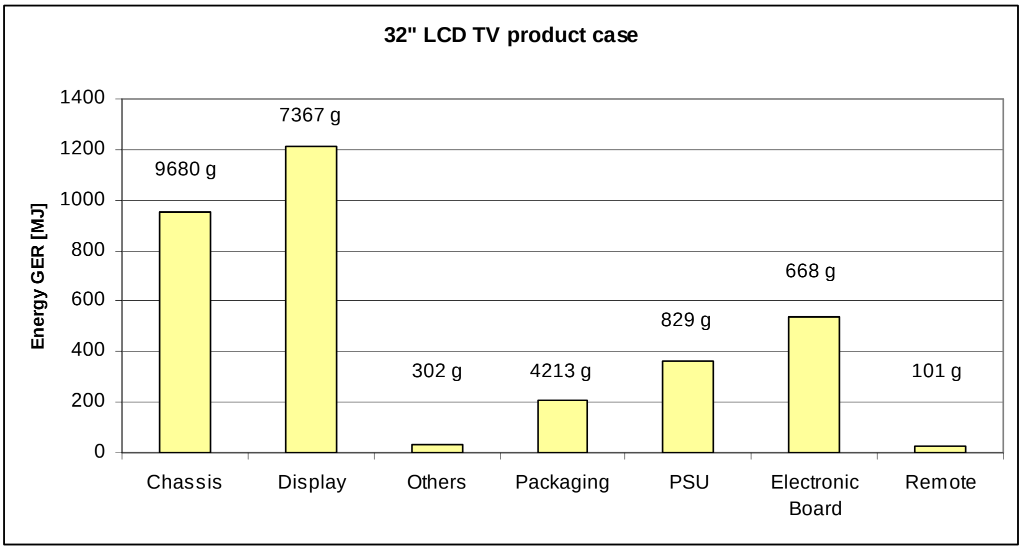


Figure 3: Total energy consumption related to the production phase of 32" LCD-TV base case

Chassis, PWB and PSU

Table 5 provides the material related specific environmental loads for all impacts categories and modules. Material and components causing more than 50% of total impact in the respective impact category has been marked with red color. Material and components causing between 15% and 50% of total impact in the respective impact category has been marked with orange color. This assessment is helpful to indicate prominent materials and components that cause significant environmental impact. As said before the LCD panel has the most significant impact regarding total energy (GER), process water consumption (cooling), and greenhouse gas emission (GER). The environmental impact (energy, waste, and emission to air) of the chassis derives primarily from the more than 3285g bulk plastics (10-ABS) in the housing and more than 5000g ferro metal (21-steel sheet) for the frame and stand. However, due to the good options for recycling these materials they seem to be less critical in total. The environmental impact of the electronic boards on the other hand is very difficult to assess with VHK. The input categories are very rough and technical development in electronic components and board technology is very fast. The mass of electronic boards (50-PWB) with populated, higher integrated electronics components (48-SMD and 46-ICs) result in a considerably environmental impact regarding process energy and water consumption as well as acidification and heavy metals (for exact data see again Table 5).

Table 5: Material related environmental impacts by categories (32" LCD-TV)

Version 5 VHK for European Commission 28 Nov. 2005 — Document subject to a legal notice (see below)

ECO-DESIGN OF ENERGY-USING PRODUCTS — EuP EcoReport: RAW OUTPUTS, Assessment of Environmental Impact

Nr: 0 **Product:** **Primary case 32" LCD TV** **Date:** **Author:**

MATERIALS EXTRACTION & PRODUCTION

	Product				Energy			Water		Waste		Emissions to Air							to Water	
nr	component	wght	cat.	material	GER	electr	feedst	water (proces	water (cool)	haz. Waste	non-haz. Waste	GWP	AD	VOC	POP	HM	PAH	PM	Metal	EUP
		in g			MJ	MJ	MJ	ltr.	ltr.	g	g	kg CO2eq	g SO2eq	mg	ng i-Teq	mg Ni eq	mg Ni eq	g	mg Hg/20eq	mg PO4 eq
1	CHASSIS	0	0	0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
2	Housing, plastic parts	3285	1-BlkPlastics	10-ABS	312,09	22,83	[illegible]	30,55	541,94	32,85	301,93	10,91	58,37	0,00	0,00	0,00	5,94	9,53	6,37	2068,72
3	Metal frame	5052	3-Ferro	21-St sheet galv.	171,77	11,51	0,37	0,00	0,00	0,00	8697,12	14,28	37,71	0,69	[illegible]	17,91	0,35	13,68	17,94	329,24
4	Speakers	251,8	6-Electronics	44-big caps & coils	96,49	0,00	0,00	8,72	13,85	4,93	151,19	5,46	35,70	0,03	0,54	1,93	51,52	8,97	18,69	1,80
5	Stand, Metal parts	321,5	3-Ferro	23-Cast iron	3,22	0,04	-0,02	0,42	1,18	0,00	101,39	0,34	1,04	0,04	1,93	0,64	0,00	4,50	0,29	8,43
6	Stand, Metal parts	205	4-Non-ferro	26-Al sheet/extrusion	39,49	0,00	0,00	0,00	0,00	0,00	803,60	2,12	13,80	0,01	1,02	0,75	19,79	3,47	7,18	1,01
7	Stand, Plastic parts	246	1-BlkPlastics	10-ABS	23,37	1,71	11,26	2,29	40,59	2,46	22,61	0,82	4,37	0,00	0,00	0,00	0,44	0,71	0,48	154,94
8	Stand, Plastic parts	195	1-BlkPlastics	5-PS	16,91	0,71	9,27	0,96	34,52	0,13	4,26	0,54	3,36	0,00	0,00	0,00	23,56	0,29	0,00	10,82
9	Screws	124,5	3-Ferro	25-Stainless 18/8 coil	7,72	1,21	0,50	9,43	1,05	0,00	124,50	0,77	6,97	0,02	0,96	10,46	0,00	0,99	10,75	209,83
10	0	0	0	0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
11	DISPLAY	0	0	0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
12	LCD Module	282,3	6-Electronics	42-LCD per m2 scrn	1005,86	[illegible]	0,00	12,70	189,14	0,28	14,68	52,04	16,71	0,12	0,08	0,22	0,03	0,16	0,08	0,00
13	LCD Module, mass dummy	6708	7-Misc.	0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
14	Electronic module	216	6-Electronics	44-big caps & coils	82,79	0,00	0,00	7,49	11,88	4,23	129,72	4,68	30,63	0,03	0,47	1,65	44,20	7,69	16,03	1,54
15	Electronic module	2	6-Electronics	45-slots / ext. ports	0,37	0,12	0,00	0,15	0,51	0,03	0,62	0,02	0,37	0,00	0,00	0,08	0,00	0,03	0,06	12,94
16	Electronic module	2	6-Electronics	46-IC's avg., 5% Si, Au	11,02	10,72	0,00	10,03	0,00	0,50	10,36	0,85	5,57	0,14	0,10	0,89	0,03	0,15	7,48	42,96
17	Electronic module	3	6-Electronics	48-SMD/ LED's avg.	8,91	8,66	0,00	2,78	0,00	0,39	8,49	0,50	4,86	0,02	0,04	1,27	0,01	0,15	0,04	6,59
18	Electronic module	154	6-Electronics	50-PWB 6 lay 4.5 kg/m2	56,55	22,51	1,31	74,70	11,83	291,34	627,29	2,42	60,98	0,16	0,78	10,79	1,06	5,70	19,32	376,18
19	0	0	0	0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
20	POWER SUPPLY UNIT	0	0	0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
21	Heatsink	84,5	4-Non-ferro	26-Al sheet/extrusion	16,28	0,00	0,00	0,00	0,00	0,00	331,24	0,87	5,69	0,01	0,42	0,31	8,16	1,43	2,96	0,42
22	Electronic module	477,6	6-Electronics	44-big caps & coils	183,06	0,00	0,00	16,55	26,27	9,36	286,82	10,35	67,73	0,06	1,03	3,66	97,74	17,01	35,45	3,41
23	Electronic module	22,9	6-Electronics	47-IC's avg., 1% Si	20,02	15,42	0,07	14,00	2,37	14,76	40,04	1,35	18,69	0,00	0,22	4,24	0,07	0,56	0,22	98,39
24	Electronic module	0,1	6-Electronics	46-IC's avg., 5% Si, Au	0,56	0,54	0,00	0,50	0,00	0,03	0,52	0,04	0,28	0,01	0,00	0,04	0,00	0,01	0,37	2,15
25	Electronic module	14,5	6-Electronics	52-Solder SnAg4Cu0.5	3,39	2,81	0,00	1,02	0,00	0,07	3,30	0,17	0,94	0,00	0,02	0,05	0,03	0,02	0,00	0,09
26	Label	0,05	7-Misc.	57-Office paper	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,26
27	Power Cord PVC part	17,25	1-BlkPlastics	8-PVC	0,98	0,19	0,40	0,19	1,07	0,09	1,16	0,04	0,26	0,00	0,00	0,00	0,00	0,05	0,05	5,42
28	Power Cord Copper part	22,4	4-Non-ferro	29-Cu wire	2,61	0,00	0,00	0,00	0,00	0,01	448,27	0,14	6,54	0,00	0,08	1,23	0,12	0,06	2,11	3,48
29	Connectors	22,9	6-Electronics	45-slots / ext. ports	4,28	1,36	0,00	1,71	5,85	0,39	7,05	0,23	4,22	0,00	0,03	0,87	0,04	0,30	0,73	148,16
30	Electronic module	0,514	6-Electronics	48-SMD/ LED's avg.	1,53	1,48	0,00	0,48	0,00	0,07	1,46	0,09	0,83	0,00	0,01	0,22	0,00	0,03	0,01	1,13
31	Electronic module	10,2	3-Ferro	21-St sheet galv.	0,35	0,02	0,00	0,00	0,00	0,00	17,56	0,03	0,08	0,00	0,27	0,04	0,00	0,03	0,04	0,66
32	Electronic module	0,4	4-Non-ferro	30-Cu tube/sheet	0,02	0,00	0,00	0,00	0,00	0,00	3,21	0,00	0,03	0,00	0,00	0,01	0,00	0,00	0,02	0,02
33	Electronic module	156,4	6-Electronics	49-PWB 1/2 lay 3.75kg/m2	43,96	23,54	1,33	26,59	12,01	271,08	410,60	1,75	33,43	0,36	0,42	5,65	0,56	0,79	2,31	576,56
34	0	0	0	0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
35	REMOTE CONTROL	0	0	0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
36	Electronic module	14,1	6-Electronics	50-PWB 6 lay 4.5 kg/m2	5,18	2,06	0,12	6,84	1,08	26,67	57,43	0,22	5,58	0,01	0,07	0,99	0,10	0,52	1,77	34,44
37	Electronic module	0,45	6-Electronics	44-big caps & coils	0,17	0,00	0,00	0,02	0,02	0,01	0,27	0,01	0,06	0,00	0,00	0,00	0,09	0,02	0,03	0,00
38	Electronic module	0,5	6-Electronics	45-slots / ext. ports	0,09	0,03	0,00	0,04	0,13	0,01	0,15	0,01	0,09	0,00	0,00	0,02	0,00	0,01	0,02	3,23
39	Electronic module	0,5	6-Electronics	46-IC's avg., 5% Si, Au	2,75	2,68	0,00	2,51	0,00	0,13	2,59	0,21	1,39	0,03	0,02	0,22	0,01	0,04	1,87	10,74
40	Electronic module	0,4	6-Electronics	47-IC's avg., 1% Si	0,35	0,27	0,00	0,24	0,04	0,26	0,70	0,02	0,33	0,00	0,00	0,07	0,00	0,01	0,00	1,72
41	Rubber	11,9	2-TecPlastics	16-Flex PUR	1,24	0,22	0,47	0,83	3,55	0,39	6,53	0,05	0,38	0,00	0,00	0,00	0,24	0,10	0,04	67,66
42	Housing	22	1-BlkPlastics	7-HI-PS	2,03	0,10	1,08	0,12	4,09	0,01	0,66	0,06	0,43	0,00	0,00	0,00	1,34	0,04	0,00	1,31
43	Housing	32,4	1-BlkPlastics	10-ABS	3,08	0,23	1,48	0,30	5,36	0,32	2,98	0,11	0,58	0,00	0,00	0,00	0,06	0,09	0,06	20,41
44	Screw	0,1	3-Ferro	21-St sheet galv.	0,00	0,00	0,00	0,00	0,00	0,00	0,17	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,01
45	Terminal	0,8	3-Ferro	25-Stainless 18/8 coil	0,05	0,01	0,00	0,06	0,01	0,00	0,80	0,00	0,04	0,00	0,01	0,12	0,00	0,01	0,07	1,86
46	Battery	17,88	6-Electronics	44-big caps & coils	6,85	0,00	0,00	0,62	0,98	0,35	10,73	0,39	2,54	0,00	0,04	0,14	3,66	0,64	1,33	0,13
47	0	0	0	0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
48	0	0	0	0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
49	ELECTRONIC BOARDS	0	0	0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
50	Shielding	27,7	3-Ferro	21-St sheet galv.	0,94	0,06	0,00	0,00	0,00	0,00	47,69	0,08	0,21	0,00	0,72	0,10	0,00	0,07	0,10	1,81
51	Electronic module	0,3	3-Ferro	24-Ferrite	0,02	0,00	0,00	0,01	0,00	0,00	0,77	0,00	0,00	0,00	0,01	0,01	0,00	0,00	0,00	0,02
52	Heatsink	20	4-Non-ferro	26-Al sheet/extrusion	3,85	0,00	0,00	0,00	0,00	0,00	78,40	0,21	1,35	0,00	0,10	0,07	1,93	0,34	0,70	0,10
53	Electronic module	1	4-Non-ferro	30-Cu tube/sheet	0,05	0,00	0,00	0,00	0,00	0,00	8,01	0,00	0,06	0,00	0,01	0,03	0,01	0,00	0,04	0,06
54	Electronic module	28,98	6-Electronics	44-big caps & coils	11,11	0,00	0,00	1,00	1,59	0,57	17,40	0,63	4,11	0,00	0,06	0,22	5,93	1,03	2,15	0,21
55	Electronic module	56,85	6-Electronics	45-slots / ext. ports	10,63	3,37	0,00	4,24	14,52	0,97	17,49	0,57	10,48	0,00	0,06	2,16	0,11	0,74	1,81	367,80
56	Electronic module	17,53	6-Electronics	46-IC's avg., 5% Si, Au	69,03	67,14	0,00	62,87	0,00	3,16	64,93	5,31	34,93	0,86	0,61	5,60	0,18	0,91	46,86	269,17
57	Electronic module	0,633	6-Electronics	47-IC's avg., 1% Si	0,55	0,43	0,00	0,39	0,07	0,41	1,11	0,04	0,52	0,00	0,01	0,12	0,00	0,02	0,01	2,72
58	Electronic module	65,04	6-Electronics	48-SMD/ LED's avg.	193,08	187,66	0,00	60,19	0,00	8,50	164,11	10,86	105,39	0,49	0,97	27,43	0,29	3,31	0,96	142,76
59	Electronic module	360	6-Electronics	50-PWB 6 lay 4.5 kg/m2	132,18	52,62	3,07	174,62	27,65	681,04	1466,39	5,65	142,56	0,37	1,83	25,22	7,48	13,33	45,16	879,39
60	Electronic module	94,5	6-Electronics	50-PWB 6 lay 4.5 kg/m2	34,70	13,81	0,81	45,84	7,26	178,77	384,93	1,48	37,42	0,10	0,48	6,62	0,66	3,50	11,86	230,84
61	Electronic module	0,15	6-Electronics	52-Solder SnAg4Cu0.5	0,04	0,03	0,00	0,01	0,00	0,00	0,03	0,00	0,01	0,00	0,00	0,00	0,00	0,00	0,00	0,00
62	0	0	0	0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
63	PACKAGING	0	0	0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
64	Cardboard box	2439	7-Misc.	56-Cardboard	88,28	4,87	39,02	17,19	0,00	0,11	127,57	1,71	2,53	0,00	0,03	0,08	0,01	0,03	0,03	209,86
65	Plastic bag	121,7	1-BlkPlastics	1-LDPE	9,46	1,62	6,27	0,36	5,47	0,54	5,38	0,23	0,91	0,06	0,00	0,08	0,02	0,11	0,00	3,24
66	Polystyrene Foam	706	1-BlkPlastics	6-EPS	99,06	2,39	33,75	4,02	124,26	0,66	26,72	1,91	12,80	0,00	0,00	0,00	42,96	1,27	0,00	87,95
67	Manual	946,7	7-Misc.	57-Office paper	37,87	5,67	25,56	72,08	0,00	0,32	63,95	0,53	4,75	0,19	0,04	0,10	0,01	1,57	0,04	5006,52
68	0	0	0	0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
69	OTHERS	0	0	0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
70	Internal/ external cables	123,3	4-Non-ferro	29-Cu wire	14,37	0,00	0,00	0,00	0,00	0,03	2467,48	0,76	36,02	0,00	0,46	6,79	0,06	0,35	11,60	19,05
71	Internal/ external cables	49,45	1-BlkPlastics	8-PVC	2,80	0,56	1,13	0,54	3,07	0,25	3,32	0,11	0,74	0,00	0,00	0,00	0,00	0,14	0,14	15,53
72	Internal/ external cables	1,65	2-TecPlastics	11-PA 6	0,20	0,02	0,06	0,03	0,36	0,03	0,29	0,01	0,06	0,00	0,00	0,00	0,00	0,01	0,08	3,09
73	Internal/ external cables	0,6	2-TecPlastics	13-PMMA	0,07	0,01	0,03	0,01	0,02	0,00	0,06	0,00	0,03	0,00	0,00	0,00	0,00	0,00	0,00	1,24
74	Internal/ external cables	1,6	2-TecPlastics	16-Flex PUR	0,17	0,03	0,06	0,11	0,48	0,05	0,88	0,01	0,05	0,00	0,00	0,00	0,03	0,01	0,01	9,10
75	Internal/ external cables	71,85	3-Ferro	21-St sheet galv.	2,44	0,16	0,01	0,00	0,00	0,00	123,69	0,20	0,54	0,01	1,87	0,25	0,00	0,19	0,26	4,88
76	Internal/ external cables	20,5	3-Ferro	24-Ferrite	1,04	0,07	0,00	0,01	0,00	0,00	52,94	0,09	0,23	0,00	0,80	0,74	0,00	0,08	0,05	1,61
77	Internal/ external cables	7,7	3-Ferro	25-Stainless 18/8 coil	0,17	0,03	0,01	0,20	0,00	0,00	2,70	0,02	0,15	0,00	0,02	0,40	0,00	0,02	0,23	6,29
78	Internal/ external cables	2,6	4-Non-ferro	30-Cu tube/sheet	0,13	0,00	0,00	0,00	0,00	0,01	20,84	0,01	0,16	0,00	0,03	0,09	0,01	0,00	0,10	0,16
79	Internal/ external cables	27,5	6-Electronics	45-slots / ext. ports	5,14	1,63	0,00	2,05	7,02	0,47	8,46	0,28	5,07	0,00	0,04	1,04	0,05	0,36	0,87	177,92
	TOTAL	0	0	0	2792,77	1113,95	287,78	679,41	1101,07	1537,03	17807,53	142,59	831,67	3,82	148,13	149,54	314,57	105,17	277,20	11727,81
				80%	2234,21	891,16	230,22	543,53	880,86	1229,63	14246,03	114,07	665,34	3,06	118,51	119,63	251,62	84,13	221,76	9382,25

Colour coding

Components causing more than 50% of total impact in the respective category: [red]

Components causing between 15% and 50% of total Impact in the respective category: [orange]

Components added to receive a sum of all colour coded processes (red, orange, yellow) that is about 80%: [yellow]

We have to assume that the electronic boards will gain in impact with further demand of TV integrated signal and data processing/storage functionality. On the other hand has higher system integration (miniaturization) the potential to improve the proportion between the amounts of electronics and provided functionality. Regarding the PSU the environmental impact is related to the mass of electronic boards, power electronics (44-big caps & coils), and non-ferro metals. The electrical efficiency improvement of the power supply unit through application of advanced electronic components will not have a considerable negative effect in the production phase.

LCD Panel

According to the assessment results the LCD panel has the single most important environmental impact in the production phase. The assessment of the LCD panel is based on a default impact value (input category 42-LCD) given by VHK EcoReport. In terms of total energy consumption (1200 MJ) and global warming potential (52 kg/CO_2 eq.) the resulting environmental impact from the LCD panel manufacturing seems on average somewhat underestimated. As a matter of fact considerable differences in LCD panel manufacturing efficiency exist resulting from the maturity of manufacturing process and the applied production generation respectively[1]. For the purpose of assessing the validity of the VHK results a comparison with existing impact data from another assessment is given in the following paragraph.

Table 6 shows environmental impacts that have been stated by LG Philips for manufacturing and upstream processes of LCD-TV display module production („cradle-to-gate“) in conjunction with the Environmental Product Declaration (EPD)

Table 6: Manufacturing and upstream environmental impacts of LCD-TV display modules

LG Philips LCD-TV displays	32“ module	37“ module	42“ module
Global warming (kg CO2 equivalents)	326	382	392
Acidification (kmol H+)	0,012	0,015	0,022
Ozone depletion (kg CFC-11 equivalents)	3,2 E-08	4,4 E-08	7,2 E-08
Photochemical oxidant formation (kg ethane equivalents)	0,33	0,42	0,44
Eutrophication (kg O2)	0,36	0,42	0,52
Hazardous waste (kg)	5,7	7,3	7,9
Non-hazardous waste (kg)	70	80	89

[1] This aspect became obvious when comparing the received production data for plasma display panels manufacturing (see later chapter on PDP-TV base case).

When comparing the global warming potential (GWP) of the 32” LCD-TV display module (mass 7200g) the Environmental Product Declaration by LG Philips calculates 326 kg/CO_2 equivalents in comparison to the VHK EcoReport which calculates approximately 52 kg/CO_2 equivalent. This is a considerable difference that should be critically assessed. The EPD provides a “cradle-to-gate” assessment (including the packaging of the LCD panel) whereas VHK provides a “gate-to-gate plus glass manufacturing” value. This means that VHK does not include the up-stream processes for raw material refinery of steel, plastics, electronics etc., except for glass (which we assume is highly processed glass and is therefore also underestimated by VHK).

Table 7: Material Composition of 32” LCD-TV Display Modules (VHK input table adaptation)

Content	EPD Material Input		VHK Material Input (Adaptation)		
Metals	**47.58%**	**4 329 g**			
Steel	47.25%	*4 300 g*	4300,0g	3-Ferro	21-St sheet gal.
Copper	0.33%	*30 g*	30,0g	4-Non-ferro	29-Cu wire
Plastics	**28.30%**	**2575 g**			
EPS	6.17%	*561 g*	561,0	1-BlkPlastics	6-EPS
PMMA	7.63%	*694 g*	694,0	2-TecPlastics	13-PMMA
PET	7.40%	*673 g*	Part of packaging		
PC	6.35%	*577 g*	577,0	2-TecPlastics	12-PC
PE	0.70%	*64 g*	Part of packaging		
Others	0.04%	*4 g*	Part of packaging		
Glass	**14.52%**	**1321 g**			
Paper	**8.69%**	**791 g**	Part of packaging		
Electronics	**0.92%**	***84 g***	**84,0**	6-Electronics	98-Controller

Applying the VHK unit indicators (spreadsheet “raw”) to the material input data of the EPD (without packaging material and glass) results in an extra 37 kg/CO_2 equivalent for the cradle-to-gate assessment of the (in the VHK EcoReport data set) missing up-stream impacts of the metals, plastics and electronics which goes into the panel manufacturing fab. The respective input categories are shown in Table 7. By adding these 37 kg/CO_2 equivalent to the original VHK result (42-LCD) of 52 kg/CO_2 equivalent a total of 89 kg/CO_2 equivalent is calculated. Finally a comparison with the EPD result of 326 kg/CO_2 equivalent has to consider the impact of the packaging material. It is assumed that 6 kg/CO_2 equivalent is subtracted resulting in 320 kg/CO_2 equivalent as a reference value for a cradle-to-gate global warming potential of a 32” LCD-TV panel production.

Through this calculation we receive a factor 3.6 difference between the VHK EcoReport results and the environmental product declaration (EPD) of LG Philips. When applying this factor to the total energy consumption of the 32” LCD-TV display manufacturing we would add approximately 3000 MJ to the total of the original VHK EcoReport result. In consequence this added energy would increase the overall energy related impact of the production phase to more than 6000 MJ what is almost doubling the impact from the original VHK EcoReport assessment. This example – although a very rough estimation and only done for illustration purposes – indicates that the production phase is an important factor in the environmental assessment of the 32” LCD-TV. We of cause recognize the continuous improvement in LCD panel through the introduction of advanced manufacturing generations. Nevertheless, the improvement of manufacturing processes (efficiency in cleanroom process steps, etc.) is an important task from an environmental point of view. In conclusion we would also recommend a thorough environmental analysis of different LCD panel manufacturing lines in order to confirm the validity of VHK EcoReport assessment.

5.2.1.3. Distribution, Use, and End-of-Life Phase

Comparing the environmental impacts and primary energy consumption of the distribution phase with the other life cycle stages, the distribution phase is negligible. In terms of environmental impact (transportation efficiency) the products dimensions (volume) are more important that the weight of the product. Flat panel TVs such as LCDs have an advantage in that respect when compared to cubic CRT-TVs or RP-TVs. The use phase, which is described by a “primary use product life” of 10 years, has the single most important environmental impact due to the electricity consumption in on-mode and standby. The comparison of the primary energy consumption of the use phase is between 7 to 9 times higher, than for the manufacturing phase. An overall analysis of power consumption issues and their total impact will be given in Task 5.4 and therefore not further discussed at this point. However, it is clearly visible that the power consumption in on-mode is the most significant aspect related to the environmental improvement of LCD-TVs. Therefore the use phase has to be considered more detailed for the identification of improvement potentials of the product.

According to the results of the VHK EcoReport assessment the caused environmental impact of the end-of-life phase as well as the credits for recycling are negligible. From our perspective this result is somewhat insufficient. The growing material value of LCD-TVs (e.g. Sharp Corporation has developed a proprietary technology to recycle valuable Indium metal form the Indium Tim Oxide [ITO] layer used to form the transparent electrode in LCD panels[2]), expected shorter product life times (8 years in primary use), and the growing dissemination of LCD-TVs in the market will

[2] Yohei Kawaguchi (Environmental Protection Group of Sharp Corporation): „Recycling technology for LCD-TVs and closed-loop material recycling of waste plastics“, in: Proceedings of 6th International Electronics Recycling Congress (IERC), 17-19 January 2007, Hamburg, Germany.

consequently lead to a high volume (millions) of discarded devices in the next decades. Against that background we suggest to investigate environmental sound but also cost efficient ways of LCD-TV recycling. Under the current WEEE Directive the TV manufacturers have only very limited incentives to improve the material composition and design of their products with the goal of better recycling. It is recommended to investigate how the TV manufacturers can in close collaboration with recycling companies improve this situation with a mutual cost benefit.

For further comparison the Figure 4 takes into account the full set of environmental impact categories besides primary energy consumption. For most categories the use phase remains the dominant life cycle phase, but with some exemptions: Disposal contributes by 70% to the impacts related to hazardous / incinerated waste. In this context we also like to point to the fact that the mercury containing backlight systems (CCFL) have to be treated separately due to the health risks from toxic pollution. The manual or automated disassembly (under protective gas) of the backlight lamps is a considerable cost factor.

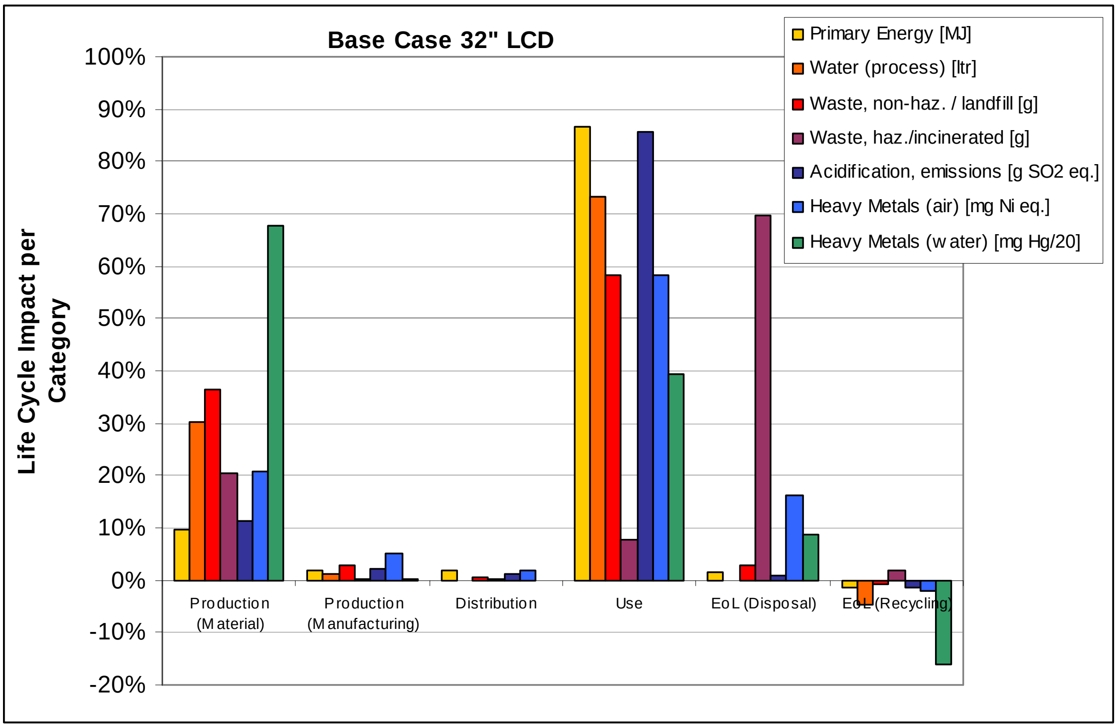


Figure 4: Environmental impacts related to different impact categories over life cycle of 32" LCD-TV

Heavy metal emissions to water are correlated to production (material) mainly, with second priority on the use phase. Production (manufacturing) is well below 10% in all displayed categories, which is somewhat surprising taking into account the complex manufacturing of LCD panels (multiple mask steps). A comprehensive environmental analysis of LCD panel manufacturing is recommended in order to verify the results of VHK EcoReport or if necessary to adjust the data set.

In general, taking into account other impact categories besides total energy consumption (GER) does not change the priorities as such, although especially the production phase (materials) gains more importance.

5.2.2. Base Case 42” PDP-TV

Table 8 presents the environmental impact assessment results for the 42” PDP-TV base case from the VHK EcoReport result table[3]. If we take again total energy consumption (GER) as a reference the results indicate a similar proportion of the use phase in comparison to the production phase as in the LCD-TV case. The use phase contributes most significantly to the overall environmental impact followed by the production phase. All other life cycle phase have only minor impact.

Table 8: Environmental assessment results form VHK EcoReport for 42” PDP-TV base case

Version 5 VHK for European Commission 28 Nov. 2005 — Document subject to a legal notice (see below))

ECO-DESIGN OF ENERGY-USING PRODUCTS — EuP EcoReport: RESULTS — Assessment of Environmental Impact

Table . Life Cycle Impact (per unit) of Primary case 42" PDP TV

Nr	Life cycle Impact per product:	Date	Author
0	Primary case 42" PDP TV	0	

Nr	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	Total	BUTION		Disposal	Recycl.	Total	
	Materials	**unit**									
1	Bulk Plastics	g			**3314**			2982	331	**3314**	**0**
2	TecPlastics	g			**1443**			1299	144	**1443**	**0**
3	Ferro	g			**14225**			711	13514	**14225**	**0**
4	Non-ferro	g			**5043**			252	4790	**5043**	**0**
5	Coating	g			**0**			0	0	**0**	**0**
6	Electronics	g			**3122**			1618	1504	**3122**	**0**
7	Misc.	g			**18762**			938	17824	**18762**	**0**
	Total weight	g			**45909**			7801	38108	**45909**	**0**
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	MJ	5288	922	**6210**	**255**	**52951**	549	582	**-33**	**59382**
9	of which, electricity (in primary MJ)	MJ	2710	321	**3032**	**0**	**52919**	0	176	**-176**	**55775**
10	Water (process)	ltr	1694	40	**1734**	**0**	**3543**	0	159	**-159**	**5118**
11	Water (cooling)	ltr	885	244	1129	0	141047	0	42	-42	142134
12	Waste, non-haz./ landfill	g	53874	2668	**56542**	**149**	**61887**	2816	512	**2303**	**120882**
13	Waste, hazardous/ incinerated	g	2432	13	**2444**	**3**	**1243**	5785	197	**5588**	**9279**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	kg CO2 eq.	292	56	**348**	**17**	**2312**	41	40	**1**	**2677**
15	Ozone Depletion, emissions	mg R-11 eq					negligible				
16	Acidification, emissions	g SO2 eq.	2375	279	**2654**	**49**	**13645**	82	163	**-81**	**16266**
17	Volatile Organic Compounds (VOC)	g	14	10	**24**	**3**	**20**	2	2	**-1**	**46**
18	Persistent Organic Pollutants (POP)	ng i-Teq	415	51	**466**	**1**	**351**	20	2	**18**	**836**
19	Heavy Metals	mg Ni eq.	503	121	**624**	**8**	**914**	151	22	**129**	**1674**
	PAHs	mg Ni eq.	711	8	**719**	**9**	**111**	0	18	**-18**	**822**
20	Particulate Matter (PM, dust)	g	223	65	**288**	**513**	**294**	709	7	**701**	**1796**
	Emissions (Water)										
21	Heavy Metals	mg Hg/20	564	1	**565**	**0**	**347**	46	100	**-54**	**858**
22	Eutrophication	g PO4	28	2	**31**	**0**	**2**	3	1	**1**	**34**
23	Persistent Organic Pollutants (POP)	ng i-Teq					negligible				

[3] The results only include material assessments and not the impacts related to PDP manufacturing processes because VHK does not provide a PDP input category.

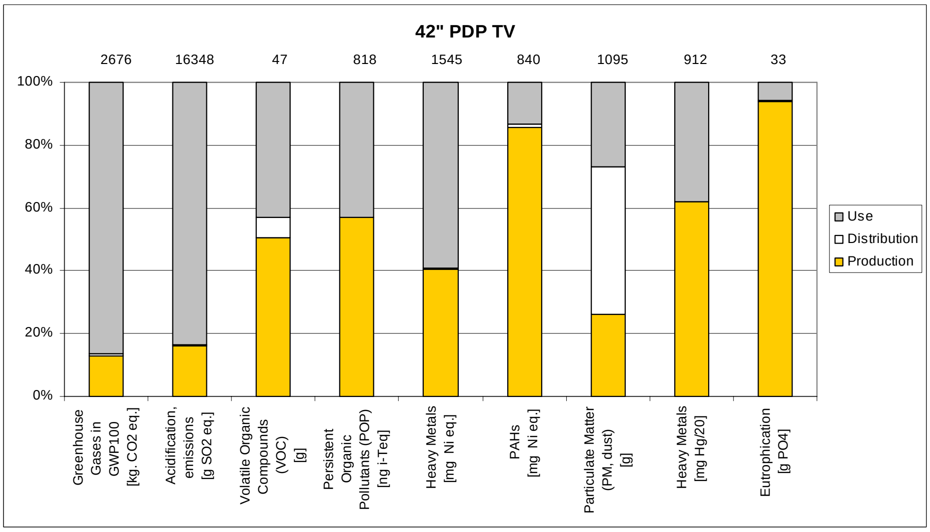


Figure 5: 42" PDP-TV base case assessment by environmental impact categories for life cycle phases

The graphic comparison of the total energy consumption for the different life cycle phases for 42" PDP-TV base case is given in Figure 6 below. Based on a ten year primary use lifetime the use phase contributes 52951 MJ followed by 6210 MJ for the production phase. The material and component related impacts (production phase) are proportionally larger in comparison to the LCD base case. A detailed analysis follows below. Due to the fact that the VHK EcoReport input table does not provide a default impact assessment for PDP (input category that exists for LCD and CRT), the total energy of the manufacturing process is not included in this graph.

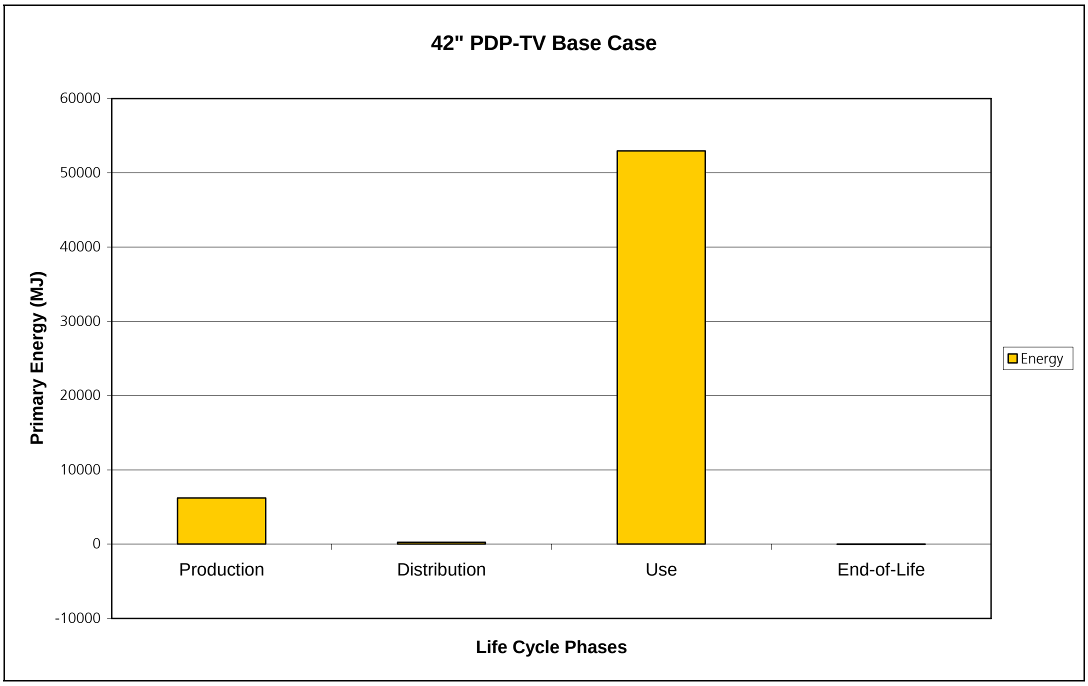


Figure 6: Total energy consumption of 42" PDP-TV base case over all life cycle phases

5.2.2.1. Raw Material and Manufacturing (Production Phase)

Among the production phase the VHK EcoReport results show the relevance of the raw materials (e.g. metals, glass, and plastics) and highly processed components (e.g. electronics). However it does not provide an environmental impact assessment regarding the plasma display panel (PDP) manufacturing itself. Especially the energy consumption in PDP manufacturing has a significant influence on the environmental impacts. Therefore the total energy consumption GER for the PDP production was calculated on the basis of 3583 MJ (per m² panel, confirmed data from industry) and by the raw datasets from the VHK EcoReport spreadsheet[4].

The resulting values for the PDP production process are compiled in the following Table 9.

Table 9: Additional impact values for 42" PDP manufacturing

			Electricity per 42" panel	Gas, η 86%, atmospheric per 42" panel	Water per 42" panel
Energy	GER	MJ	4167,13	565,46	0,00
	electr	MJ	4167,13	0,00	0,00
	feedst	MJ	0,00	0,00	0,00
Water	water proces	ltr.	277,81	0,00	486,29
	water (cool)	ltr.	11112,35	0,00	0,00
Waste	haz.	g	96,02	0,00	0,00
	non-haz.	g	4831,55	0,00	0,00
Emissions to Air	GWP	kg CO2eq	181,85	31,26	0,00
	AD	g SO2eq	1073,04	9,10	0,00
	VOC	mg	1,57	0,41	0,00
	POP	ng i-Teq	27,31	0,00	0,00
	HM	mg Ni eq	71,49	0,00	0,00
	PAH	mg Ni eq	8,21	0,02	0,00
	PM	g	22,92	0,16	0,00
to Water	Metal	mg Hg/20eq	26,87	0,00	0,00
	EUP	mg PO4 eq	128,12	0,00	0,00

Table 5 shows the added environmental impact – the additional 4167 MJ (electricity) and 565 MJ (thermal energy) from the PDP production – to the results of the VHK EcoReport. They are stacked in red on top of the original VHK EcoReport data. In order to not calculate the panel glass twice 148 MJ have been subtracted resulting in a total energy of 10794 MJ.

[4] For discussion of the acquisition and allocation of the PDP manufacturing data please see the introduction of Task 4 report.

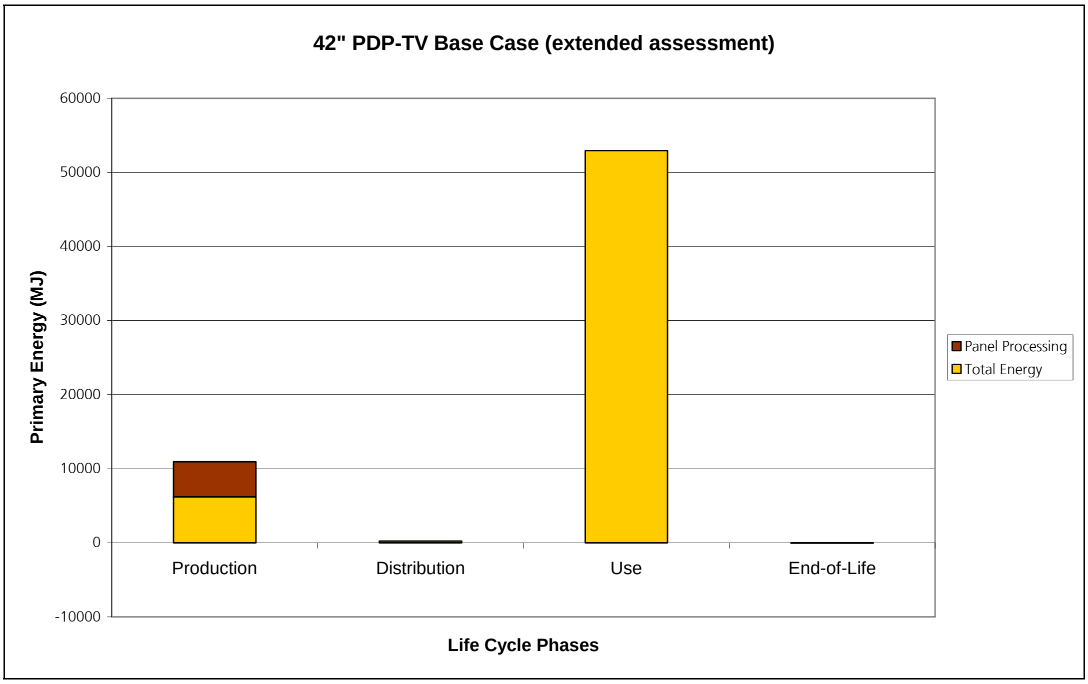


Figure 7: Total energy consumption of 42” PDP-TV base case (with additional panel processing)

The magnitude of this total energy demand is considerable. But this result needs further discussion. The resource efficiency of plasma panel manufacturing is improving from one manufacturing generation to next. The assessment was made based on average values for a second generation PDP production. During a meeting and further consultations with four PDP manufacturers in March 2007 it was confirmed that the third generation requires approximately 25% less energy (3500 MJ) than the second generation. The reduction in greenhouse gas emission is proportional. The improvement is also seen in the reduction of water usage.

If we now look again at the production related (material and components) total energy demand without the added panel processing than we still have a considerable 6000 MJ production phase. Following Figure 8 provides a breakdown of the production related energy (GER) for the main modules. For the display we added plasma panel related energy according to assumed 2nd or 3rd manufacturing generation.

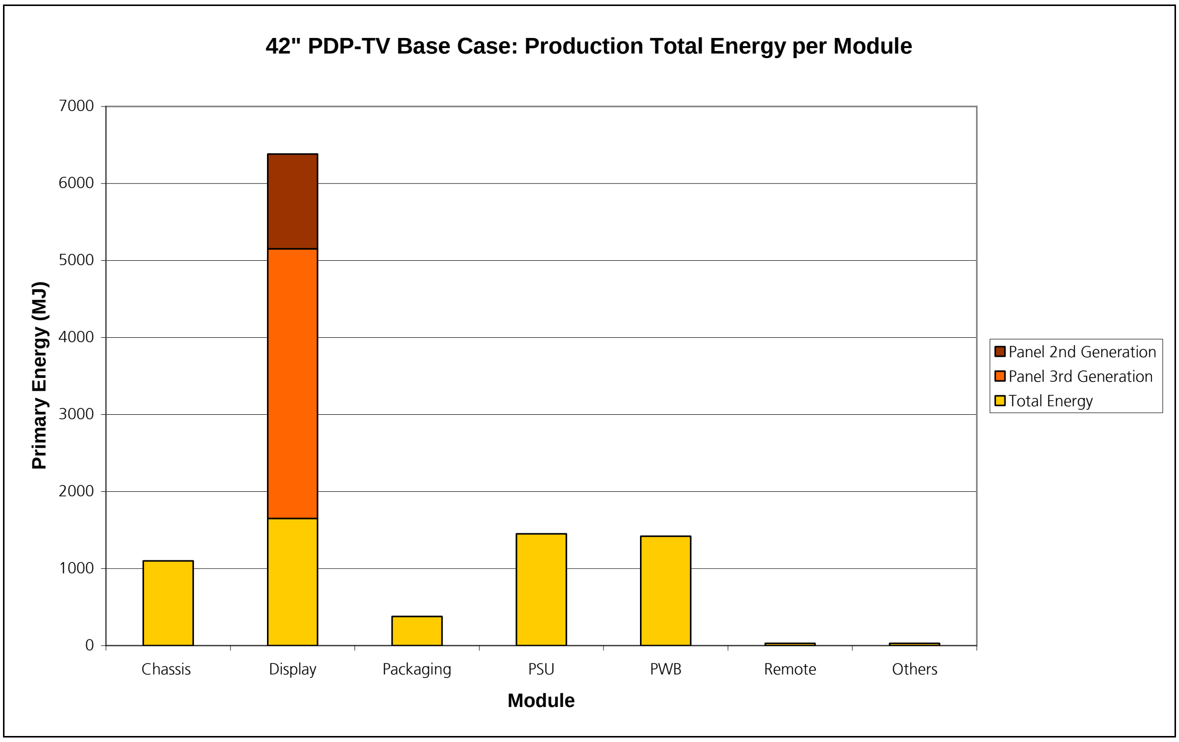


Figure 8: Total energy consumption related to the production phase of the 42" PDP-TV base case

Table 10 provides the material related specific environmental loads for all impacts categories and modules. Material and components causing more than 50% of total impact in the respective impact category has been marked with red color. Material and components causing between 15% and 50% of total impact in the respective impact category has been marked with orange color. This assessment is helpful to indicate prominent materials and components that cause significant environmental impact. The impact of the power supply unit (PSU) and the electronic boards (PWB) is most significant and the proportion (compared to the LCD base case) surprisingly high.

Table 10: Material related environmental impacts by categories (42" PDP-TV)

Version 5 VHK for European Commission 28 Nov. 2005 — Document subject to a legal notice (see below)

ECO-DESIGN OF ENERGY-USING PRODUCTS — EuP EcoReport: RAW OUTPUTS — Assessment of Environmental Impact

Nr: 0 — Product: Primary case 42" PDP TV — Date: — Author:

MATERIALS EXTRACTION & PRODUCTION

	Product				Energy			Water		Waste		Emissions to Air							to Water	
nr	component	wght	cat.	material	GER	electr	feedst	water (proces)	water (cool)	haz. Waste	non-haz. Waste	GWP	AD	VOC	POP	HM	PAH	PM	Metal	EUP
		in g			MJ	MJ	MJ	ltr.	ltr.	g	g	kg CO2eq	g SO2eq	mg	ng i-Teq	mg Ni eq	mg Ni eq	g	mg Hg/20eq	mg PO4 eq
1	CHASSIS	0	0	0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
2	Other plastic parts	5,5	1-BlkPlastics	2-HDPE	0,42	0,05	0,30	0,02	0,17	0,03	0,21	0,01	0,03	0,00	0,00	0,00	0,00	0,00	0,00	0,16
3	Other plastic parts	0,467	1-BlkPlastics	3-LLDPE	0,03	0,00	0,02	0,00	0,05	0,00	0,01	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,02
4	Other plastic parts	13,9	1-BlkPlastics	4-PP	1,01	0,10	0,73	0,07	0,56	0,06	0,39	0,03	0,08	0,00	0,00	0,00	0,01	0,01	0,00	2,29
5	Housing	502,8	1-BlkPlastics	5-PS	43,61	1,82	23,90	2,46	89,00	0,34	10,98	1,40	8,66	0,00	0,00	0,00	60,76	0,75	0,00	27,90
6	Other plastic parts	4,333	1-BlkPlastics	6-EPS	0,36	0,01	0,21	0,02	0,76	0,00	0,16	0,01	0,08	0,00	0,00	0,00	0,26	0,01	0,00	0,54
7	Other plastic parts	50,66	1-BlkPlastics	8-PVC	2,07	0,56	1,16	0,56	3,14	0,25	3,40	0,11	0,76	0,00	0,00	0,00	0,00	0,15	0,14	15,91
8	Housing	1430	1-BlkPlastics	10-ABS	135,86	9,94	65,44	13,30	235,92	14,30	131,44	4,75	25,41	0,00	0,00	0,00	2,58	4,15	2,77	900,57
9	Other plastic parts	11,47	2-TecPlastics	11-PA 6	1,37	0,17	0,45	0,18	2,51	0,22	2,02	0,10	0,45	0,00	0,00	0,00	0,00	0,06	0,56	21,47
10	Other plastic parts	728	2-TecPlastics	12-PC	85,03	10,82	27,66	10,19	82,99	7,28	128,53	3,93	18,51	0,00	0,00	0,00	0,26	4,88	0,12	366,91
11	Frame	13177	3-Ferro	21-St sheet galv.	448,02	30,02	0,98	0,00	0,00	0,00	22684,64	37,26	98,37	1,80	347,60	46,71	0,91	35,68	46,78	868,75
12	Other metal parts	13,33	3-Ferro	22-St tube/profile	0,23	0,06	0,00	0,00	0,00	0,00	10,68	0,02	0,05	0,00	0,16	0,03	0,00	0,01	0,02	0,51
13	Other metal parts	142,3	3-Ferro	23-Cast iron	1,42	0,02	-0,01	0,19	0,52	0,00	44,89	0,15	0,46	0,02	0,85	0,28	0,00	1,99	0,13	3,73
14	Other metal parts	109	3-Ferro	24-Ferrite	5,52	0,37	0,01	4,29	0,00	0,00	281,47	0,46	1,22	0,02	4,25	3,92	0,00	0,44	0,26	8,57
15	Other metal parts	735	4-Non-ferro	26-Al sheet/extrusion	141,58	0,00	0,00	0,00	0,00	0,00	2881,20	7,61	49,47	0,05	3,67	2,67	70,95	12,43	25,74	3,64
16	Cable	14,33	4-Non-ferro	28-Cu winding wire	2,05	0,00	0,00	0,00	0,00	0,01	287,24	0,11	4,35	0,00	0,06	0,81	0,08	0,04	0,09	2,27
17	Front glass	2867	7-Misc.	54-Glass for lamps	46,51	37,06	0,00	24,42	0,00	0,77	38,78	2,39	8,61	0,01	0,22	0,51	0,00	0,18	0,11	1,03
18	Labels	111,5	7-Misc.	57-Office paper	4,46	0,67	3,01	8,49	0,00	0,04	7,53	0,06	0,56	0,02	0,00	0,01	0,00	0,19	0,00	589,85
19	Other plastic parts	80	2-TecPlastics	15-Rigid PUR	8,34	1,40	3,09	4,80	24,08	1,57	34,17	0,33	2,48	0,00	0,00	0,00	1,62	0,59	3,46	254,06
20	0	0	0	0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
21	DISPLAY	0	0	0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
22	Other plastic parts	54	1-BlkPlastics	10-ABS	5,13	0,38	2,47	0,50	8,91	0,54	4,96	0,18	0,96	0,00	0,00	0,00	0,10	0,16	0,10	34,01
23	Other plastic parts	290	2-TecPlastics	12-PC	33,87	4,31	11,02	4,06	33,06	2,90	51,20	1,56	7,37	0,00	0,00	0,00	0,11	1,94	0,05	146,17
24	Other plastic parts	304,5	2-TecPlastics	13-PMMA	33,56	3,98	12,73	2,98	7,92	0,43	31,90	1,83	13,27	0,00	0,00	0,00	0,00	1,56	0,85	629,71
25	Other metal parts	40	3-Ferro	24-Ferrite	2,02	0,14	0,00	1,57	0,00	0,00	103,29	0,17	0,45	0,01	1,56	1,44	0,00	0,16	0,09	3,15
26	Other metal parts	236	3-Ferro	25-Stainless 18/8 coil	14,64	2,29	0,95	17,07	1,99	0,00	236,00	1,46	13,22	0,03	1,82	35,00	0,01	1,87	20,38	549,39
27	Frame	3409	4-Non-ferro	26-Al sheet/extrusion	656,63	0,00	0,00	0,00	0,00	0,00	13362,89	35,28	229,42	0,23	17,02	12,39	329,08	57,67	119,38	16,87
28	Other metal parts	171	4-Non-ferro	27-Al diecast	9,43	0,00	0,00	0,00	0,00	0,00	128,25	0,61	2,67	0,01	5,73	0,14	3,02	0,69	1,11	0,21
29	Cable	5,5	4-Non-ferro	29-Cu wire	0,64	0,00	0,00	0,00	0,00	0,00	110,07	0,03	1,61	0,00	0,02	0,30	0,03	0,02	0,52	0,85
30	Electronic module	127	6-Electronics	44-big caps & coils	48,68	0,00	0,00	4,40	6,99	2,49	76,27	2,75	18,01	0,02	0,27	0,97	25,99	4,52	9,43	0,91
31	Electronic module	32	6-Electronics	45-slots / ext. ports	5,99	1,90	0,00	2,39	8,17	0,55	9,85	0,32	5,90	0,00	0,04	1,22	0,06	0,41	1,02	207,03
32	Electronic module	19,5	6-Electronics	46-IC's avg., 5% Si, Au	107,43	104,49	0,00	97,83	0,00	4,91	101,04	8,26	54,35	1,32	0,95	8,71	0,29	1,42	72,93	418,88
33	Electronic module	117,5	6-Electronics	48-SMD/ LED's avg.	348,84	339,05	0,00	108,74	0,00	15,36	332,63	19,62	190,41	0,88	1,76	49,55	0,53	5,97	1,73	257,97
34	Electronic module	303	6-Electronics	49-PWB 1/2 lay 3.75kg/m2	85,16	45,61	2,58	51,52	23,27	525,18	795,48	3,40	64,77	0,70	0,82	10,95	1,08	1,54	4,47	1116,99
35	Electronic module	6	6-Electronics	52-Solder SnAg4Cu0.5	1,40	1,16	0,00	0,42	0,00	0,03	1,37	0,07	0,39	0,00	0,01	0,02	0,01	0,01	0,00	0,04
36	Panel glass	9109	7-Misc.	54-Glass for lamps	147,79	117,76	0,00	77,60	0,00	2,45	123,22	7,59	27,36	0,03	0,70	1,61	0,00	0,58	0,36	3,27
37	0	28,55	7-Misc.	57-Office paper	1,14	0,17	0,77	2,17	0,00	0,01	1,93	0,02	0,14	0,01	0,00	0,00	0,00	0,06	0,00	160,98
38	Other metal parts	239	3-Ferro	21-St sheet galv.	8,13	0,54	0,02	0,00	0,00	0,00	411,44	0,68	1,70	0,03	6,21	0,85	0,02	0,65	0,85	15,58
39	0	0	0	0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
40	0	0	0	0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
41	0	0	0	0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
42	POWER SUPPLY UNIT	0	0	0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
43	Cable insulation, other parts	50	1-BlkPlastics	8-PVC	2,83	0,56	1,15	0,55	3,10	0,25	3,35	0,11	0,75	0,00	0,00	0,00	0,00	0,15	0,14	15,70
44	Other plastic parts	4,267	2-TecPlastics	12-PC	0,50	0,06	0,16	0,06	0,49	0,04	0,75	0,02	0,11	0,00	0,00	0,00	0,00	0,03	0,00	2,15
45	Other plastic parts	10	2-TecPlastics	14-Epoxy	1,41	0,25	0,43	0,19	3,84	0,19	4,07	0,07	0,44	0,00	0,00	0,00	0,00	0,15	0,00	96,50
46	Other metal parts	27	3-Ferro	21-St sheet galv.	0,92	0,06	0,00	0,00	0,00	0,00	46,48	0,08	0,20	0,00	0,70	0,10	0,00	0,07	0,10	1,76
47	Other metal parts	14,7	3-Ferro	24-Ferrite	0,74	0,05	0,00	0,58	0,00	0,00	37,96	0,06	0,16	0,00	0,57	0,53	0,00	0,06	0,03	1,16
48	Heatsink	355,7	4-Non-ferro	26-Al sheet/extrusion	68,52	0,00	0,00	0,00	0,00	0,00	1394,34	3,68	23,94	0,02	1,78	1,29	34,34	6,02	12,46	1,76
49	Cable	23,7	4-Non-ferro	29-Cu wire	2,76	0,00	0,00	0,00	0,00	0,01	474,28	0,15	6,92	0,00	0,09	1,30	0,13	0,07	2,23	3,66
50	Other metal parts	5,8	4-Non-ferro	31-CuZn38 cast	0,22	0,00	0,00	0,00	0,00	0,00	17,65	0,01	0,20	0,00	0,15	0,33	0,02	0,01	0,05	0,09
51	Electronic board	440	6-Electronics	44-big caps & coils	168,64	0,00	0,00	15,25	24,20	0,63	264,24	9,54	62,40	0,05	0,95	3,37	90,05	15,67	32,66	3,14
52	Electronic board	10,3	6-Electronics	45-slots / ext. ports	3,42	1,09	0,00	1,37	4,67	0,31	5,63	0,10	3,37	0,00	0,03	0,70	0,04	0,24	0,58	110,40
53	Electronic board	10	6-Electronics	46-IC's avg., 5% Si, Au	55,09	53,58	0,00	50,17	0,00	2,52	51,81	4,23	27,87	0,68	0,49	4,47	0,15	0,73	37,40	214,81
54	Electronic board	21,7	6-Electronics	47-IC's avg., 1% Si	18,97	14,61	0,06	13,27	2,25	13,99	37,94	1,28	17,71	0,00	0,21	4,01	0,06	0,52	0,21	93,23
55	Electronic board	292	6-Electronics	48-SMD/ LED's avg.	866,91	842,58	0,00	270,23	0,00	38,16	826,63	48,76	473,18	2,18	4,38	123,14	1,32	14,84	4,30	641,09
56	Electronic board	214,3	6-Electronics	49-PWB 1/2 lay 3.75kg/m2	60,23	32,26	1,83	36,44	16,46	371,44	562,61	2,40	45,81	0,50	0,58	7,75	0,76	1,09	3,16	790,00
57	Electronic board	63,8	6-Electronics	52-Solder SnAg4Cu0.5	14,93	12,36	0,00	4,40	0,00	0,29	14,54	0,74	4,12	0,00	0,08	0,21	0,12	0,09	0,00	0,39
58	0	0	0	0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
59	0	0	0	0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
60	REMOTE CONTROL	0	0	0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
61	Housing	55	1-BlkPlastics	10-ABS	5,23	0,38	2,52	0,51	9,08	0,55	5,06	0,18	0,98	0,00	0,00	0,00	0,10	0,16	0,11	34,64
62	Frame	41,5	3-Ferro	21-St sheet galv.	1,41	0,09	0,00	0,00	0,00	0,00	71,44	0,12	0,31	0,01	1,08	0,15	0,00	0,11	0,15	2,70
63	Other metal parts	1,5	3-Ferro	23-Cast iron	0,02	0,00	0,00	0,00	0,01	0,00	0,47	0,00	0,00	0,00	0,01	0,00	0,00	0,02	0,00	0,04
64	Electronic board	1	6-Electronics	45-slots / ext. ports	0,19	0,06	0,00	0,07	0,26	0,02	0,31	0,01	0,18	0,00	0,00	0,04	0,00	0,01	0,03	6,47
65	Electronic board	1	6-Electronics	46-IC's avg., 5% Si, Au	5,51	5,36	0,00	5,02	0,00	0,25	5,18	0,42	2,79	0,07	0,05	0,45	0,01	0,07	3,74	21,48
66	Electronic board	1	6-Electronics	47-IC's avg., 1% Si	0,87	0,67	0,00	0,61	0,10	0,64	1,75	0,06	0,82	0,00	0,01	0,19	0,00	0,02	0,01	4,30
67	Electronic board	1,5	6-Electronics	48-SMD/ LED's avg.	4,46	4,33	0,00	1,39	0,00	0,20	4,25	0,25	2,43	0,01	0,02	0,63	0,01	0,08	0,02	3,29
68	Electronic board	15	6-Electronics	49-PWB 1/2 lay 3.75kg/m2	4,22	2,26	0,13	2,55	1,15	26,00	39,38	0,17	3,21	0,03	0,04	0,54	0,05	0,08	0,22	55,30
69	Electronic board	2,5	6-Electronics	52-Solder SnAg4Cu0.5	0,58	0,40	0,00	0,10	0,00	0,01	0,57	0,03	0,16	0,00	0,00	0,01	0,00	0,00	0,00	0,02
70	Rubber parts	15	2-TecPlastics	16-Flex PUR	1,57	0,28	0,60	1,05	4,47	0,49	8,23	0,07	0,40	0,00	0,00	0,00	0,30	0,12	0,05	85,28
71	0	0	0	0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
72	ELECTRONIC BOARD	0	0	0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
73	Other metal parts	33,3	3-Ferro	21-St sheet galv.	1,13	0,08	0,00	0,00	0,00	0,00	57,33	0,09	0,25	0,00	0,87	0,12	0,00	0,09	0,12	2,17
74	Heatsink	181,7	4-Non-ferro	26-Al sheet/extrusion	35,00	0,00	0,00	0,00	0,00	0,00	712,26	1,88	12,73	0,01	0,91	0,66	17,54	3,07	6,36	0,90
75	Electronic board	17,3	6-Electronics	44-big caps & coils	6,63	0,00	0,00	0,60	0,95	0,34	10,39	0,37	2,45	0,00	0,04	0,13	3,54	0,62	1,28	0,12
76	Other metal parts	37,3	3-Ferro	24-Ferrite	1,89	0,13	0,00	1,47	0,00	0,00	96,32	0,16	0,42	0,01	1,45	1,34	0,00	0,15	0,09	2,93
77	Electronic board	170,1	6-Electronics	45-slots / ext. ports	31,82	10,09	0,00	12,70	43,44	2,91	52,33	1,71	31,36	0,00	0,24	6,46	0,33	2,20	5,41	1100,50
78	Electronic board	21,7	6-Electronics	46-IC's avg., 5% Si, Au	119,55	116,28	0,00	108,87	0,00	5,46	112,44	9,19	60,49	1,47	1,06	9,69	0,32	1,58	81,16	466,14
79	Electronic board	84,4	6-Electronics	47-IC's avg., 1% Si	73,78	56,82	0,25	51,61	8,74	54,40	147,56	4,96	68,89	0,00	0,83	15,61	0,25	2,04	0,81	362,61
80	Electronic board	2,7	4-Non-ferro	31-CuZn38 cast	0,10	0,00	0,00	0,00	0,00	0,00	8,22	0,00	0,09	0,00	0,07	0,15	0,01	0,00	0,02	0,04
81	Electronic board	231,6	6-Electronics	48-SMD/ LED's avg.	887,59	868,30	0,00	214,33	0,00	30,27	555,64	38,58	375,30	1,73	3,47	97,67	1,05	11,77	3,41	508,48
82	Electronic board	457,8	6-Electronics	49 PWB 1/2 lay 3.75kg/m2	120,67	60,91	3,90	77,04	35,16	793,40	1201,88	5,14	97,06	1,06	1,24	16,56	1,63	2,33	6,75	1687,66
83	Electronic board	262,7	6-Electronics	50 PWB 6 lay 4.5 kg/m2	96,46	38,40	2,24	127,42	20,18	496,97	1070,06	4,12	104,03	0,27	1,34	18,40	1,01	9,73	32,95	641,71
84	Electronic board	182,6	6-Electronics	52-Solder SnAg4Cu0.5	42,72	35,37	0,00	12,82	0,00	0,83	41,61	2,12	11,78	0,01	0,24	0,81	0,34	0,25	0,00	1,10
85	Electronic board	6,7	6-Electronics	44-caps and coils	2,57	0,00	0,00	0,23	0,37	0,13	4,02	0,15	0,95	0,00	0,01	0,05	1,37	0,24	0,50	0,05
86	Cable	10,7	4-Non-ferro	29-Cu wire	1,25	0,00	0,00	0,00	0,00	0,00	214,13	0,07	3,13	0,00	0,04	0,59	0,06	0,03	1,01	1,65
87	0	0	0	0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
88	0	0	0	0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
89	PACKAGING	0	0	0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
90	Plastic bag	32,92	1-BlkPlastics	2-HDPE	2,52	0,32	1,78	0,11	1,02	0,18	1,26	0,06	0,20	0,01	0,00	0,00	0,01	0,03	0,00	3,98
91	Other plastic parts	44	1-BlkPlastics	4-PP	3,20	0,32	2,32	0,21	1,76	0,19	1,24	0,09	0,25	0,00	0,00	0,00	0,02	0,03	0,00	7,24
92	Bumpers	940,3	1-BlkPlastics	6-EPS	78,67	3,18	44,96	5,36	165,50	0,87	95,59	2,54	17,05	0,00	0,00	0,00	57,21	1,69	0,00	117,19
93	Other metal parts	8	3-Ferro	21-St sheet galv.	0,27	0,02	0,00	0,00	0,00	0,00	13,77	0,02	0,06	0,00	0,21	0,03	0,00	0,02	0,03	0,52
94	Cardboard packaging	3939	7-Misc.	56-Cardboard	110,29	7,87	63,03	27,76	0,00	0,18	206,08	2,77	4,09	0,00	0,05	0,14	0,02	0,04	0,05	339,00
95	Manual/ packaging	2700	7-Misc.	57 Office paper	108,30	16,23	73,11	206,16	0,00	0,92	182,09	1,52	13,60	0,55	0,11	0,30	0,03	4,50	0,11	[illegible]
96	0	0	0	0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
97	OTHER	0	0	0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
98	Cable	130	1-BlkPlastics	8-PVC	7,36	1,44	2,98	1,43	8,06	0,65	8,72	0,28	1,95	0,00	0,00	0,00	0,00	0,38	0,37	40,82
99	Cable	127,5	4-Non-ferro	29-Cu wire	14,86	0,00	0,00	0,00	0,00	0,03	2561,53	0,79	37,24	0,00	0,48	7,02	0,69	0,36	17,00	19,70
100	Metal parts	104,9	3-Ferro	21-St sheet galv.	3,57	0,24	0,01	0,00	0,00	0,00	180,59	0,30	0,78	0,01	2,73	0,37	0,01	0,28	0,37	6,84
	TOTAL	0	0	0	5207,51	2710,22	350,97	1693,95	805,25	2431,51	53074,33	292,17	2374,62	13,91	415,33	503,21	711,50	222,63	563,92	28435,51
				80%	4230,01	2168,18	207,17	1355,16	700,20	1945,21	43099,46	233,73	1899,70	11,13	332,26	402,56	569,20	178,10	451,14	22740,41

The environmental impact regarding PSU and PWB results from the proportionally high mass of advanced (miniaturized) electronic components and boards respectively. The input category 48-SMD, which was chosen by the industry to describe their boards, has a tremendous impact on the overall assessment. When comparing this input data allocation with the 32” LCD-TV base case the difference becomes noticeable. Regarding the 32” LCD-TV base case the industry had only used the input category 48-SMD to a very small extent and mostly allocated their boards to the input category 49-PWB, which is rated considerably lower from the environmental impact. From technical point of view we assume that the electronic boards for signal processing etc. as well as for power supply are more equal and that there is not such big difference between LCD and PDP at least on the board level. An exemption is of cause the high voltage power supply of the backlight unit of the LCD.

In conclusion, the assessment data indicate the environmental importance of the manufacturing phase particularly regarding the plasma panel and the advanced electronic components / boards. The review of the 42” PDP-TV production data furthermore indicated that the allocation of electronic components to the existing VHK input categories may influence significantly the overall assessment. In view of these findings it is suggested to increase the rate impact of the PSU and PWB production in the 32” LCD-TV base case or decrease this impact in the case of he 42” PDP-TV.

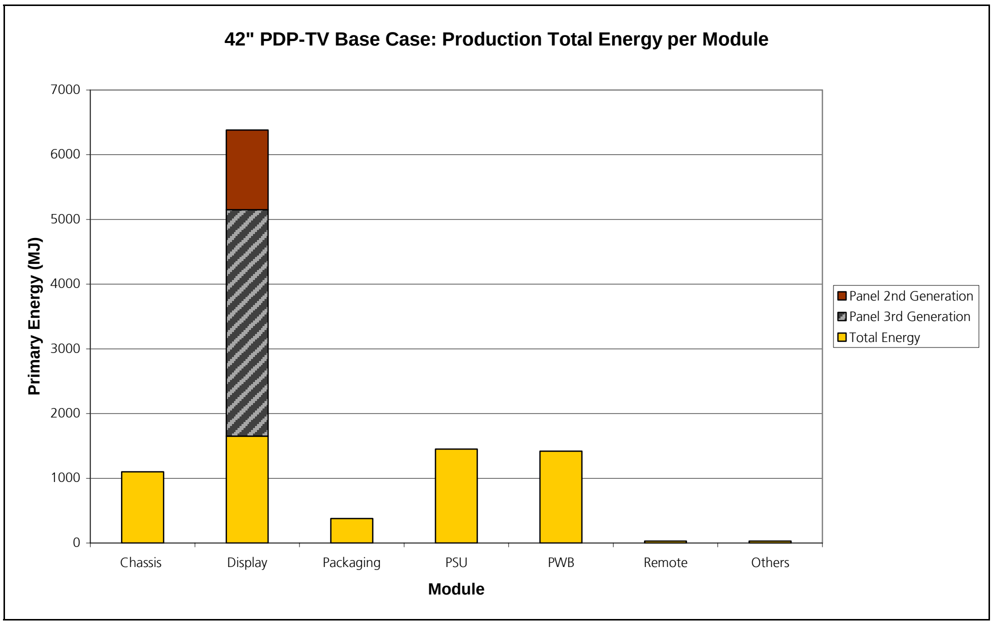
5.2.2.2. Distribution, Use and End-of-life Phase

Comparing the environmental impacts and primary energy consumption of the distribution phase to the other considered life cycle stages (see Figure 6), the distribution phase for the 42” PDP-TV is negligible. The same assessment applies to the end-of-life phase and the credits for recycling of materials. Material recovery in the case of PDP-TVs seems reasonable due to the high amount of bulk materials in the chassis as well as aluminum (large heat sinks), copper (power electronics), and precious metals on the backplanes. The panel is dominated by glass which currently still contains lead. A treatment should be similar to CRT.

Due to the significant amount of electricity consumption is the use phase the most significant life cycle stage regarding the environmental impacts of the 42” PDP-TV base case. An overall analysis of power consumption issues and their total impact will be given in Task 5.4 and therefore not further discussed at this point.

5.2.2.3. Comparison of the 42" PDP-TV Base Case and 42" LCD-TV

Figure 9 presents the comparison of total energy consumption (GER) for the production phase of the 42" PDP-TV base case with a single 42" LCD-TV product case. There are assumptions for panel manufacturing related total energy added to the results of the VHK EcoReport.



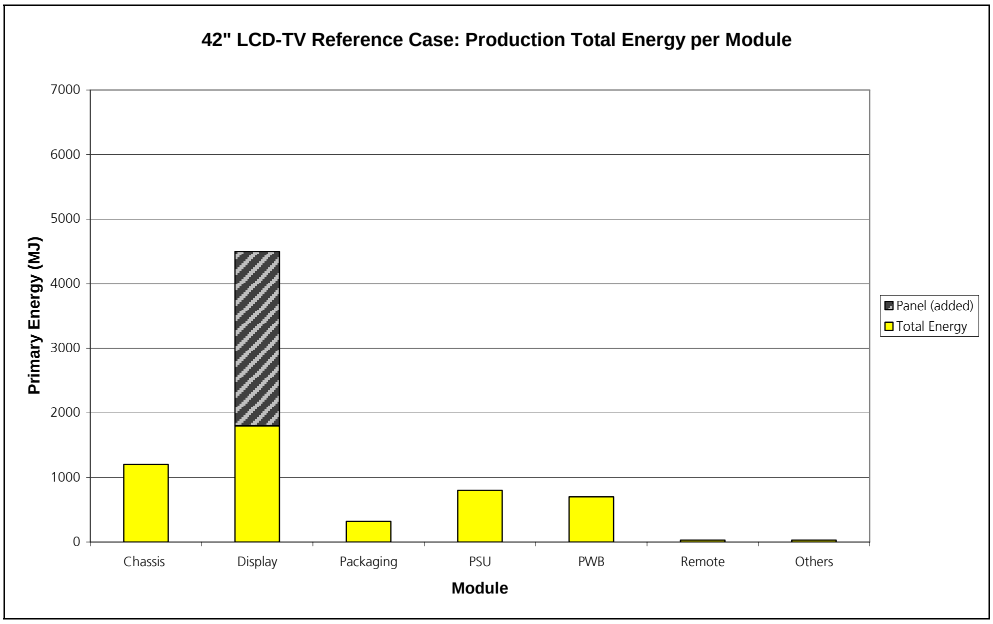


Figure 9: Comparison of total energy regarding the production phase of a 42" LCD and 42" PDP-TV

Regarding both TVs the results from the VHK EcoReport assessment are similar in magnitude for the chassis and the display module. The difference in the PSU and the electronic boards become obvious again. There are some aspects which contribute to this result as discussed already before.

As a matter of fact the 42” PDP-TV base case features a larger amount (mass) of electronic boards. According to the received data does the PDP-TV base case also features more highly integrated electronic components (48-SMD) which in comparison to the more conventional large electronic components (44-Big caps & coils) declared for the LCD-TV product case result a much higher impact. Due to the fact that electronic components can only be chosen by groups and not specified in more detail, the results of the considered TVs also depend on the choice of the dataset in the VHK spreadsheet. To give an example, according to the VHK unit indicators (spreadsheet “raw”) the category “48-SMD” has a seven times higher environmental impact as the category “44-Big caps & coils”. It is therefore necessary to check all input data regarding their allocation to the VHK unit indicators.

Regarding the display the 42” PDP-TV base case features in the display module high amount of non-ferro metals (26-Al sheet) for the frame, a considerably higher amount of populated PWB with SMD components, particularly more simple 1/2 layer for power electronics (49-PWB) but also higher integrated boards (50-PWB) with SMD components. These materials mainly contribute to the environmental impact calculated by applying the VHK EcoReport. But, as indicated before, the VHK EcoReport assessments regarding the manufacturing of the display (panel) modules are in both cases not fully sufficient. In Figure 9 we have therefore added again the energy consumption related to the PDP production based on a calculated average of the received manufacturing data from industry for an assumed 2nd and 3rd production generation (see chapter 5.2.2.1). We assume furthermore that the panel manufacturing of the LCD also demands more energy as it was discussed already in chapter 5.2.1.2.

In order to give a rough estimate regarding the magnitude of this impact we again draw you attention to the environmental product declaration (EPD) of LG Philips for a 42” LCD-TV display module (see Table 6). According to the EPD of LG Philips the global warming potential of a 42” LCD module was calculated to be 392 kg/CO_2 equivalent. This value is comparatively higher than calculated with VHK EcoReport. In order to make both results more comparable we follow the same procedure as in chapter 5.2.1.2. Applying the VHK unit indicators (spreadsheet “raw”) to the material input data of the EPD (without packaging material and glass) results in an extra 62 kg/CO_2 equivalent for the cradle-to-gate assessment of the (in the VHK EcoReport data set) missing up-stream impacts of the metals, plastics and electronics which goes into the panel manufacturing fab. The respective input categories are shown in Table 11.

By adding these 62 kg/CO_2 equivalent to the original VHK result (42-LCD) of 89 kg/CO_2 equivalent a total of 151 kg/CO2 equivalent is calculated. Finally a comparison with the EPD result of 392 kg/CO_2 equivalent has to consider the impact of the packaging material. It is assumed that

12 kg/CO_2 equivalent is subtracted resulting in 380 kg/CO_2 equivalent as a reference value for a cradle-to-gate global warming potential of a 42” LCD-TV panel production. The difference between the calculated VHK assessment (including the raw materials) and the EPD of LG Philips results in a factor 2.5 which could be added also in terms of total power consumption to the production phase of the 32” LCD-TV display module. The comparison with the EPD is intended to illustrate the necessity of further assessments of LCD display module manufacturing.

Table 11: Material Composition of 42” LCD-TV Display Modules (VHK input table adaptation)

Content	**EPD Material Input**		**VHK Material Input (Adaptation)**		
Metals	43.37%	6 896 g			
Steel	42.96%	6 831 g	6 831 g	3-Ferro	21-St sheet gal.
Copper	0.42%	67 g	67 g	4-Non-ferro	29-Cu wire
Plastics	34.19%	5 436 g			
EPS	13.19%	2 097 g	2 097 g	1-BlkPlastics	6-EPS
PMMA	7.09%	1 127 g	1 127 g	2-TecPlastics	13-PMMA
PET	6.89%	1 096 g	Part of packaging		
PC	6.12%	973 g	973 g	2-TecPlastics	12-PC
PE	0.85%	135 g	Part of packaging		
Others	0.05%	8 g	Part of packaging		
Glass	14.91%	2 371 g			
Paper	6.58%	1 046 g	Part of packaging		
Electronics	0.94%	149 g	149 g	6-Electronics	98-Controller

5.2.3. Case Study CRT

Table 12 (VHK EcoReport result table) and Figure 11 (total energy consumption related to life cycle phases) present the environmental impact assessment results for the 29" CRT-TV reference case. If we take total energy consumption (GER) as a reference the results indicate that the use phase contributes with 22264 MJ most significantly to the overall environmental impact followed by the production phase with 3516 MJ. All other life cycle phase have only minor impact.

Table 12: Environmental assessment results form VHK EcoReport for 29" CRT-TV reference case

Version 5 VHK for European Commission 28 Nov. 2005 Document subject to a legal notice (see below))

ECO-DESIGN OF ENERGY-USING PRODUCTS

EuP EcoReport: RESULTS
Assessment of Environmental Impact

Table . Life Cycle Impact (per unit) of Primary case 29" CRT TV

Nr	Life cycle Impact per product:	Date	Author
0	Primary case 29" CRT TV	0	

	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	Total	BUTION		Disposal	Recycl.	Total	
	Materials	**unit**									
1	Bulk Plastics	g			**5653**			5088	565	**5653**	**0**
2	TecPlastics	g			**97**			87	10	**97**	**0**
3	Ferro	g			**4232**			212	4020	**4232**	**0**
4	Non-ferro	g			**2127**			106	2021	**2127**	**0**
5	Coating	g			**0**			0	0	**0**	**0**
6	Electronics	g			**2872**			1577	1295	**2872**	**0**
7	Misc.	g			**30558**			1528	29030	**30558**	**0**
	Total weight	g			**45539**			8598	36942	**45539**	**0**
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	MJ	2867	649	**3516**	**391**	**22264**	595	532	**63**	**26234**
9	of which, electricity (in primary MJ)	MJ	714	196	**910**	**1**	**22238**	0	152	**-152**	**22996**
10	Water (process)	ltr	411	33	**444**	**0**	**1486**	0	137	**-137**	**1793**
11	Water (cooling)	ltr	1153	179	1332	0	59289	0	39	-39	60582
12	Waste, non-haz./ landfill	g	48611	1428	**50039**	**215**	**26273**	2793	444	**2350**	**78876**
13	Waste, hazardous/ incinerated	g	808	11	**819**	**4**	**520**	6470	170	**6300**	**7644**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	kg CO2 eq.	146	40	**186**	**25**	**972**	44	36	**8**	**1190**
15	Ozone Depletion, emissions	mg R-11 eq				negligible					
16	Acidification, emissions	g SO2 eq.	1427	203	**1630**	**74**	**5740**	89	143	**-54**	**7389**
17	Volatile Organic Compounds (VOC)	g	211	8	**219**	**5**	**11**	2	2	**0**	**235**
18	Persistent Organic Pollutants (POP)	ng i-Teq	136	12	**149**	**1**	**147**	19	2	**18**	**315**
19	Heavy Metals	mg Ni eq.	424	31	**455**	**11**	**386**	163	19	**144**	**995**
	PAHs	mg Ni eq.	1073	7	**1079**	**14**	**55**	0	16	**-16**	**1132**
20	Particulate Matter (PM, dust)	g	848	51	**899**	**855**	**131**	768	7	**762**	**2647**
	Emissions (Water)										
21	Heavy Metals	mg Hg/20	240	1	**241**	**0**	**146**	50	86	**-37**	**351**
22	Eutrophication	g PO4	7	2	**9**	**0**	**1**	3	1	**2**	**12**
23	Persistent Organic Pollutants (POP)	ng i-Teq				negligible					

***=Note: Recycling credits only relate to recycling of plastics and electronics (excl. LCD/CRT). Recycling credits for metals and other fractions are already taken into account in the production phase.**

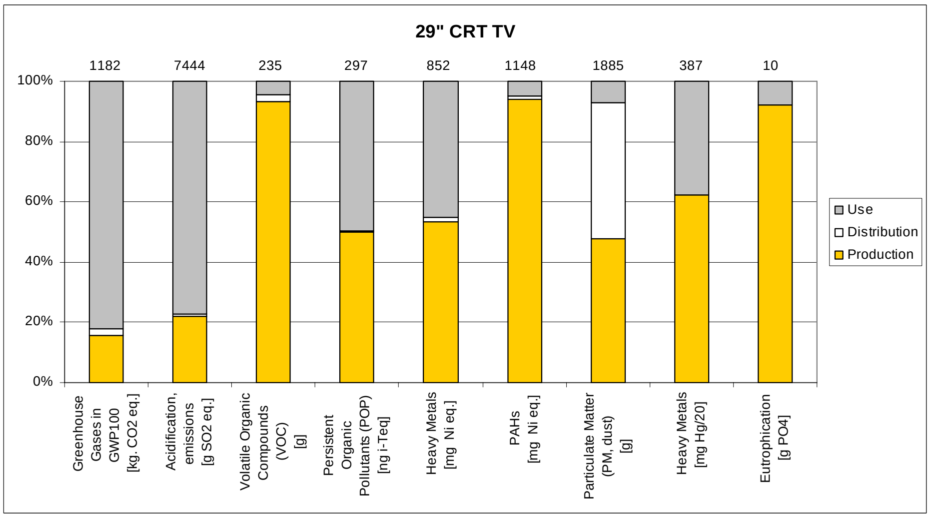


Figure 10: 29" CRT-TV base case assessment by environmental impact categories for life cycle phases

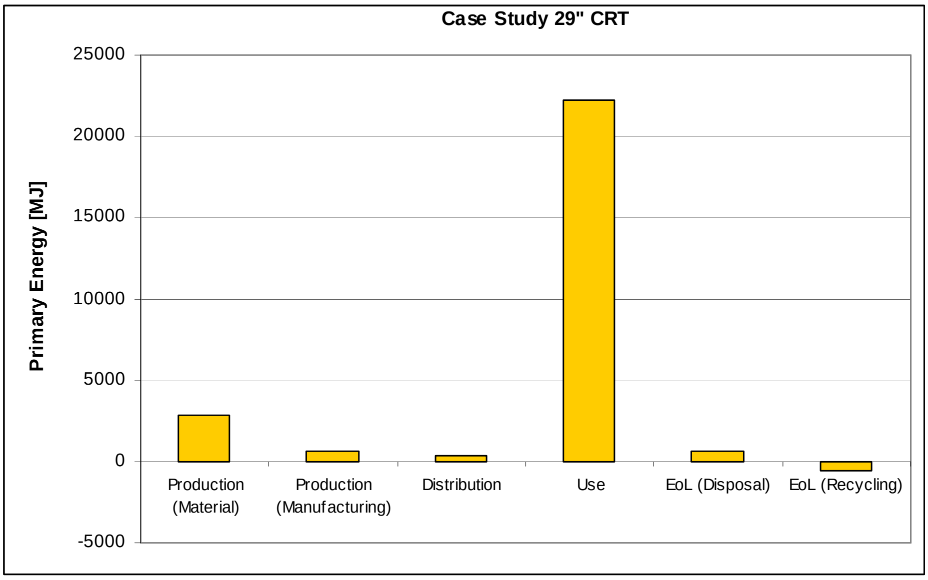


Figure 11: Total energy consumption of 29" CRT-TV reference case over all life cycle phases

The greenhouse gas emission value correlates directly with the total energy value. The production phase has an impact of 186 kg/CO_2 and the use phase 972 kg/CO_2 equivalent. It is noticeable that the toxicity of the CRT-TV measured by Heavy Metals and PAH is considerably higher even in comparison to the larger screen size LCD-TV. This is related to the lead content in the CRT glass.

5.2.3.1. Raw Material and Manufacturing (Production Phase)

Figure 12 shows at the example of total energy consumption that the most significant modules concerning the production phase of the CRT-TV are the display module, the chassis and the electronic boards. For further details we have added Table 13 which provides material related environmental impacts by categories and module. Especially for the display module (33kg) and the chassis module (5kg) the high primary energy consumption is due to their high mass proportions related to the total product mass. Furthermore the CRT manufacturing process for the display is included in the CRT of the VHK spreadsheet. The high primary energy consumption for the electronic board module (PWB) results from the high amount of populated PWB with power electronics (44-big caps & coils), aluminum heat sinks (26-Al sheet), and other advanced electronic components.

Table 13: Material related environmental impacts by categories (29” CRT-TV)

Version 5 VHK for European Commission 28 Nov. 2005 — Document subject to a legal notice (see below)

ECO-DESIGN OF ENERGY-USING PRODUCTS — EuP EcoReport: RAW OUTPUTS — Assessment of Environmental Impact

Nr: 0 **Product Primary case 29" CRT TV** **Date:** **Author:**

MATERIALS EXTRACTION & PRODUCTION

	Product			Energy			Water		Waste		Emissions to Air							to Water	
nr	component	wght	material	GER	electr	feedst	water (proces)	water (cool)	haz. Waste	non-haz.	GWP	AD	VOC	POP	HM	PAH	PM	Metal	EUP
		in g		MJ	MJ	MJ	ltr.	ltr.	g	g	kg CO2eq	g SO2eq	mg	ng i-Teq	mg Ni eq	mg Ni eq	g	mg Hg/20eq	mg PO4 eq
1	CHASSIS	0	0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
2	Housing	4600	5-PS	398,96	16,65	218,64	22,54	814,20	3,16	100,45	12,84	79,23	0,00	0,00	0,00	555,88	6,90	0,00	255,27
3	SCREWS	60	22-St tube/profile	1,02	0,27	-0,01	0,00	0,00	0,00	48,04	0,08	0,22	0,01	0,72	0,16	0,00	0,06	0,09	2,30
4	Antenna connector	7	31-CuZn38 cast	0,27	0,00	0,00	0,00	0,00	0,00	21,30	0,01	0,25	0,00	0,18	0,40	0,02	0,01	0,06	0,11
5	Speakers	673	44-big caps & coils	257,95	0,00	0,00	23,32	37,02	13,19	404,16	14,58	95,44	0,08	1,46	5,16	137,73	23,97	49,95	4,80
6	0	0	0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
7	DISPLAY	0	0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
8	CRT panel (Aspect ratio) 4:3	260,43	43-CRT per m2 scrn	825,30	554,98	0,00	75,58	0,00	12,76	642,74	44,53	280,48	208,60	3,65	242,98	0,00	735,19	3,65	163,99
9	CRT panel glass (mass dummy)	27100	0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
10	Rubber Part	21	16-Flex PUR	2,19	0,39	0,84	1,47	6,26	0,68	11,52	0,09	0,67	0,00	0,00	0,00	0,42	0,17	0,07	119,40
11	resin	35	1-LDPE	2,72	0,47	1,80	0,11	1,58	0,16	1,55	0,07	0,26	0,02	0,00	0,00	0,00	0,03	0,00	0,93
12	plastic parts	162	5-PS	14,05	0,59	7,70	0,79	28,67	0,11	3,54	0,45	2,79	0,00	0,00	0,00	19,58	0,24	0,00	8,99
13	cable	140	8-PVC	7,93	1,56	3,21	1,54	8,68	0,70	9,39	0,30	2,10	0,00	0,00	0,00	0,00	0,41	0,39	43,96
14	tubes	13	8-PVC	0,74	0,14	0,30	0,14	0,81	0,07	0,87	0,03	0,19	0,00	0,00	0,00	0,00	0,04	0,04	4,08
15	plastic parts	50	11-PA 6	5,98	0,76	1,95	0,80	10,95	0,95	8,81	0,43	1,95	0,00	0,00	0,00	0,02	0,27	2,45	93,61
16	Steel parts	3471	21-St sheet galv.	118,01	7,91	0,26	0,00	0,00	0,00	5975,40	9,81	25,91	0,47	90,25	12,30	0,24	9,40	12,32	226,20
17	ferrite cores	575	24-Ferrite	29,09	1,97	0,06	22,62	0,00	0,00	1484,81	2,44	6,41	0,12	22,43	20,66	0,00	2,34	1,36	45,21
18	copper coil	485	28-Cu winding wire	69,22	0,00	0,00	0,00	0,00	0,39	9719,40	3,57	147,36	0,01	1,93	27,41	2,68	1,47	3,14	76,73
19	cable	1260	28-Cu winding wire	179,83	0,00	0,00	0,00	0,00	1,01	25250,40	9,28	382,83	0,04	5,00	71,21	6,97	3,81	8,15	199,33
20	Coils	93	44-big caps & coils	35,65	0,00	0,00	3,22	5,12	1,82	55,85	2,02	13,19	0,01	0,20	0,71	19,03	3,31	6,90	0,66
21	connector	3	45-slots / ext. ports	0,56	0,18	0,00	0,22	0,77	0,05	0,92	0,03	0,55	0,00	0,00	0,11	0,01	0,04	0,10	19,41
22	PWB (minor devices, with solder)	28	49-PWB 1/2 lay 3.75kg/m2	7,87	4,21	0,24	4,76	2,15	48,53	73,51	0,31	5,99	0,07	0,08	1,01	0,10	0,14	0,41	103,22
23	0	0	0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
24	0	0	0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
25	POWER SUPPLY UNIT	0	0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
26	Electronic board	370	44-big caps & coils	141,82	0,00	0,00	12,82	20,35	7,25	222,20	8,02	52,47	0,05	0,80	2,83	75,72	13,18	27,46	2,64
27	Electronic board	2	45-slots / ext. ports	0,37	0,12	0,00	0,15	0,51	0,03	0,62	0,02	0,37	0,00	0,00	0,08	0,00	0,03	0,06	12,94
28	Electronic board	38	49-PWB 1/2 lay 3.75kg/m2	10,68	5,72	0,32	6,46	2,92	65,86	99,76	0,43	8,12	0,09	0,10	1,37	0,14	0,19	0,56	140,08
29	Electronic board	2,7	52-Solder SnAg4Cu0.5	0,63	0,52	0,00	0,19	0,00	0,01	0,62	0,03	0,17	0,00	0,00	0,01	0,01	0,00	0,00	0,02
30	0	0	0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
31	REMOTE	0	0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
32	Housing	69	5-PS	5,98	0,25	3,28	0,34	12,21	0,05	1,51	0,19	1,19	0,00	0,00	0,00	8,34	0,10	0,00	3,83
33	Plastic part	3	10-ABS	0,29	0,02	0,14	0,03	0,50	0,03	0,28	0,01	0,05	0,00	0,00	0,00	0,01	0,01	0,01	1,89
34	Screws	2	22-St tube/profile	0,03	0,01	0,00	0,00	0,00	0,00	1,60	0,00	0,01	0,00	0,02	0,01	0,00	0,00	0,00	0,08
35	Electronic board	0,2	48-SMD/ LED's avg.	0,59	0,58	0,00	0,19	0,00	0,03	0,57	0,03	0,32	0,00	0,00	0,08	0,00	0,01	0,00	0,44
36	Electronic board	14	49-PWB 1/2 lay 3.75kg/m2	3,93	2,11	0,12	2,38	1,08	24,27	36,75	0,16	2,99	0,03	0,04	0,51	0,05	0,07	0,21	51,61
37	Electronic board	0,2	52-Solder SnAg4Cu0.5	0,05	0,04	0,00	0,01	0,00	0,00	0,05	0,00	0,01	0,00	0,00	0,00	0,00	0,00	0,00	0,00
38	switch rubber sheet (material: silicone rubber)	17	16-Flex PUR	1,78	0,32	0,68	1,19	5,07	0,55	9,33	0,08	0,55	0,00	0,00	0,00	0,34	0,14	0,06	96,65
39	batteries (alcaline)	36	44-big caps & coils	13,80	0,00	0,00	1,25	1,98	0,71	21,62	0,78	5,11	0,00	0,08	0,28	7,37	1,28	2,67	0,26
40	0	0	0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
41	0	0	0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
42	ELECTRONIC BOARD	0	0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
43	Plastic part	2	5-PS	0,17	0,01	0,10	0,01	0,35	0,00	0,04	0,01	0,03	0,00	0,00	0,00	0,24	0,00	0,00	0,11
44	Frame	56	21-St sheet galv.	1,90	0,13	0,00	0,00	0,00	0,00	96,41	0,16	0,42	0,01	1,46	0,20	0,00	0,15	0,20	3,65
45	Screws	4	22-St tube/profile	0,07	0,02	0,00	0,00	0,00	0,00	3,20	0,01	0,01	0,00	0,05	0,01	0,00	0,00	0,01	0,15
46	Ferrite core	6	24-Ferrite	0,30	0,02	0,00	0,24	0,00	0,00	15,49	0,03	0,07	0,00	0,23	0,22	0,00	0,02	0,01	0,47
47	Heat sink	321	26-Al sheet/extrusion	61,83	0,00	0,00	0,00	0,00	0,00	1258,32	3,32	21,60	0,02	1,60	1,17	30,99	5,43	11,24	1,59
48	Elecronic board	864	44-big caps & coils	331,16	0,00	0,00	29,94	47,52	16,94	518,86	18,72	122,53	0,11	1,87	6,62	176,82	30,77	64,13	6,17
49	Elecronic board	87	45-slots / ext. ports	16,27	5,16	0,00	6,50	22,22	1,49	26,77	0,87	16,04	0,00	0,12	3,31	0,17	1,13	2,77	562,87
50	Elecronic board	5	46-IC's avg., 5% Si, Au	27,55	26,79	0,00	25,09	0,00	1,26	25,91	2,12	13,94	0,34	0,24	2,23	0,07	0,36	18,70	107,41
51	Elecronic board	10	47-IC's avg., 1% Si	8,74	6,73	0,03	6,11	1,04	6,45	17,48	0,59	8,16	0,00	0,10	1,85	0,03	0,24	0,10	42,96
52	Elecronic board	262	49-PWB 1/2 lay 3.75kg/m2	73,64	39,44	2,23	44,55	20,12	454,11	687,84	2,94	56,01	0,61	0,71	9,47	0,94	1,33	3,86	965,85
53	Elecronic board	72	50-PWB 6 lay 4.5 kg/m2	26,44	10,52	0,61	34,92	5,53	136,21	293,28	1,13	28,51	0,07	0,37	5,04	0,50	2,67	9,03	175,88
54	Elecronic board	22,8	52-Solder SnAg4Cu0.5	5,33	4,42	0,00	1,60	0,00	0,10	5,20	0,26	1,47	0,00	0,03	0,08	0,04	0,03	0,00	0,14
55	Electronic board	11	98-controller board	8,60	6,37	0,03	5,76	1,16	7,18	18,48	0,57	4,81	0,07	0,07	0,81	0,66	0,25	3,67	51,72
56	0	0	0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
57	PACKAGING	0	0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
58	Plastic bag	116	1-LDPE	9,02	1,54	5,98	0,35	5,22	0,52	5,13	0,22	0,86	0,06	0,00	0,00	0,02	0,11	0,00	3,09
59	Cushion	447	6-EPS	37,40	1,51	21,37	2,55	78,67	0,42	16,92	1,21	8,11	0,00	0,00	0,00	27,20	0,80	0,00	55,71
60	Cardboard	2847	56-Cardboard	79,72	5,69	45,55	20,06	0,00	0,13	148,95	2,00	2,96	0,00	0,04	0,10	0,01	0,03	0,04	245,02
61	Manual	611	57-Office paper	24,44	3,66	16,50	46,52	0,00	0,21	41,27	0,34	3,07	0,12	0,03	0,07	0,01	1,01	0,03	3231,20
62	0	0	0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
63	OTHERS	0	0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
64	Cable	53	8-PVC	3,00	0,59	1,22	0,58	3,29	0,27	3,56	0,11	0,79	0,00	0,00	0,00	0,00	0,15	0,15	16,64
65	Plastic part	13	8-PVC	0,74	0,14	0,30	0,14	0,81	0,07	0,87	0,03	0,19	0,00	0,00	0,00	0,00	0,04	0,04	4,08
66	Plastic part	9	11-PA 6	1,08	0,14	0,35	0,14	1,97	0,17	1,59	0,08	0,35	0,00	0,00	0,00	0,00	0,05	0,44	16,85
67	Antenna plug	1	21-St sheet galv.	0,03	0,00	0,00	0,00	0,00	0,00	1,72	0,00	0,01	0,00	0,03	0,00	0,00	0,00	0,00	0,07
68	Ferrite core	57	24-Ferrite	2,88	0,19	0,01	2,24	0,00	0,00	147,19	0,24	0,64	0,01	2,22	2,05	0,00	0,23	0,13	4,48
69	Cable	53	29-Cu wire	6,18	0,00	0,00	0,00	0,00	0,01	1060,64	0,33	15,48	0,00	0,20	2,92	0,29	0,15	4,99	8,19
70	Antenna plug	1	31-CuZn38 cast	0,04	0,00	0,00	0,00	0,00	0,00	3,04	0,00	0,04	0,00	0,03	0,06	0,00	0,00	0,01	0,02
71	Connectors	17	45-slots / ext. ports	3,18	1,01	0,00	1,27	4,34	0,29	5,23	0,17	3,13	0,00	0,02	0,65	0,03	0,22	0,54	109,99
72	Solder	1	52-Solder SnAg4Cu0.5	0,23	0,19	0,00	0,07	0,00	0,00	0,23	0,01	0,06	0,00	0,00	0,00	0,00	0,00	0,00	0,01
73	0	0	0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
74	0	0	0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
75	0	0	0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
76	0	0	0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
77	0	0	0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
78	0	0	0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
79	0	0	0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	TOTAL	0	0	2867,23	714,04	333,80	410,78	1153,03	808,17	48611,16	146,11	1426,50	211,04	136,35	424,12	1072,68	848,01	240,20	7292,95
			80%	2293,78	571,23	267,04	328,62	922,43	646,54	38888,93	116,89	1141,20	168,83	109,08	339,30	858,15	678,41	192,16	5834,36

Colour coding

Components causing more than 50% of total impact in the respective category: (red)

Components causing between 15% and 50% of total impact in the respective category: (orange)

Components added to receive a sum of all colour coded processes (red, orange, yellow) that is about 80%: (yellow)

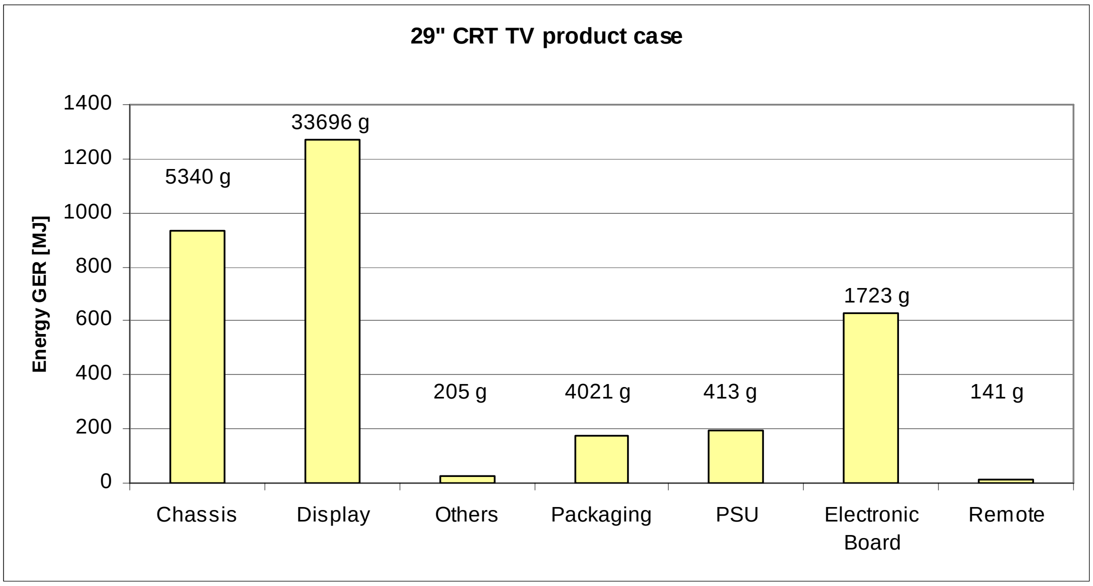


Figure 12: Total energy consumption related to the production phase of the 29" CRT-TV

Regarding the display the comparison is difficult due to the indicated problems related to the impact assessment of the LCD and PDP display panels. But still, the display manufacturing has the most significant environmental impact for the CRT-TV. The direct comparison (see results in previous chapters) also shows the difficulties related to the assessment of electronic boards and the power supply unit. The allocation of electronic components to the VHK unit indicators (spreadsheet input) might contribute to the large differences in the assessment results of the boards. In conclusion the production phase impact assessment shows that not only the mass of materials, but also the manufacturing processes particularly of the display module have a considerable environmental impact and should more thoroughly assessed in the future.

5.2.3.2. Distribution, Use and End-of-life Phase

Regarding the results from the VHK spreadsheet the distribution phase for the 29" CRT-TV reference case is negligible, although packaging materials (mass) contributes considerably more in comparison to the flat panel display TVs. As discussed for both base cases the electricity consumption in the use phase is the most significant life cycle stage regarding total energy consumption and will be analyzed separately in Task 5.4. The end-of-life phase does not show a significant impact based on the VHK EcoReport results.

According to an older study on CRT recycling in German [Behrendt et al, 2002][5] have been the capacities for industrial-scale recycling of lead containing CRT glass not sufficient. This situation might have improved regionally over the past years, but it is likely that this issue still remains in the European Union. The separation and melting of CRT funnel glass and panel glass would be the best environmental option due to the potential of high-level replacement of primary resources. Such recycling scheme requires however the disassembly and separation of the CRT funnel glass in a well defined quality. This recycling scheme is labor intensive, which partly hinders recycling in high wage countries. A further problem for high-level CRT glass recycling is the inadequate recirculation of separated funnel and panel glass of high quality as these recycling technologies compete with low cost land-filling. The shift of CRT manufacturing to China and Japan also results in uncertainties concerning future processing capacity of the CRT industry in the European Union. The study concludes that a shipping of CRT waste for a high-level CRT glass recycling to East Asia is not desirable from an environmental point of view. The transportation efforts outweigh the environmental recycling benefits. The labor intensity of recycling processes is partly overcome by automation of processes. As an example the study mentions the company VICOR, which developed an implosion tape dismantling and picture tube separation units for advanced CRT recycling. Other CRT glass recycling options are lead and secondary copper smelters, which have the slight disadvantage of slagging and only partial recovery of lead. The use of CRT glass for fiberglass (mineral wool) production depends on the feasibility of costs and the actual replacement of primary resource. The recycling of CRT panel and partially funnel glass with application in the ceramics industry (e.g. for replacement of feldspar) and construction industry (e.g. for bricks) is known, but not uncritical due to leaching possibility of lead, barium, antimony. The most common and currently most cost efficient end-of-life option for cleaned CRT panel glass is mine-filling.

5.2.4. Conclusion

The environmental impact assessment for the 32” LCD-TV and 42” PDP-TV base cases as well as the 29” CRT reference case shows that the use phase is environmentally the most significant life cycle stage. Despite the environmentally most relevant aspect of power consumption in the use phase (see assessment in Task 5.4) the production phase is important too. Whereas we could show that the display production has potential for improvement it is also noticeable that electronic components and boards have a growing impact. VHK EcoReport poses difficulties regarding an exact assessment of electronics. The VHK unit indicators reflect to some extent this complex

[5] Behrendt, S.; Erdmann, L.; Würtenberger, F.: Fokusthema Displays, Trendanalyse und Szenarien zur Entwicklung einer Roadmap im Rahmen des Projektes „Nachhaltigkeit in der Informations- und Kommunikationstechnik“ (NIK), Berlin, 2002.

situation. However, particularly for electronic components (substrate materials and PWB structure, active and passive electronic devices, etc.) the VHK unit indicators are a little bit to rough, which causes allocation problems and results in over or under estimations of impacts. The assessment of the power supply units (PSU) and printed wiring boards (PWB) are therefore very difficult to interpret. Despite these short comings, it becomes clear that the environmental impacts form materials and manufacturing of the electronic components are significant and should be reduced. The environmental assessment of the LCD and PDP display panel manufacturing caused a particular challenge. The missing VHK unit indicator for PDP made it necessary to obtain a VHK comparable impact assessment form PDP manufacturers. The received data sets on total energy consumption (GER) showed initially very large discrepancies. However, after a review together with PDP manufacturers reasons for these discrepancies were detected. It was agreed to use an average second generation factor of approximately 3600 MJ total energy per square-meter panel. A positive effect of this time consuming data collection for PDP manufacturing was the critical approach to the VHK unit indicator for LCD panel manufacturing. In this case we assume an underestimation in the environmental impacts resulting form average LCD panel manufacturing materials and processes. This assumption was confirmed in interviews with industry. In order to illustrate this aspect we compared the year 2005 environmental product declaration (EPD) of LG Philips for different LCD-TV display modules with the results of VHK EcoReport. The EPD assessment indicated a factor 2.5 to 3.5 higher environmental impact in terms of global warming potential compared to the VHK EcoReport results. A generalization of these results is not suggested, rather a critical recheck and reassessment of the existing LCD panel manufacturing situation. Despite this critical view on the VHK unit indicator for LCD we recognize the ongoing technical and environmental improvement in LCD panel manufacturing[6].

Final remark; the analysis of improvement potential should primarily focus on technologies and technical measures that reduce the power consumption of the TV in the use phase. The second focus should be placed on applied materials and electronic components in the TV design, particularly the reduction of weight and the support of efficient recycling. In that respect should the analysis of BAT also focus on toxic or otherwise harmful materials in the design and manufacturing of TVs. Finally, it seems in the interest of every manufacturer to reduce the energy and resource consumption related to the production phase.

[6] Take the example of the Ishikawa Plant from Toshiba Matsushita Display Technology Co. (TMD). This production line for low-temperature poly-silicon (LTPS) TFT LCD panels (not for TVs) started operations in April 2006 with a monthly production capacity of 5.5 million LCD panels (in terms of 2.2-inch panels as of April 2007). Compared with conventional manufacturing lines, the new line is expected to achieve a 53 % reduction in greenhouse gas emissions. According to preliminary calculations, the new line incorporating all these innovations will reduce greenhouse gas emissions to 28,258 tons of CO2 equivalent annually, while a comparable conventional line would emit 60,082 tons annually. (Source: Japan for Sustainability Newsletter #054, in the internet: http://www.japanfs.org/en/newsletter/index.html)

5.3. Base-Case Life Cycle Costs

5.3.1. Input Data for LCC Analysis

The year 2005 total EU-25 life cycle cost calculation (LCC) for the TV base-cases requires following data input:

- EU-25 market (stock) data for the household penetration of TVs year 2005 (in 1000 units)
- EU-25 annual sales for TVs year 2005 by market segment (in 1000 units)
- Average sales price for typical technology/screen size segments (in Euro)
- Average repair and maintenance costs (in Euro)
- Average electricity rates (Euro Cent/kWh)
- Average lifetime of a product (in years)
- Average annual power consumption including on-mode, standby and off-mode (in kWh)

In the subsequent paragraph we will explain the selection and aggregation of input data for the life cycle cost calculation of the 32" LCD-TV and 42" PDP-TV base-case and a 29" CRT-TV and 50" RP-TV reference case.

5.3.1.1. Market Data Aggregation

Due to the requirement of calculating the LCC for the year 2005 the EU-25 stock for TVs were calculated based on the 2003 stock data (cp. Task 2.2.2). The following Table 14 provides year 2005 stock data for CRT, LCD, PDP and RP televisions in three aggregated screen size segments namely small (14"-26"), medium (27"-39"), and large (40"-65"). For the purpose of comparison (trend description) we also list the relevant stock estimates for the year 2010 in the table.

Table 14: TV Stock in EU-25 Households for years 2005 and 2010 (in 1000 Units)

	Small (14"-26")		**Medium (27"-39")**		**Large (40"-65")**	
	2005	**2010**	**2005**	**2010**	**2005**	**2010**
CRT*	208.139	176.049	53.201	75.450	-	-
LCD**	7.158	40.982	3.230	53.702	145	17.910
PDP**	-	-	374	646	2.503	24.614
RP**	-	-	-	-	1.172	2.159

* The 2005 stock is calculated based on the 2003 stock data plus the year 2004 and 2005 sales (Task 2 report) minus the annual 10% of resulting stock.

** The 2005 stock is calculated based on the 2003 stock plus the year 2004 and 2005 sales.

Table 15: TV Sales in EU-25 market for years 2005 and 2010 (in 1000 Units)

	Small (14"-26")		Medium (27"-39")		Large (40"-65")	
	2005	2010	2005	2010	2005	2010
CRT	14.648	2.944	7.888	1.963	-	-
LCD	4.339	5.695	2.748	13.721	145	6.472
PDP	-	-	179	-	1.617	5.518
RP	-	-	-	-	237	215

Table 15 provides TV sales data for 2005 and 2010 in the same structure as in the Table 14 above. There are some problems regarding the allocation of the market data (stock and sales) to the LCC assessment. The base cases 32" LCD-TV and 42" PDP-TV, as well as the reference product cases 29" CRT-TV and 50" RP-TV are very specific in scope. Unfortunately, we could not obtain precise market data for these particular product segments. Therefore we will allocate the existing market data (stock and sales) by taking 70% of the respective screen size market segment for the 32" LCD-TV (medium LCD) and 42" PDP-TV (large PDP) into account. As for the 29" CRT-TV reference product case we assume a 50% market penetration of the medium screen size CRT market segment. For the 50" RP-TV reference case we assume a 70% market penetration of the total RP-TV market. The following Table 16 shows the respective market data for the base cases life cycle cost analysis.

Table 16: Stock and sales data for base cases/reference product cases LCC assessment (in 1000 Units)

	Stock Data		Sales Data	
	2005	2010	2005	2010
32" LCD-TV	2.261	37.591	1.923	9.605
42" PDP-TV	1.752	17.230	1.132	3.862
29" CRT-TV	26.600	37.725	3.944	982
50" RP-TV	820	1.511	166	150

5.3.1.2. Costs/Price Data Aggregation

The average sales price for TVs of different technology and screen size segments in 2005 derives form the price statistics in Task 2.4.2. The 2010 sales price is calculated based on a 50% price reduction ratio compared to 2005 figures.

Table 17: TV Sales Price in EU-25 market for years 2005 and 2010 (in Euro)

	Small (14"-26")		Medium (27"-39")		Large (40"-65")	
	2005	2010	2005	2010	2005	2010
CRT*	200	100	650	325	-	-
LCD	620	310	1.600	800	2.800	1.400
PDP	-	-	2.500	1.250	3.500	1.750
RP	-	-	-	-	1.850	925

* For the 29" CRT-TV product case we assume a sales price of 500 Euro in 2005 and 250 Euro in 2010 respectively.

Data for **repair costs** and the amount of TVs that get repaired annually could not be obtained. As indicated in Task 3 it seems plausible that due to the lower sales price of new TVs and potentially increasing standard repair costs less CRT-TV get repaired. What number of CRT-TVs gets still repaired is not known. Furthermore, due to the novelty of LCD-TV and PDP-TV we can only assume that repair workshops do not yet repair such devices or that these products still fall under warranty terms. The same assumption applies to RP-TV. A possible exchange of the lamp system - known for some RP-TV - might be a significant cost factor. The price for the exchange lamps varies[7]. Against that background we will not include repair costs into the LCC analysis.

5.3.1.3. Power Consumption Data and Electricity Rates

A ten year primary use is assumed for the product life cycle input. The power consumption values are taken from the use phase input data of Task 4.3, see Table 18. We calculate the electricity costs based on 0,14 Euro per kWh.

Table 18: Power consumption data for primary product cases

	32" LCD-TV	42" PDP-TV	29" CRT-TV	50” RP-TV
Power consumption [kW]				
On-mode	0,15	0,33	0,13	0,19
Off-mode	0	0	0	0
Standby-mode	0,002	0,003	0,003	0,002
Working hours per year [h]				
On-mode (4 h per day)	4	4	4	4
Off-mode	0	0	0	0
Standby-mode (20 h per day)	20	20	20	20
Annual power consumption (MWh)	**0,23**	**0,50**	**0,21**	**0.29**

[7] In online discount stores (e.g. laptop for less) RP-TV lamps costs between 150 and 210 US Dollar. http://www.laptopsforless.com/projector-lamps/rptvlamps.html (download 01/2007)

5.3.2. LCC Analysis

The results of the life cycle cost analysis for the 32”LCD-TV and 42”PDP-TV base cases as well as the 29”CRT-TV and 50” RP-TV reference product case is shown in the following tables. In order to indicate the ongoing shift in market towards flat panel display TVs we have calculated the LCC for the reference year 2005.

5.3.2.1. LCC Analysis for 32” LCD-TV Base Case

Table 19 shows the results of the VHK EcoReport LCC assessment for the 32” LCD-TV base case. The sales price is dominating the overall life cycle costs. In 2005 the use costs (297 € electricity costs for ten years primary use) are 15.6% of the total LCC. The assumed reduction of sales price for the reference year 2010 will result in an increase of use phase costs. In terms of total annual consumer expenditure the 32” LCD-TV could be expected to be the most significant market segment in 2010.

Table 19: Life cycle costs – 32“LCD-TV product case 2005

	Products *Item*	LCC new product		total annual consumer expenditure in EU25	
D	Product price	1600	€	3077	mln.€
E	Installation/ acquisition costs (if any)	0	€	0	mln.€
F	Fuel (gas, oil, wood)	0	€	0	mln.€
F	Electricity	297	€	74	mln.€
G	Water	0	€	0	mln.€
H	Aux. 1: None	0	€	0	mln.€
I	Aux. 2 :None	0	€	0	mln.€
J	Aux. 3: None	0	€	0	mln.€
K	Repair & maintenance costs	0	€	0	mln.€
	Total	**1897**	€	**3151**	mln.€

5.3.2.2. LCC Analysis for 42” PDP-TV Base Case

Table 20 shows the results of the VHK EcoReport LCC assessment of the 42” PDP-TV base case. Like in the 32” LCD-TV base case the sales price is dominating the overall life cycle costs of the 42” PDP-TV. In total, the LCC for a single 42” PDP-TV is twice as high in comparison to the 32” LCD-TV base case due to the larger screen size. This correlation is also reflected by the use phase costs of 640 Euro. In terms of total annual consumer expenditure the LCC will almost increase in accordance to the market data and double until 2010. The use phase cost ratio will simultaneously increase until 2010 due to the assumed reduction in sales price. The total costs however might shrink even more when power consumption is further reduced in new products.

Table 20: Life cycle costs – 42"PDP-TV product case 2005

	Products *Item*	LCC new product		total annual consumer expenditure in EU25	
D	Product price	3500	€	3962	mln.€
E	Installation/ acquisition costs (if any)	0	€	0	mln.€
F	Fuel (gas, oil, wood)	0	€	0	mln.€
F	Electricity	640	€	124	mln.€
G	Water	0	€	0	mln.€
H	Aux. 1: None	0	€	0	mln.€
I	Aux. 2 :None	0	€	0	mln.€
J	Aux. 3: None	0	€	0	mln.€
K	Repair & maintenance costs	0	€	0	mln.€
	Total	**4140**	€	**4086**	mln.€

5.3.2.3. LCC Analysis for 29" CRT-TV Reference Case

Table 21 shows the results of the VHK EcoReport LCC assessment of the 29" CRT-TV reference case. The CRT-TV reference case shows the lowest LCC is comparison to all products. This is due to the low sales price and power consumption. Total annual consumer expenditure in 2010 will shrink by factor 2 in reference to the year 2005. The power consumption will have a tremendous effect on the overall costs due to the ratio of almost 50% to total LCC.

Table 21: Life cycle costs – 29"CRT-TV product case 2005

	Products *Item*	LCC new product		total annual consumer expenditure in EU25	
D	Product price	500	€	1972	mln.€
E	Installation/ acquisition costs (if any)	0	€	0	mln.€
F	Fuel (gas, oil, wood)	0	€	0	mln.€
F	Electricity	269	€	788	mln.€
G	Water	0	€	0	mln.€
H	Aux. 1: None	0	€	0	mln.€
I	Aux. 2 :None	0	€	0	mln.€
J	Aux. 3: None	0	€	0	mln.€
K	Repair & maintenance costs	0	€	0	mln.€
	Total	**769**	€	**2760**	mln.€

5.3.2.4. LCC Analysis for 50” RP-TV Reference Case

Following Table 22 shows the results of the VHK EcoReport LCC assessment of the 50” RP-TV reference case.

Table 22: Life cycle costs – 50“RP-TV product case 2005

	Products *Item*	LCC new product	total annual consumer expenditure in EU25
D	Product price	1850 €	307 mln.€
E	Installation/ acquisition costs (if any)	0 €	0 mln.€
F	Fuel (gas, oil, wood)	0 €	0 mln.€
F	Electricity	380 €	34 mln.€
G	Water	0 €	0 mln.€
H	Aux. 1: None	0 €	0 mln.€
I	Aux. 2 :None	0 €	0 mln.€
J	Aux. 3: None	0 €	0 mln.€
K	Repair & maintenance costs	182 €	16 mln.€
	Total	**2412** €	**358** mln.€

The 50” RP-TV reference case shows a very good costs-performance ratio due to the comparatively low product price and power consumption. In comparison to the other product cases however we have included a one-time exchange of the lamp system (repair and maintenance costs), which adds to the overall costs. Depending on the improvement of the lamp system and further reduction in power consumption the costs will shrink furthermore. On the other hand it seems that the RP technology becomes more complex, and we have to assume that the sales price will not shrink as drastically as we have assumed for the 2010 LCC input data. Therefore the single product costs might not decrease as much in comparison to LCD-TVs and PDP-TVs.

5.3.3. Conclusion

The life cycle cost analysis indicates the high value of TVs. The sales price is the most significant cost factor. The screen size of the TV indicates the purchasing price and the use phase costs (electricity consumption). With decreasing screen size the ratio of purchasing price and electricity costs changes towards the use phase. Roughly 15 to 40 percent of total LCC derive from power consumption in the use phase based on a ten years primary use scenario. The longer the actual use phase the more important becomes the electricity costs and therefore the power consumption of the TV. The expected decline in the sales prices for new flat panel TVs might not occur as sharply as we have assumed in our 50% scenario (year 2005 in comparison to year 2010). The high purchasing price for medium and large size TVs reflects the complexity and novelty of the display technology. It is an indicator for the environmental impact of the components and production of modern TVs. The aspect of repair costs seems to decline. A possible exchange of the lamp system in RP-TVs should be added to the overall purchasing costs.

5.4. EU Totals

5.4.1. TV on-mode annual power consumption assessment

In order to analyze the magnitude of on-mode and standby power consumption it is necessary to chart power consumption data across all display technologies as well as all screen size segments in the European market. Despite the actual data from the product cases we have compiled additional power consumption data of 272 TVs (182 LCD, 58 PDP, 18 CRT, and 16 RP) from online catalogs, company websites and technical bulletin boards. The products are predominantly HD-Ready in format 16:9 and were placed on the European market in 2006 (see Figure 13). No full HD TV has been considered.

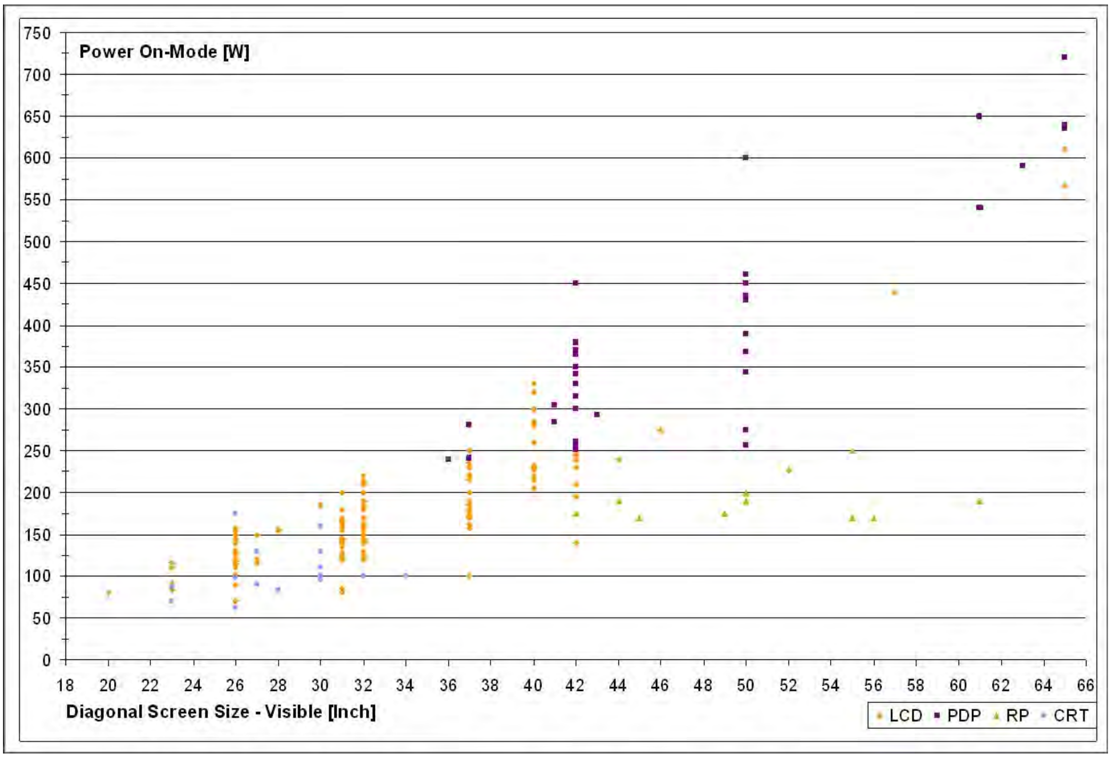


Figure 13: TV on-mode power consumption from 2006 catalogue data

The power consumption data are not transparent in a way that we could not determine what kind of value they represent (e.g. average or rated power consumption) or with which standard they were measured (e.g. old or new IEC 62087). We therefore asked EICTA in January 2007 to provide a similar list based on data from standardized power measurement tests. The data we have received from EICTA members following this request indicate lower power consumption values. To give an example, the on-mode power consumption data for 32”LCD-TV are raging between 112W and

160W which is on average 10-15% lower than in our chart. Regarding the 42”PDP-TV segment the data are ranging between 204W and 300W which is on average 15-20% lower than the values from catalogue sources. The new figures indicate the ongoing improvement regarding power consumption. For the purpose of the following analysis we will resort to the first data set, because they reflect the situation of the reference year 2005 better than the most recent values. However we will take the later one’s for the analysis of the improvement potential into consideration.

The exemplary on-mode data indicate a large range or magnitude of power consumption within the same screen size segment as well as within the same display technology. In some cases the difference between the lowest and highest power consumption value within the same screen size segment is a factor of two. In the smaller segments it seems that CRTs still perform better in terms of on-mode power consumption in comparison to LCDs. However the latest figures show considerable improvement potential for small size LCDs. To give an example; new 26” LCD-TVs consume about 110W on average. In the medium to large segments LCDs have in comparison to PDPs considerable lower power consumption although overlaps occur in the 37” to 43” screen size segments. Power consumption of new 37” PDP-TV is already under 200W and similar improvements (15-20%) are recognizable also in the 42” and 50” PDP segments. RP-TVs show exceptional good energy performance with significantly lower on-mode power consumption in comparison to LCD-TVs and PDP-TVs particular in the very large screen size segments of 50” and above. In the 42”/43” segment however the latest improvements in on-mode power consumption of LCD-TVs and PDP-TVs reach values that are comparable to RP-TVs.

Unfortunately we can not conclude from the data the reasons for the large differences in power consumption in the same screen size and technology segments. As mentioned before the reasons could be related to the particular declaration of power consumption (e.g. average or rated value). It could be also related to the set of product features, quality aspects or the display generation that is utilized. Despite these uncertainties the catalogue data can still illustrate differences between technologies and screen size segments as well as their magnitudes. In that respect it is important to notice that the power consumption of TVs is not increasing linear with screen size (screen surface area). In order to illustrate this aspect we have calculated the on-mode power consumption per one square inch (W/in^2) screen surface area and plotted as a line the average power consumption per display technology over all screen size segments (see Figure 14). This aspect should be strongly considered when attempting to set power consumption target values purely along the line of an “X Watts per Inch^2” approach. The distribution of power consumption within the devices should therefore be taken into consideration.

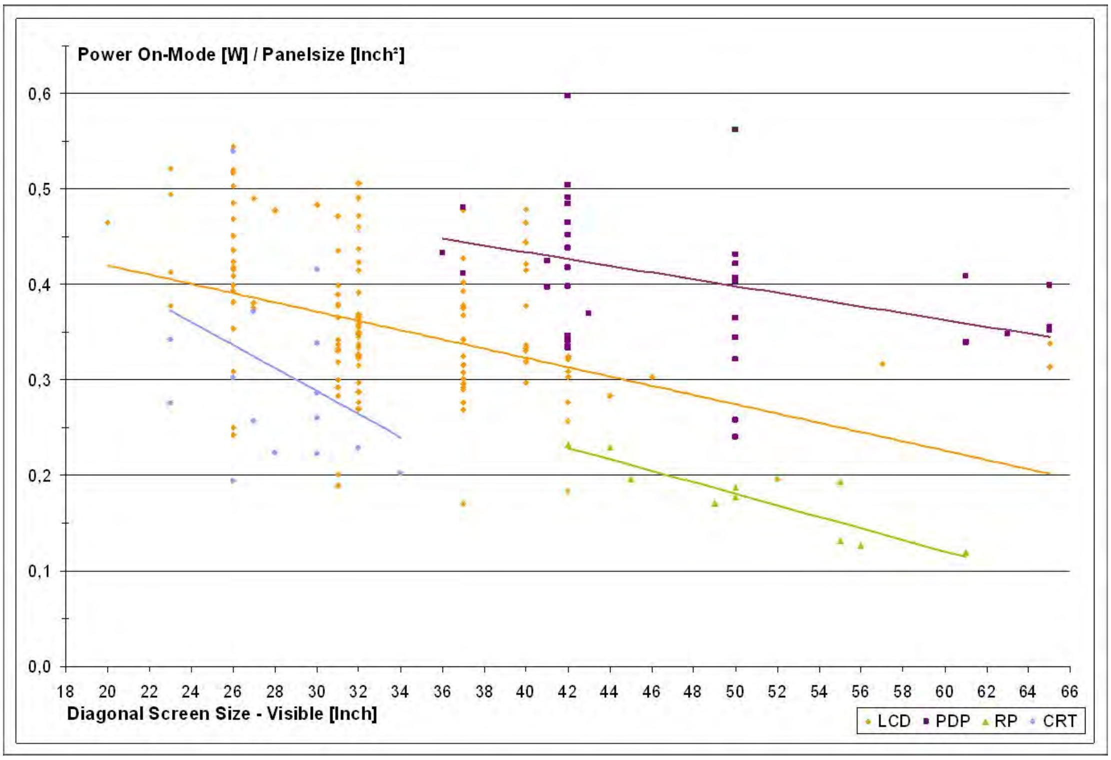


Figure 14: Rated TV power consumption per one square inch screen surface area

5.4.1.1. Data basis for TV on-mode power consumption calculation

The main purpose for compiling power consumption data for all screen size segments and display technologies is to support annual power consumption calculation for the total EU market. By reflecting the market analysis (Task 2) – the phase out of CRT and the rapid introduction of larger screen size flat panel technologies – we assume that overall power consumption related to TV usage will increase over the next years. It is therefore necessary to at least indicate the magnitude of this change for the whole market. Due to the fact that the stock data (market penetration rate) are describing changes in market segments (display technologies and screen sizes) only over a very long period of time, we would like to indicate the magnitude also by a comparison related to the development in product sales.

The following tables provide the data basis for the calculation of average on-mode power consumption for different display technologies (CRT, LCD, PDP, RP) and screen size segments (small 14”-26”, medium 27”-39”, large 40”-65”). Average on-mode power consumption (in W) was calculated for single screen size segments (e.g. 20”, 23”, etc.) from existing catalogue product data of year 2006. The annual power consumption was then calculated based on a 4h on-mode scenario. The Resulting value was aggregated for the predefined small, medium, and large screen size segments respectively. Due to the fact that the averages do not reflect the actual distribution of products in the particular screen sizes market segments a weighting factor was applied (in % of market share) in order to obtain an average value for annual power consumption per segment. Based on this average (aggregated) value (in kWh) the total EU-25 annual power consumption will be calculated for:

- Annual power consumption for the TV stock in year 2005 (based on 4h on-mode per day, 365 days per year)
- Annual power consumption for the TV stock in year 2010 (based on current power consumption averages)
- Annual power consumption for TV sales in the year 2005 (based on current power consumption averages
- Annual power consumption for TV sales in the year 2010 (based on current power consumption averages)

The following tables provide all relevant data for the EU-25 total power consumption assessment. The market data derive form Task 2.

Table 23: CRT-TV on-mode power consumption analysis

CRT-TV on-mode power consumption analysis									
Segment	Small Screen Size (14"-26")			Medium Screen Size (27"-39")			Large Screen Size (40"-65")		
Screen size (in inch)	20"	23"	26"	29"	32"	37"	42"	46"	65"
On-mode power (in Watt)	70 W	80 W	100 W	120 W	130 W				
Annual on-mode power consumption 4h/d/a (in kWh)	102,2 kWh	116,8 kWh	146,0 kWh	175,2 kWh	189,8 kWh				
Weighting of screen size segment by market share in %	15%	15%	70%	50%	50%				
Average annual power consumption weighted by market share (in kWh)	130 kWh			180 kWh					
Number of TV Stock in 2005 (in Tsd units)	208.139			53.201					
Annual Power Consumption for Stock in 2005 (in GWh)	27058,1 GWh			9576,2 GWh					
Number of TV Stock in 2010 (in Tsd units)	176.049			75.450					
Annual Power Consumption for Stock in 2010 (in GWh)	22886,3 GWh			13581,0 GWh					
Number of TV Sales in 2005 (in Tsd Units)	14.648			7.888					
Annual Power Consumption for Sales in 2005 (in GWh)	1904,2 GWh			1419,8 GWh					
Number of TV Sales in 2010 (in Tsd Units)	2.944			1.962					
Annual Power Consumption for Sales in 2010 (in GWh)	382,7 GWh			353,1 GWh					

Table 24: LCD-TV on-mode power consumption analysis

LCD-TV on-mode power consumption analysis									
Segment	Small Screen Size (14"-26")			Medium Screen Size (27"-39")			Large Screen Size (40"-65")		
Screen size (in inch)	20"	23"	26"	29"	32"	37"	42"	46"	65"
On-mode power (in Watt)	80 W	90 W	120 W	130 W	150 W	180 W	220 W	275 W	540 W
Annual on-mode power consumption 4h/d/a (in kWh)	116,8 kWh	131,4 kWh	175,2 kWh	189,8 kWh	219,0 kWh	262,8 kWh	321,2 kWh	401,5 kWh	788,4 kWh
Weighting of screen size segment by market share in %	15%	15%	70%	15%	70%	15%	70%	15%	15%
Average annual power consumption weighted by market share (in kWh)	160 kWh			220 kWh			400 kWh		
Number of TV Stock in 2005 (in Tsd units)	7.158			3.230			145		
Annual Power Consumption for Stock in 2005 (in GWh)	1145,3 GWh			710,6 GWh			58,0 GWh		
Number of TV Stock in 2010 (in Tsd units)	40.982			53.702			17.910		
Annual Power Consumption for Stock in 2010 (in GWh)	6557,1 GWh			11814,4 GWh			7164,0 GWh		
Number of TV Sales in 2005 (in Tsd Units)	4.339			2.748			145		
Annual Power Consumption for Sales in 2005 (in GWh)	694,2 GWh			604,5 GWh			58,0 GWh		
Number of TV Sales in 2010 (in Tsd Units)	5.695			13.721			6.472		
Annual Power Consumption for Sales in 2010 (in GWh)	911,2 GWh			3018,6 GWh			2588,8 GWh		

Table 25: PDP-TV on-mode power consumption analysis

PDP-TV on-mode power consumption analysis									
Segment	Small Screen Size (14"-26")			Medium Screen Size (27"-39")			Large Screen Size (40"-65")		
Screen size (in inch)	20"	23"	26"	29"	32"	37"	42"	50"	65"
On-mode power (in Watt)						240 W	330 W	410 W	610 W
Annual on-mode power consumption 4h/d/a (in kWh)						350,4 kWh	481,8 kWh	598,6 kWh	890,6 kWh
Weighting of screen size segment by market share in %						100%	70%	15%	15%
Average annual power consumption weighted by market share (in kWh)				350 kWh			550 kWh		
Number of TV Stock in 2005 (in Tsd units)				374			2.503		
Annual Power Consumption for Stock in 2005 (in GWh)				130,9 GWh			1376,6 GWh		
Number of TV Stock in 2010 (in Tsd units)				646			24.614		
Annual Power Consumption for Stock in 2010 (in GWh)				226,1 GWh			13537,7 GWh		
Number of TV Sales in 2005 (in Tsd Units)							1.617		
Annual Power Consumption for Sales in 2005 (in GWh)							889,3 GWh		
Number of TV Sales in 2010 (in Tsd Units)							5.518		
Annual Power Consumption for Sales in 2010 (in GWh)							3034,9 GWh		

Table 26: RP-TV on-mode power consumption analysis

RP-TV on-mode power consumption analysis									
Segment	Small Screen Size (14"-26")			Medium Screen Size (27"-39")			Large Screen Size (40"-65")		
Screen size (in inch)	20"	23"	26"	29"	32"	37"	42"	50"	61"
On-mode power (in Watt)							175 W	190 W	190 W
Annual on-mode power consumption 4h/d/a (in kWh)							255,5 kWh	277,4 kWh	277,4 kWh
Weighting of screen size segment by market share in %							40%	30%	30%
Average annual power consumption weighted by market share (in kWh)							265 kWh		
Number of TV Stock in 2005 (in Tsd units)							1.172		
Annual Power Consumption for Stock in 2005 (in GWh)							310,6 GWh		
Number of TV Stock in 2010 (in Tsd units)							2.159		
Annual Power Consumption for Stock in 2010 (in GWh)							572,1 GWh		
Number of TV Sales in 2005 (in Tsd Units)							237		
Annual Power Consumption for Sales in 2005 (in GWh)							62,8 GWh		
Number of TV Sales in 2010 (in Tsd Units)							215		
Annual Power Consumption for Sales in 2010 (in GWh)							56,9 GWh		

5.4.1.2. Interpretation of TV on-mode power consumption development

A comparison of total TV stock of 2005 with the predicted stock of 2010 shows an overall increase of on-mode power consumption. The data in Figure 15 (next page) indicate that with the same daily on-mode time duration of 4 hours the total annual power consumption increases considerably by almost factor two from 40 TWh in 2005 to 76 TWh in 2010.

This result needs a critical interpretation. The sharp increase in power consumption is partially related to the overall increase in the overall TV stock itself. The number of TVs in the EU raises from 271 Million units in 2005 to 391 Million units in 2010. Almost half of these TVs will be used as a secondary device within households. We could assume that these “secondary” TVs might not be used such intensely (less than 4 hours per day) than the “primary” device. However, as indicated in Task 3, there are indications that overall on-mode time of the primary TV will increase in the next years and be more than 4 hours per day. So the applied scenario of 4 hours for both primary and secondary TV seems a feasible compromise.

A further aspect that should be recognized is the contribution of the different display technologies as well as the screen size segments to the total power consumption. Figure 15 again indicates the growing contribution of medium and large screen size TVs to total power consumption. This is an important aspect to consider.

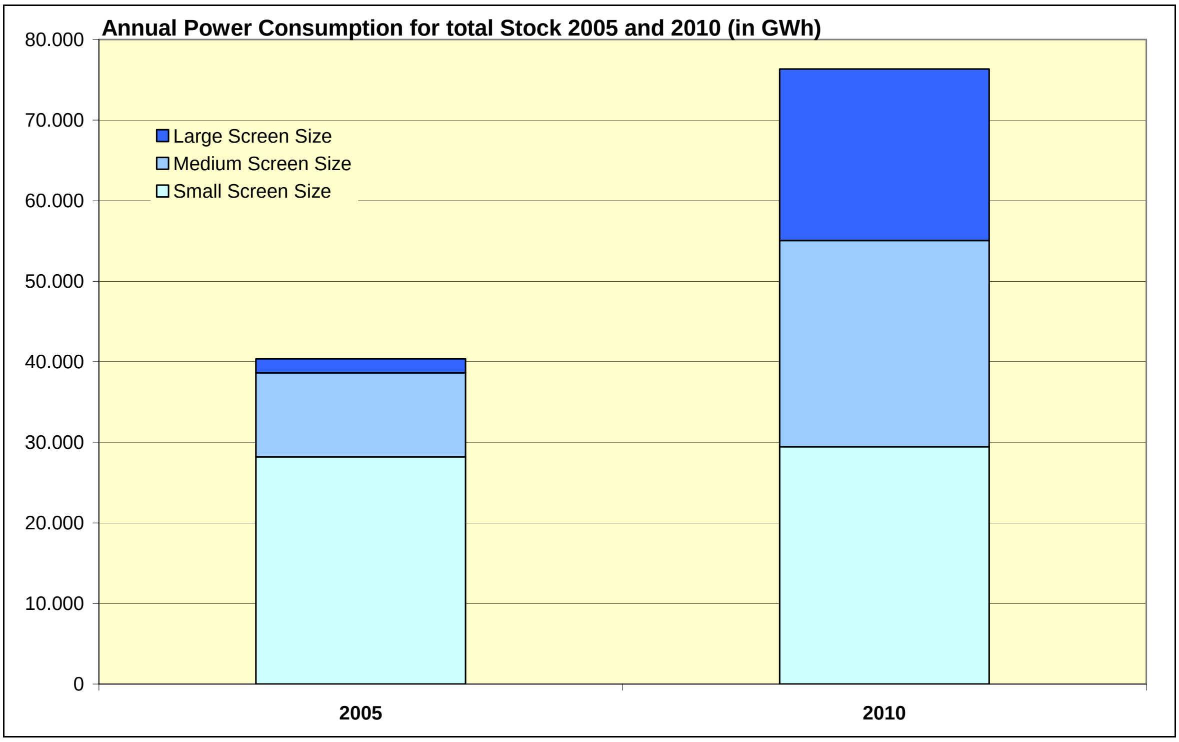


Figure 15: Annual TV on-mode power consumption of total stock 2005 and 2010

The following Figure 16 shows a more detailed picture of the contributions of single display technology and screen size segments to the annual power consumption. Although the CRT-TV segment remains to be the strongest contributor to the power consumption (due to the amount of products on stock), it is clearly visible that the medium and large flat panel displays gain considerably in the contribution by the year 2010. The single contribution of the large PDP-TV segment is noticeable. However, the authors would like to stress again the fact that the power consumption data for PDP-TV might be assessed slightly to high and that real life power consumption of PDP-TV could be somewhat lower (10% – 15%). Furthermore, there is a constant improvement of average power consumption of PDP-TVs as well as LCD-TVs to be recognized. These correction factors should be considered in the interpretation of the figures.

Finally, it is necessary to recognize the potential of RP-TVs. RP-TVs show a very low impact naturally due to there marginal stock volume. But even when assuming a much greater stock volume in the large screen size segment RP-TVs consume approximately only two Third or less power than flat panel display TVs.

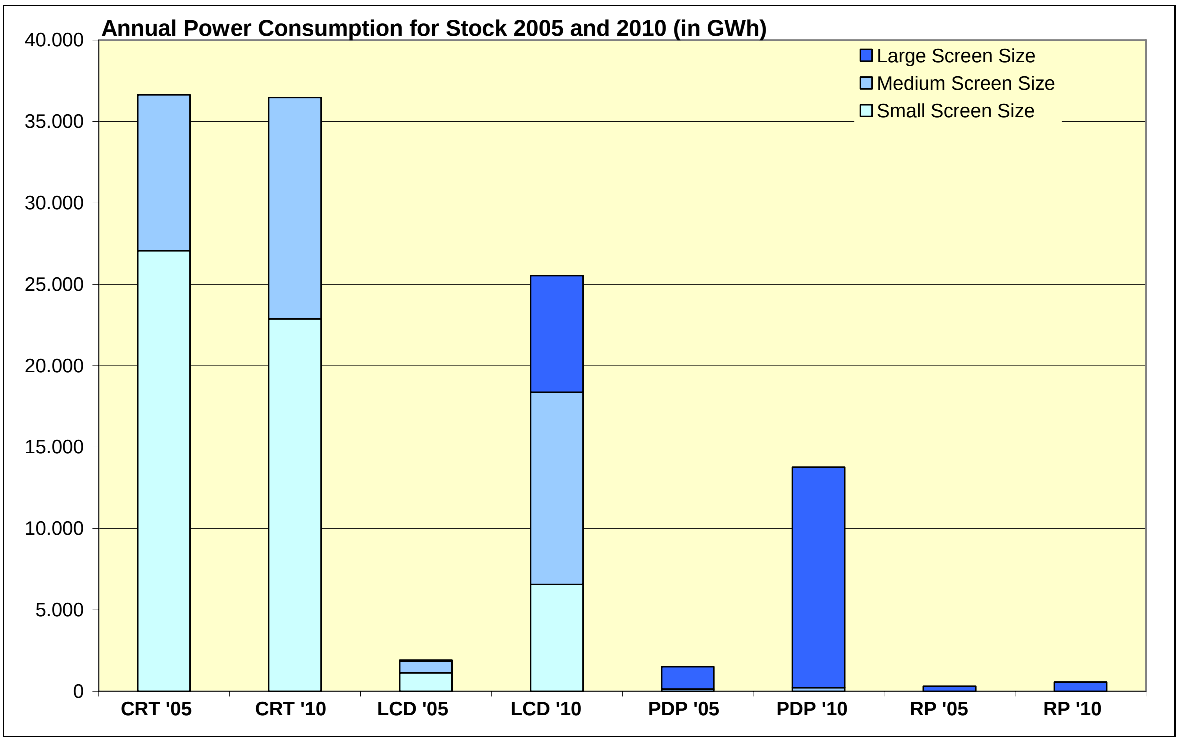


Figure 16: Annual TV on-mode power consumption for stock 2005 and 2010 by display technology

In order to detect the most important contributors to total power consumption in the years to come we have calculated the annual power consumption in terms of sales for the years 2005 and 2010.

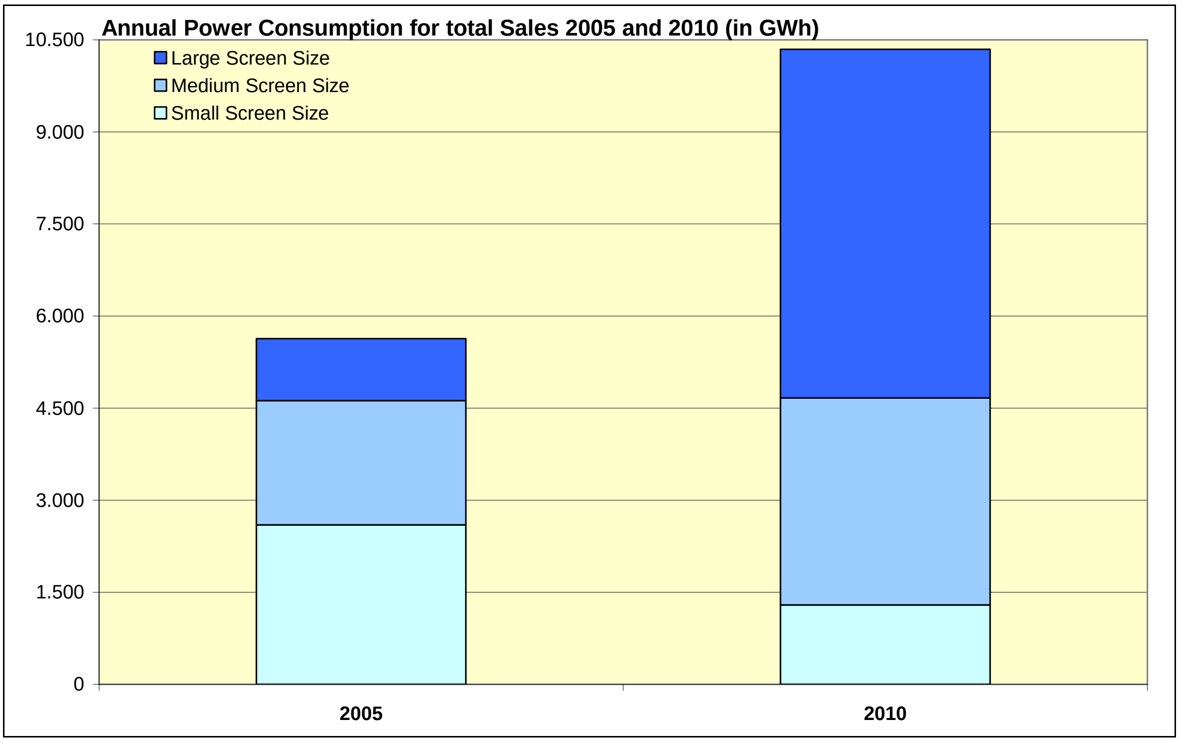


Figure 17: Annual power consumption for total sales in 2005 and 2010

Figure 17 compares annual on-mode power consumption for total sales of 2005 and 2010. In this figure we can see the shift towards larger screen sizes and the impact regarding power consumption. When breaking down these data to different display technologies is becomes apparent that LCD and PDP are dominant and CRT becomes more insignificant. This situation is reflected by the definition of the base cases.

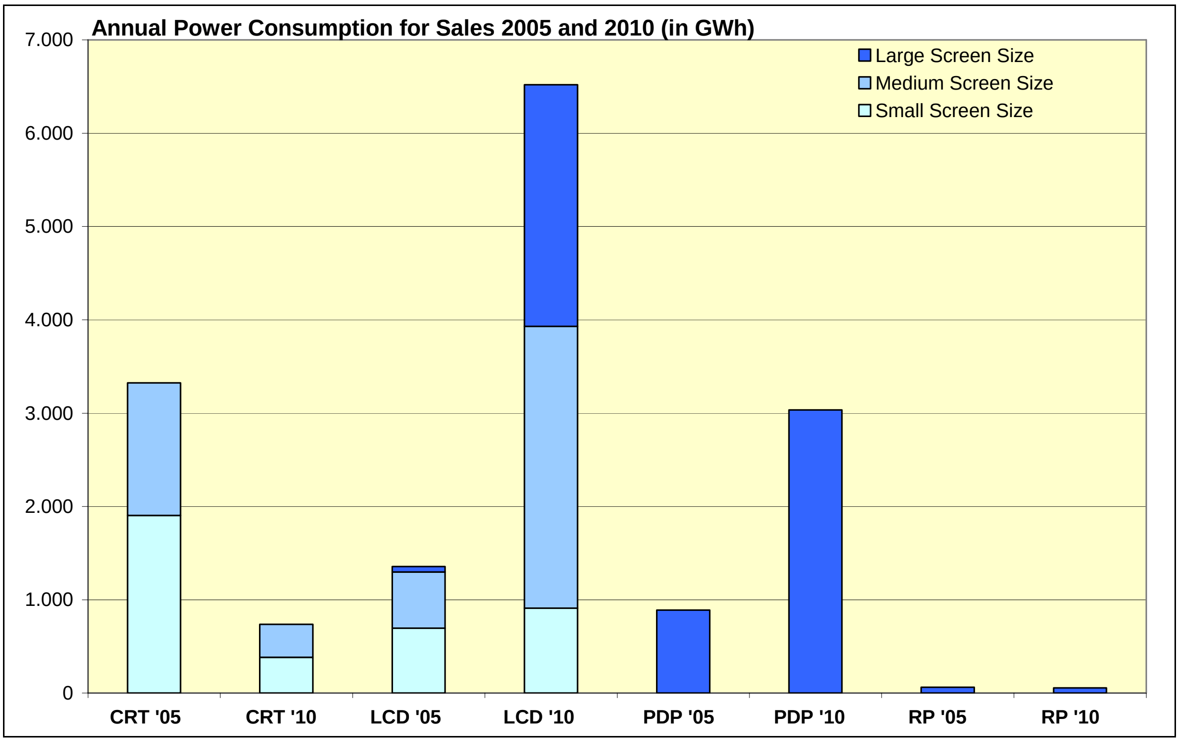


Figure 18: Annual power consumption for sales in 2005 and 2010 by display technology

5.4.2. TV annual power consumption standby scenarios

Passive and active standby are contributing factors to the overall energy consumptions of TVs in the use phase. In the standby mode the TV provides a set of functions that have been defined by the lot 6 study in the following way (lot 6 standby function clusters):

- Passive Standby
  - Reactivation: remote control reactivation, self reactivation (e.g. timer), switch reactivation
  - Continuous functions: information / status display, energy for information storage, sensor-based safety functions
- Networked Standby (active standby low)
  - Network integrity communication (e.g. search for channels or software updates), wake-up over network (e.g. reactivation for program download or recording)

In the following we will analyze the contribution of standby power to the overall annual power consumption of TVs through various scenarios. Figure 19 illustrates the principle use scheme with options for continuous passive standby or active standby low (networked standby) with limited time in active standby high.

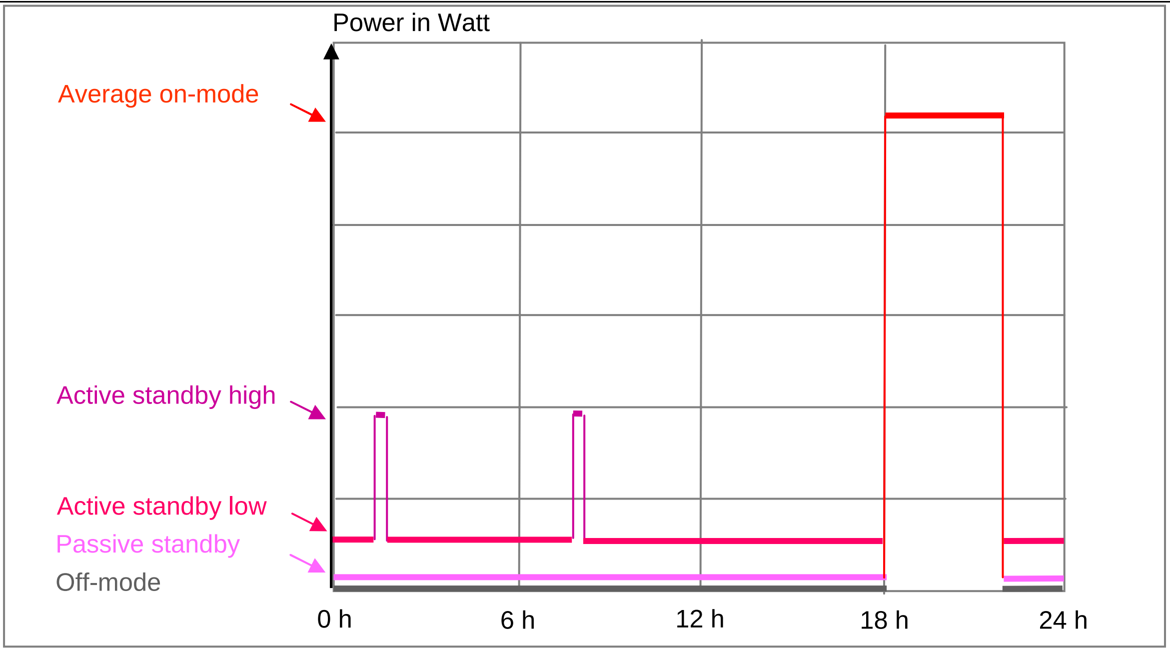


Figure 19: Standby Scenarios

In order to simplify the description of the scenarios we calculated again average standby power consumptions values for typical screen size segments, see following Table 27.

Table 27: Average power consumption of year 2006 TVs on-mode and standby (in Watt)

Screen Size	CRT TV		LCD TV		PDP TV		Rear Projection TV	
	on-mode	standby	on-mode	standby	on-mode	standby	on-mode	standby
23”	80 W	3 W	90 W	1 W				
26”	100 W	3 W	120 W	1 W				
32”	130 W	3 W	150 W	2 W				
37”			180 W	2 W	240 W	1 W		
42”			240 W	2 W	330 W	3 W	175 W	1 W
50” (46” LCD)			275 W	3 W	410 W	3 W	190 W	2,5 W
65” (61” RP)			540 W	2 W	610 W	3 W	190 W	2,5 W

Based on these figures we will calculate annual power consumption of particular TVs (see Table 28) for the following scenarios:

- 4h on-mode and 20h passive standby at 3W (current standby scenario)
- 4h on-mode and 20h passive standby at 1W (improved standby scenario)
- 4h on-mode, 18,5h active standby low at 3W, and 1,5h active standby (high) at 20W
- 4h on-mode, 19,5h active standby low at 1W, and 0,5h active standby (high) at 20W

5.4.2.1. Passive Standby

Table 28 indicates the magnitude of annual power consumption based on 4h per day on-mode and 20h per day standby scenario (365 days per year). The on-mode duration clearly determents the overall power consumption particularly for the medium and large size TVs. The magnitude of passive and active standby in relation to the overall (on-mode) power consumption is shown in the following scenarios.

Table 28: Annual power consumption of year 2006 TVs based on 4h on-mode/ 20h standby (in kWh)

Screen Size	CRT TV		LCD TV		PDP TV		Rear Projection TV	
	on-mode	standby	on-mode	standby	on-mode	standby	on-mode	standby
23”	116,8 kWh	21,9 kWh	131,4 kWh	7,3 kWh				
26”	146,0 kWh	21,9 kWh	175,2 kWh	7,3 kWh				
32”	189,8 kWh	21,9 kWh	219,0 kWh	14,6 kWh				
37”			262,8 kWh	14,6 kWh	350,4 kWh	7,3 kWh		
42”			350,4 kWh	14,6 kWh	481,8 kWh	21,9 kWh	255,5 kWh	7,3 kWh
50” (46” LCD)			401,5 kWh	21,9 kWh	598,6 kWh	21,9 kWh	277,4 kWh	18,25 kWh
65” (61” RP)			788,4 kWh	14,6 kWh	890,6 kWh	21,9 kWh	277,4 kWh	18,25 kWh

The 3 Watt passive standby scenario – scenario for the reference year 2005 – indicates the relative importance of standby in regards to small and medium size TVs. Standby power consumption amounts up to 15% of total annual power consumption (see Figure 20).

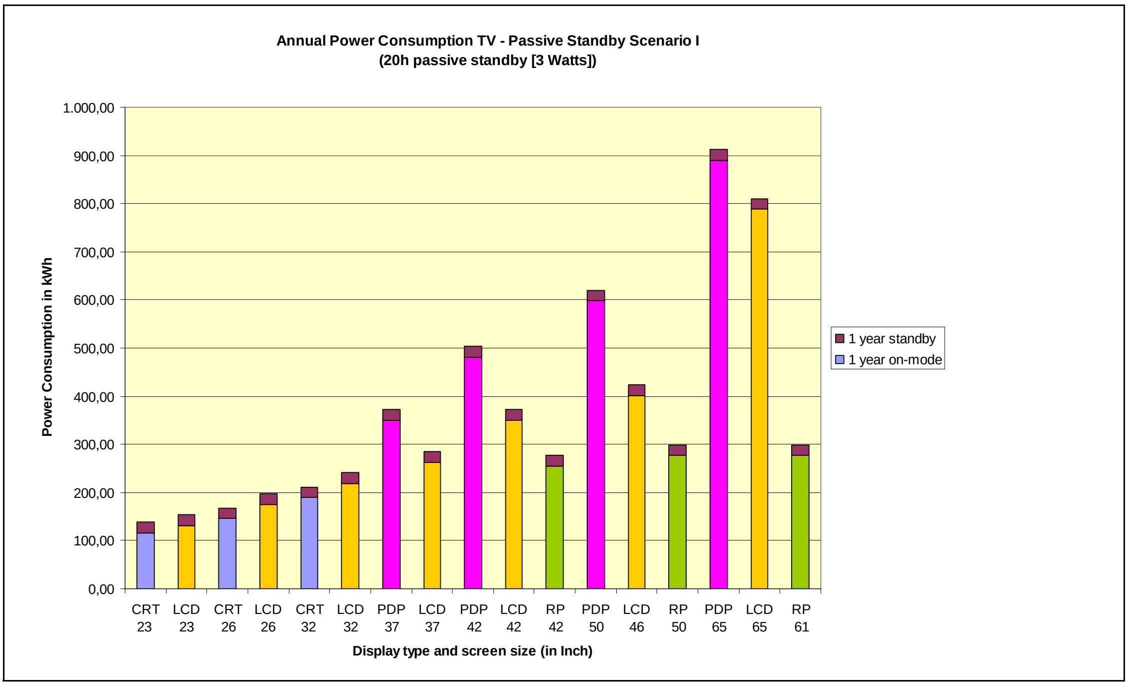


Figure 20: 3 Watts passive standby scenario

The 1 Watt passive standby scenario – scenario for the reference year 2010 – indicates a standby optimized situation (see Figure 21). One Watt passive standby has been reached from numerous manufacturers and seems to be a realistic scenario for future TVs. It shows that the impact from standby is much lower due to the considerably high on-mode power consumption of the medium and larger size televisions. These ratios would of cause increase with lower on-mode power consumption.

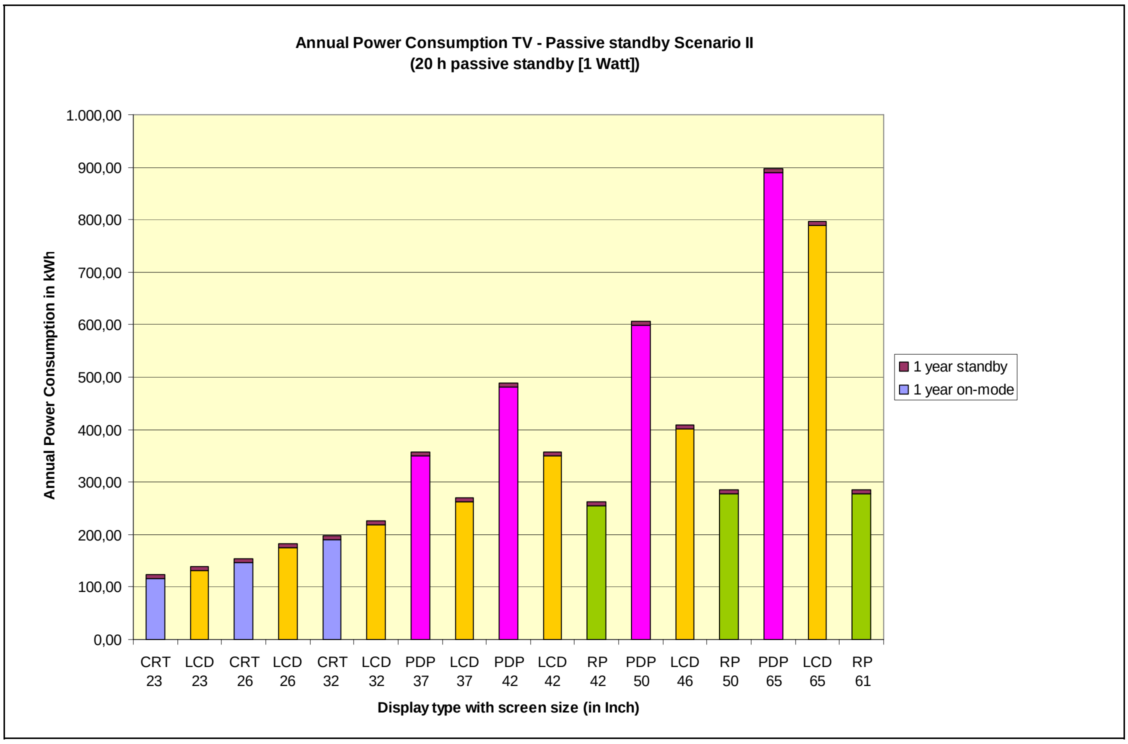


Figure 21: 1 Watt passive standby scenario

The following active standby high scenario – scenario for the reference year 2005 – indicates possible effects from yet to be seen application of active standby high (see Figure 22). The time duration is an important issue to be considered.

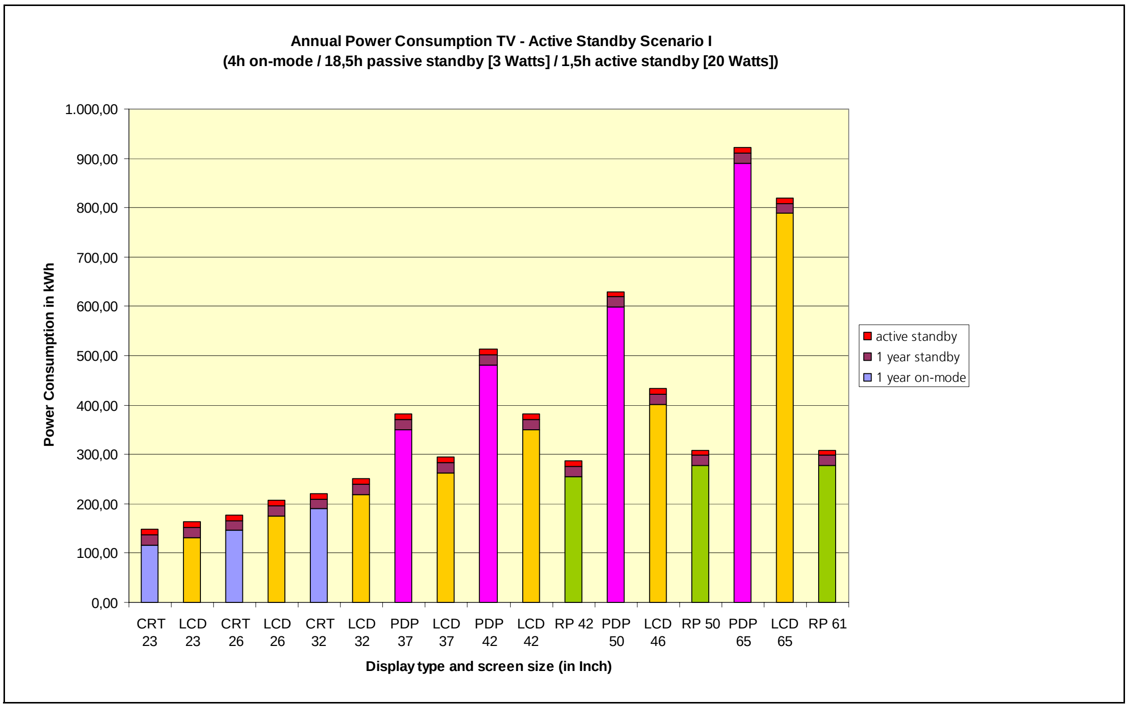


Figure 22: 1,5h active standby scenario

Figure 23 shows an active standby high scenario – scenario for the reference year 2010 – which seems some more realistic. New information from industry indicate that active standby low (net) will be activated only for a very short time duration of some minutes once a day (mostly in the early morning hours). The actual download (active standby high) is also of shorter time duration between 10 and 20 minutes. The power consumption varies, manufacturers say between 15 W and 30 W.

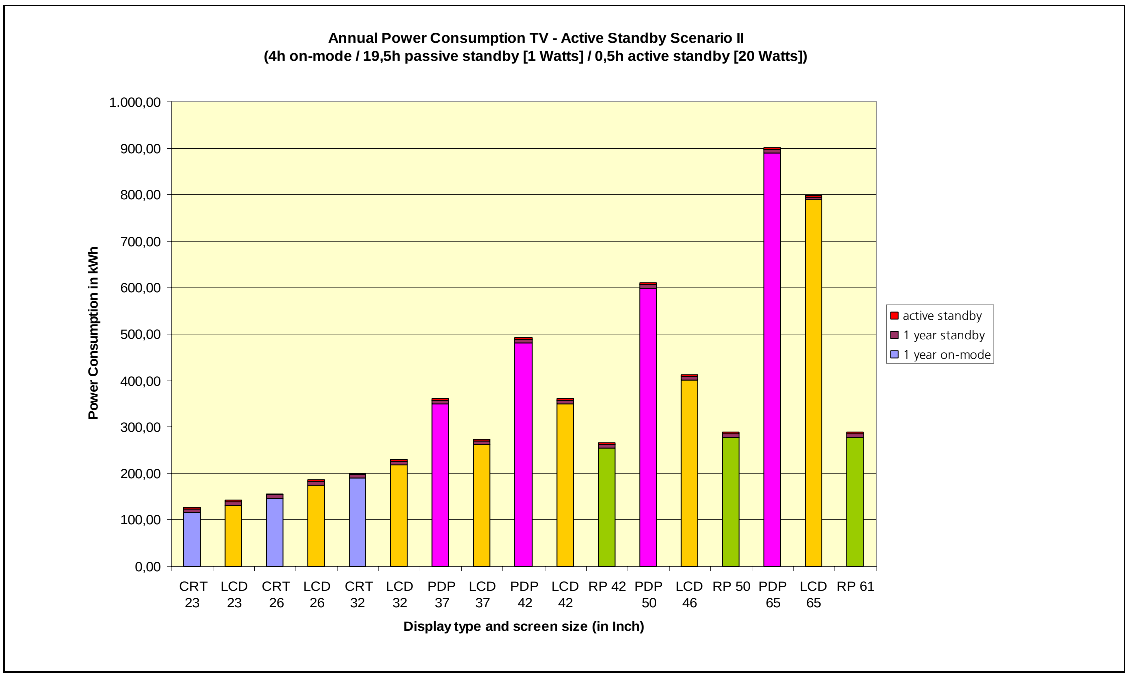


Figure 23: 0,5h active standby scenario

5.4.3. Conclusion

Power consumption in on-mode is the single most significant environmental aspect regarding the total eco-impact of TVs and in consequence the design of TVs in the mid-term future. The analysis has shown that TV-related annual power consumption will increase over the next years due to two factors; the growing market for medium and large size TVs and the growing dissemination of secondary TVs in European households. In short, there are more TVs in use, and the energy consumption in on-mode is increasing with larger screen sizes. Standby power consumption is still a relevant topic regarding the total energy efficiency, but as it has been formulated in the ENERGY STAR Qualified Televisions Specification Revision Update from January 3, 2007: "With the increase in active power tied to these newer (larger) products, EPA believes that standby power alone is no longer an effective measure of television efficiency". It is difficult to predict the precise increase in total power consumption. Our analysis was made on certain assumptions and scenarios. Despite many uncertainties it is absolutely clear from the shown magnitude of increase that on-mode power consumption needs improvement in order to reduce the overall environmental impact.

EuP Preparatory Studies "Televisions" (Lot 5)

Final Report on Task 6 "Technical Analysis BAT"

Compiled by Fraunhofer IZM

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Berlin, 2nd August 2007

Content

Introduction

This is the final report on Task 6 “Technical Analysis of Best Available Technology (BAT)” for the EuP Preparatory Studies on televisions (lot 5). The findings presented in this report are results of the research conducted by the IZM consortium and the continuous feedback from a wide range of stakeholders. The statements and recommendations presented in the final report however are not to be perceived as the opinion of the European Commission.

We like to acknowledge the fruitful collaboration and trustful working relationship with various industry partners, non-industry stakeholders, and the European Commission throughout the study. We like to thank all stakeholders for their contributions and critical reviews of our reports.

2nd August 2007

6 Technical Analysis BAT

Introduction

Task 6 has the objective to identify, describe, and evaluate best available technologies (BAT) and technologies that are currently in the development (laboratory or prototype level) and are expected to enter the mass market in two or three years (i.e. BNAT). The MEEuP differentiates BAT (Best Available Technology) and BNAT (Best Not yet Available Technology), BAT is a technology, leading to minimised environmental impacts, which is already available on the market or at least the technical feasibility has already been demonstrated (expected to be introduced at product level within 1-3 years). BNAT refers to technology, which has the potential to lead to further (environmental) performance improvements, but is still subject to research and development and is rather a future option / trend. The reference term is “best technology” and not “best product” indicating an environmental improvement potential through application of new technical principles, components, or materials. This intention is reflected by the following subtasks that are prescribed by the MEEuP:

- State-of-the-art in applied research at product level
- State-of-the-art at component level
- State-of-the-art of best existing products outside the EU

The assessment of the BAT and BNAT provides input for the identification of the improvement potential in Task 7. Intellectual property, technical feasibility, and availability on market in a strict sense are not judged here as the objective is to illustrate various technically available (or potentially available) options. However, the task 7 will take these issues into account when suggesting possible improvement options applicable to TVs. A comparison of the MEEuP prescribed subtasks (task 6) and the proclaimed objective “technical analysis best available technology” show contradictions in the description of Task 6. The subtasks require identification of “best existing products” as well as “best technologies at product and component level”. We come to the conclusion that the prescribed subtasks have to be modified for the purpose of the EuP Preparatory Study Lot 5. By reflecting the results of the market and trend analysis, the technical analysis of existing products and the definition of base cases, we propose the following structure for Task 6 report:

- State-of-the-art in TV-display technology (6.1)
- State-of-the-art in TV-set making (6.2)
- State-of-the-art in TV power consumption (6.3)

Subtask 6.1 provides an analysis of technical principles (design options), components or materials that have a potential to reduce the environmental impact of TV displays. The main focus of the analysis is put on power consumption. Further aspects are resource efficiency, new functional materials with low life cycle impact, and the reduction of hazardous substances. The analysis reflects current and expected future market developments. On the basis of our research and interviews with industry we conclude that LCD and PDP have the highest market potential, due to their novelty (Flat Panel Display) and considerable maturity of technology. In consequence we assess primarily technical developments concerning LCD-TVs (e.g. backlight units) and PDP-TVs (e.g. panel luminescence efficiency). Other TV display technologies including various RP technologies, slim CRT, SED, and OLED will be analyzed to some extent as well. Following Figure 1 provides and overview on the current developments regarding TV display technology and their market potential by screen size.

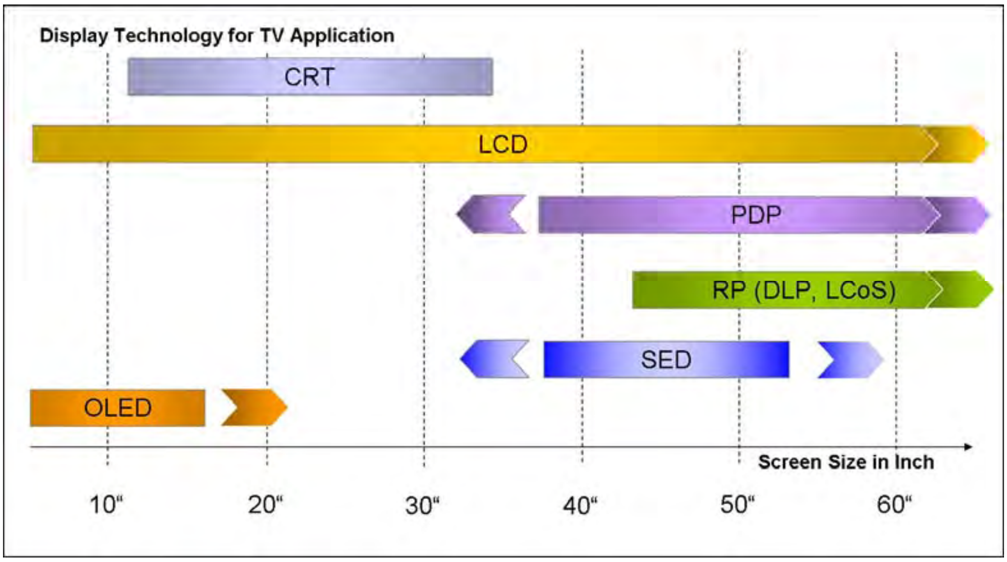

Figure 1: Display technology for TV application in different screen size segments

Subtask 6.2 analyzes state-of-the-art in TV-set making. The analysis will cover best available technology regarding electrical efficiency of the power supply units, miniaturization of electronic components and boards, as well as alternative housing materials, physical design and recycling issues.

Subtask 6.3 provides an overview on most energy efficient products (standard mode and standby mode) in various market segments, thus reflecting best available products in the global market.

The description of technologies presented here is based on ongoing research. New cutting edge technologies are highly guarded secrets and detailed public information is limited. Thus, the information presented here should be seen as a general overview of potential improvement options rather than a thorough technical analysis.

Note:

Task 6 is based on a literature search as well as contributions from stakeholders. All the registered Lot 5 stakeholders were invited to provide input to this task, and others were also welcome to contribute. Important BATs have been covered to the best of our knowledge. Most of the technical data for this task has been provided directly by the manufacturers/designers or come from other published information. However, the efficiency or other performance levels claimed by them have not been verified independently.

6.1. State-of-the art in TV-display technology

6.1.1. Liquid Crystal Display (LCD) Back-Light Units (BLU)

Today's most prevalent advanced displays, the direct-view liquid crystal display (LCD), do not emit its own light, but rather must be illuminated from behind. The reduction of power consumption is strongly related to the back-light unit (BLU). The most common BLU for LCD-TV today consists of a number of fluorescent lamps (multiple lamp configurations) that span the entire length of the display horizontally in combination with a light reflector. The polarizer on the panel side as well as the BLU driver circuitry has to be included into the system analysis.

The most commonly used lamps in LCD-TVs are Cold Cathode Fluorescent Lamps (CCFL). Advanced fluorescent lamp technologies include External Electrode Fluorescent Lamps (EEFL) and Flat Florescent Lamps (FFL). The future BLU will feature Light Emitting Diodes (LED). Prototypes are available and LCD-TVs with LED-BLU have been the attraction of showcases since 2005. But performance characteristics and manufacturing of LEDs, color mixing technology, and interconnection technology (electronic packaging) are still not matured enough to be commercialized in mass market application for all LCD-TVs.

In addition to the florescent lamp or LED backlight systems, a considerable reduction in power consumption is today already achieved by dynamic scaling (dimming) of the whole backlight unit. A vertically partial dimming through a scaling of single lamps is also possible. LED-BLUs would have the advantage of content specific (vertical and horizontal) area dimming. This kind of BLU technology has a high power saving potential.

The following sub-section describes and assesses technical and environmental aspects of backlight units for LCD-TVs. The analysis covers:

- Fluorescent lamp BLU
- LED-BLU
- Active scaling of BLU
- Efficient polarizer
- Power supply and power conversion efficiency

6.1.1.1. Cold Cathode Fluorescent Lamp (CCFL)

According to manufacturers, CCFL BLUs have according to manufacturer good performance properties; good luminous intensity (defined as cd=lm/sr, one lumen of luminous flux per steradiam), high luminance density (small form factor and light weight), good color reproduction (70% ~ 72% of NTSC spectrum) and color uniformity, vibration and impact resistance, durability, and excellent blinking characteristics, quick start at low temperature, low heating and long lifetime (20.000 ~ 60.000 hours)[1]. CCFL is very mature technology and hence the costs are relatively low. CCFL is a gas discharge lamp and classified as an electronic component. CCFL is a sealed glass tube with electrodes on both ends. The tube is phosphor coated and filled with inert gases (Ar/Ne) and a slight amount of mercury (approx. 4mg Hg per lamp). When a voltage is applied to the electrodes (strike voltage is 1.0KV ~ 2.5KV), the gas is ionized allowing the electrical current to flow. The collision of moving ions inject energy to the mercury atoms, which lets the atoms jump to a higher energy level followed by emitting ultraviolet photons when falling back into their original energy level. This effect is called gas discharge phenomenon. The wavelength or color of the visible light depends on the type of the gas and phosphor (red, green and blue phosphors for producing three band white light)[2].

During operation, the CCFL generate UVB and UVC radiation. Over time, this can damage important components inside the monitors. The LGP (Light Guide Plate) located behind the TFT (Thin Film Transistor) is primarily made of plastic and reacts quite sensitively. This component is responsible for uniform illumination, brilliance of color and brightness. UV radiation causes the components to turn yellow and, thus, impairs the image quality, brightness, and color values[3]. CCFL glass manufacturer have developed high UV-blocking glass in order to counter this problem. In the CCFL, ionized gas conducts the electrical current. The impedance of the gas conductor, unlike that of the metal conductor having a linear behavior, decreases as the current increases. Therefore, the CCFL has to be driven by an alternative current (AC) to avoid a potential explosion[4].

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[1] http://www.j-right.com/html/ccfl_lamp.htm. (03/2007)
[2] Phosphor is the limiting factor for high color gamut. Average CCFL reach just of 70% of NTSC spectrum. LG.Philips however showed at the FPD International 2005 (19th -21st October) in Yokohama a 23" WUXGA LCD with improved NTSC color gamut of 90% due to new phosphor CCFL.
[3] Schott Solutions Magazin No 1 / 2006: http://www.schott.com/magazine/english/download/sol106_09_glasstubing.pdf?PHPSESSID=916 (03/2007)
[4] Wei-Chung Cheng: Power Minimization in a Backlit TFT-LCD Display by Concurrent Brightness and Contrast Scaling. Paper in the Internet: http://atrak.usc.edu/~massoud/Papers/cbcs-journal.pdf. (03/2007).

The power consumption of the CCFL BLU depends on the number of lamps, the dimension and chemical composition of the lamps (illumination efficiency decreases with age due to deteriorating chemical properties of the CCFL), the reflector design as well as the electrical efficiency of the power supply and the driving inverter unit. The dimming (scaling) of the complete CCFL BLU according to actual ambient brightness (sensor-based active brightness control) or the average picture level of the video image is an effective measure to reduce power consumption furthermore.

According to DisplaySearch, there are usually sixteen CCFL in a 32" LCD-TV[5]. The emission (brightness) efficiency of CCFL is about 60 lm/W with improving potential (60 ~ 80 lm/W). A short investigation on CCFL drivers for LCD-TV application indicated that the inverters feature an input voltage range of DC 5 ~ 36V. The CCFL usually runs at DC 12V with a strike voltage of 1400V to 1800V. The working voltage is assumed somewhat lower at 1000V to 1200V with a working current of 5.5 to 7.5 mA. The rated power consumption of a single CCFL depends on the lamp size (BLU size) and design. For the purpose of the study we assume an average 5.5 Watt power consumption per lamp for a 32" LCD-TV.

The electrical efficiency of the power supply for the BLU is an important issue. Multiple power transformation steps (e.g. 220V [AC-DC] → 12V → 1200V [DC-AC]) contribute to the overall power consumption of a LCD-BLU. Losses particularly are related to the power transformation from a low voltage (e.g. 12V) to a high voltage (e.g. 1200V). In this case power transformation efficiency is usually only 50 to 70%. The electrical efficiency of AC and DC inverters on the other hand is usually already over 80%. One manufacturer was addressing the issue of direct power supply for the BLU in order to avoid the low power transformation step and the related losses. This approach would require however a close collaboration of BLU manufacturers, due to the fact that the TV set-maker would design the power supply and drivers for the BLU.

Improvement potential of CCFL BLU results from:

- Higher emission efficiency of the CCFL through design and chemical composition of the lamp (>60 lm/W)
- Higher electrical efficiency of power supply (avoiding of multiple power conversion steps)
- Higher electrical efficiency of the CCFL driver (DC-AC inverter efficiency >80%)
- Dimming of the CCFL to reduce power consumption (active brightness control or image APL control)

[5] DisplaySearch Presentation on Backlight system Development (Slide 27), in the Internet: http://www.displaysearch.com/free/sid_leds_in_displays_011306.pdf (03/2007)

6.1.1.2. External Electrode Fluorescent Lamp (EEFL)

EEFL differs from CCFL in a way that the electrodes are outside of the lamp. As there are no electrodes within the lamp, no wires pass through the glass tube, eliminating the need for a glass-to-metal seal, which is claimed to reduce gas leakage problems. EEFL also contains less Mercury (<4mg Hg per lamp). The principle gas discharge technology however is the same. The technical properties are defined by the external electrodes. Claimed advantages of the EEFL include high efficiency and brightness, less heat and less deterioration of the phosphors that heat causes, as well as the elimination of the electrode deterioration caused by ion bombardment. These aspects enhance the lifetime of EEFL (>60.000 hours). Illumination stability and brightness efficiency is good (60 ~ 80 lm/W). To avoid negative impedance of common gas charge lamp, EEFL external electrode allows high frequency voltage function via capacitance coupling. The EEFL operates on a lamp voltage of 1.0 ~ 1.2KV and lamp current 3.6mA[6]. Strike voltage is 1.5KV ~ 2.5KV. It is possible to run 10 to 20 EEFL from a single inverter, which reduces design costs.

According to DisplaySearch, a 32" LCD-TV EEFL-BLU consists of 20 lamps[7]. The rated power consumption of a single EEFL is 4 to 6 Watt. One high performance EEFL-BLU reportedly reduced power consumption of a large LCD-TV by 30% in comparison to a previous CCFL system[8]. According to a press statement, LG.Philips LCD America Inc. showed at the CES 2007 (January 2007 in Las Vegas) an EEFL equipped 32" HDTV LCD panel prototype with a power consumption of only 65 Watt. EEFL is a relatively new development in fluorescent lamp technology with some technical and cost advantages. Up to now EEFL is not much prevalent in current LCD-TV products. The DisplaySearch assessment from late 2005 indicated that supply of large size EEFL is limited.

Improvement potential of EEFL BLU results from:

- Lower power consumption than conventional CCFL
- Potential for power reduction through external electrode and easier inverter design
- Electrical efficiency of power supply and lamp driver circuitry (same as CCFL)
- BLU dimming (same as CCFL)
- Lower Mercury content per lamp (but more lamps necessary, ratio not known)

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[6] http://www.wellypower.com.tw/english/product1_15.php?function_page=c (03/2007)
[7] DisplaySearch Presentation on Backlight system Development (Slide 27), in the Internet: http://www.displaysearch.com/free/sid_leds_in_displays_011306.pdf (03/2007)
[8] J-B Kim et al (LG.Philips LCD): High Performance EEFL Backlight System for Large-Sized LCD TVs, Conference Paper (Session 26.3) at the SID 2006 Conference (Society of Information Display), 4 - 9 June 2006 San Francisco, CA; in the internet: http://www.sid.org (03/2007)

6.1.1.3. Flat Florescent Lamp (FFL)

FFL is a third backlight technology that has entered the market and it is mercury free[9]. The FFL is a thin, flat, rectangular lighting source that has the appearance of being an adaptation of the EEFL. According to Taiwanese Delta-Optoelectronics Inc., the first company that commercialized FFL BLUs, offer FFL backlights longer lifetimes (100.000 hours) and better color reproduction (80% of NTSC spec) and light uniformity compared to the typically round CCFL[10]. The FFL is sufficiently thin and large to cover the entire display area. For instance, a 32″ LCD-TV which typically require 16 CCFLs will require just one FFL with a FFL-based backlight system. Even for larger sizes, only one FFL will be needed, states Samsung Corning[11]. But is has to be said that the brightness efficiency is with 30 lm/W lower than that of conventional CCFL.

As for the design, the electrodes are arranged on the back surface of the FFL fixture, phosphors coat the front, while the gas plasma (Xe) occupies the space between. This permits the backlight source to be spread across the entire display area, rather than being located along its edges with distribution by reflectors, as is the case with round fluorescent tubes. According to DisplaySearch, the power consumption is rather high and thus the market potential of FFL will depend on the issue of improved ratio of power consumption to light emission, high productivity and lower costs.

Improvement potential of FFL BLU results from:

- Mercury free and free of UV leakage
- Very cheap converter design

Critical issues concerning FFL:

- Assumed higher power consumption in comparison to CCFL and EEFL
- Moderate brightness efficiency
- Supply limited for larger BLUs (>32")

[9] FFL is not an entirely new concept, cp: M. Anandan, D. Ketchum (1992): Multiplicity of Discharge Channels for a Flat Fluorescent Lamp to Backlight a Full Color LCD; in IEEE TRANSACTIONS ON ELECTRON DEVICES, VOL. 39. NO. 6, JUNE 1992 1321.

[10] http://www.delta-opto.com.tw/product/product_tech.asp (03/2007)

[11] http://displayblog.wordpress.com/2006/09/01/samsung-cornings-ffl-backlights/ (03/2007)

6.1.1.4. Light Emitting Diodes (LED)

LEDs provide many benefits as a backlight source for LCD-TV. According to an older article in the Nikkei Electronics, LED-BLU does offer a wider range of color reproduction (>100 % of NTSC specification) in comparison to CCFL, EEFF, FFL (<80%) and could achieve even better performance than CRT, PDP or SED panels which have limitations due to phosphors they use[12]. LED backlights also enhance the contrast ratio due to the option of arbitrarily scaling (dimming) individual display areas. The dimming of the LED backlight is possible with a response time of 100ns[13]. In combination with a LCD panel speed of up to 6ms this is a real advantage because it improves the deep black reproduction and prevents motion blur.

Over the past three years many manufacturers have released mostly very large LCD-TV products which use red, green and blue (RGB) LEDs for the backlight and have achieved good performance. On the downside, RGB LED backlights demand color mixing technology in order to overcome unevenness of luminance. Color mixing has significantly improved with an increased understanding of the design and function of direct backlight concept[14]. Today, RGB LED clusters (usually 1x red, 2x green, and 1x blue) are grouped with some space in between in order to facilitate good color mixing and with minimum design for thermal radiation structures. Temperature control is essential in order to avoid color shift, which is another challenge in LED backlight systems. Figure 2 shows the principle design of LED backlight system in comparison to a conventional CCFL backlight.

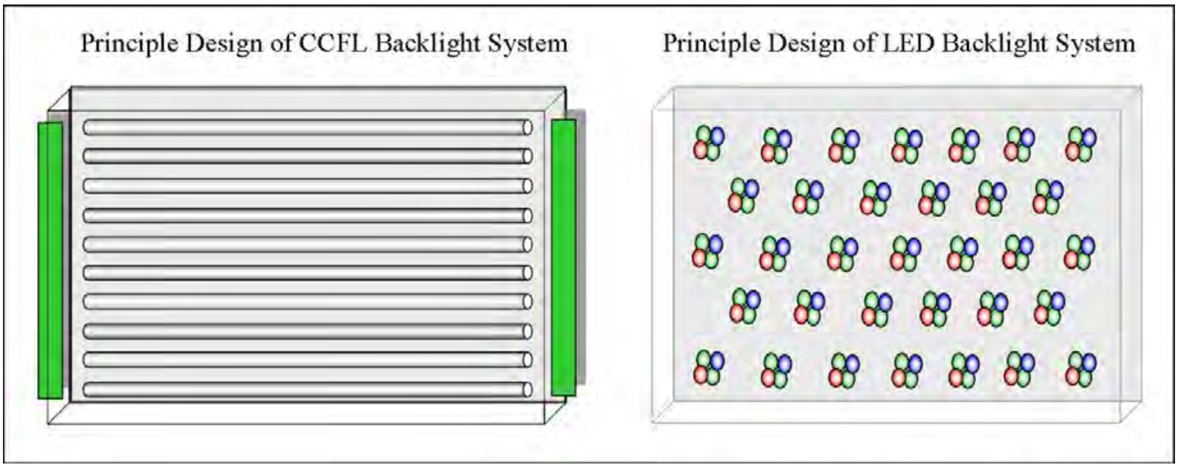

Figure 2: Principle Design if CCFL and LED Backlight System (Source: Samsung)

[12] Nikkei Electronics Asia March 2005 issue: LED Backlights Boost LCD TV color.
[13] Heise online 20.07.2005, in the Internet: http://www.heise.de/newsticker/meldung/61890 (01/2007)
[14] Robert Scott West et al (Lumileds Lighting): http://www.lumileds.com/solutions/LCD/Luxeon_Direct-SID_2003.pdf (01/2007)

The LED backlight technology is on a fast track. LED and BLU Manufacturer (e.g. Lumileds, Osram Opto Semiconductors, Toyoda Gosei) try to meet the demand of LCD manufacturers by improving the dimension (thickness), lifetime (>50.000 hours), stability (avoid nucleation and growth of dislocations), operation temperature (low) and uniform luminance characteristics (high), and related power consumption of the color LED and LED backlight units. Red, green and blue LEDs are made of a variety of inorganic semiconductor materials such as AlGaAs, AlGaP, AlNiP, AlGaN, InGaN, ZnSe, Al_2O_3, or SiC and manufactured in thin-film semiconductor processes. It is not possible to assess the environmental impacts of LED materials and manufacturing process within the scope of this study. The current costs for LED backlight unit however indicate manufacturing related impact. According to DisplaySearch has the LED backlight unit a cost factor of 2.5 ~ 3.0 in comparison to CCFL[15]. LCD-TVs with LED backlights are on average 70% more expensive than conventional CCFL LCD-TVs.

In press releases of LCD-TV manufacturers, it is usually said that LED backlights have lower power consumption. From the currently available LED backlight products it is difficult to draw precise conclusions regarding power consumption. As an example, Osram Opto Semiconductors showed in 2005 a LED backlight unit prototype for an 82” LCD-TV (!). This prototype was only 40 mm deep and featured 1120 LEDs in clusters (1x red, 2x green, and 1x blue) with a lifetime of 50.000 hours. According to Osram OS consumes this prototype 1000 Watt in use with no cooling fan necessary. In January 2006 Samsung presented at the CES showcase in Las Vegas the first 82” LCD-TV with a LED backlight acknowledging lower power consumption[16].

For comparison purposes we have calculated the power consumption of a LED-BLU based 42” and 32” LCD-TV. The calculation was simply done based on the comparison of the screen surface area in relation to the 1000 Watt power consumption of the 82” LCD-TV. Following this calculation scheme the 42” LED-BLU LCD-TV would consume 256 Watt and the 32” TV would consume 148 Watt. In comparison to the average power consumption values for conventional backlight LCD-TV (see calculation in Task 5 report chapter 5.4.1) the 42” would consume slightly more than the average (220W) and the 32” would consume exactly like the average (159W). The latest Samsung LE-40M91B (40” LCD-TV with LED backlight) with exceptional picture quality and a wide spectrum of additional features is specified in the product catalogue with 230 Watt.[17] Assuming

[15] DisplaySearch Presentation on Backlight system Development (Slide 27), in the Internet: http://www.displaysearch.com/free/sid_leds_in_displays_011306.pdf (03/2007)
[16] Samsung press release from 6 January 2006 (SEC).
[17] In an article of the EE Times Asia from 14 March 2007 Mao Yu-Hai, chief scientist at Power Analog Microelectronics (PAM), said: "When using LED backlight, the power consumption can be reduced by 50 percent. In Samsung's 40inch LCD-TV, it consumed 170W. After it changed to LED backlight, it only consumed 100W". http://www.eetasia.com/ART_8800456473_765245_7b2a9ec1200703_no.HTM.

that the backlight consumes 60% ~ 65% of total power consumption this is good performance and shows the potential of LED backlight. In combination with an advanced backlight control for partial area dimming of LED clusters or dimming of single LEDs the improvement potential for power consumption has to be assumed excellent. However, by what percentage this improvement is achievable is difficult to assess. About 34% possible decrease has been reported in an older study conducted in 2003[18]. Our assumption would be similar high (>30%), but LED backlight technology for LCD-TV application is not mature yet and commercialization for mass production will take some more time.

Improvement potential of LED BLU results from:

- Potentially low power consumption in combination with active area dimming
- No hazardous substances (Mercury free)
- Potentially longer lifetime

Issues to be solved in LED:

- LED quality, uniform color characteristics, and long-life stability
- LED system integration (e.g. control circuit design, materials of electronic packaging, and thermal management)
- Current high manufacturing and system integration costs

6.1.1.5. Conclusion

BLUs have a significant influence concerning the picture quality, lifetime, and power consumption of LCD-TVs. Today, almost all LCD-TVs feature a CCFL-BLU. CCFL will remain an important backlight technology in the near- to mid-term future due to a good price to performance ratio and limited improvement potential can be expected in the case of CCFL. EEFL and FFL have some technical advantages – EEFL shows better power efficiency and FFL is mercury free. However, our investigation indicates that LED-BLUs have the most promising market and environmental improvement potential in the mid- to long-term future. This assessment is confirmed by market forecasts for backlight units[19]. LED technology is not yet mature. It is therefore difficult to assess the actual environmental improvement potential or impact.

Comment: This statement contradicts with the catalogue data from Samsung. Mr. Mao might refer to a different product.

[18] Environmental, Technical and Market Analysis concerning the Eco-design of Television Devices, IPTS, JRC, European Commission, 2003.

[19] Digitimes online news 26 may 2006.

6.1.2. LCD Panel Efficiency

6.1.2.1. High Efficient Polarizer

The technical development in the field of LCD panels is focused on the improvement of light channeling (polarization) and light passing efficiency (transparency) of the functional layers for high and even luminance output. The improvement of the polarization filters, diffusers, glass substrate with TFT and circuitry, the liquid crystal layer, color filters and other alignment and protection layers have direct influence on the power consumption of the LCD-TV. The improvement of the light passing efficiency could result in a smaller dimensioning of the BLU (e.g. reduced number of lamps), which results in lower power consumption of the system. Most of the material and design developments in the field of LCD panels (functional layers) are proprietary technologies (IP). Due to this situation it is very difficult to provide a comprehensive analysis of best available technology (BAT) and not yet best available technology (BNAT) for LCD panels. As an example, we take the important technical aspect of polarization.

The polarizer is the functional link between the backlight (lamp) and the LCD panel. Today, reflective polarizer (e.g. marketed by 3M Electronics) or prismatic films achieve a higher utilization of the lamp's randomly emitted light. Normally S-wave light is absorbed by the polarizer and basically lost. The reflective polarizer of 3M Electronics (Vikuiti™ Dual Brightness Enhancement Film) for example achieves a higher utilization of the lamp emitted light by reflecting the s-wave light and receiving it again after reflected by the BLU. According to 3M, this "recycling of light" increases the light throughput and hence the overall efficiency of BLU by up to 50%. This positive effect can be used for reducing the number of necessary lamps in the BLU and the power consumption accordingly. In a test by 3M, a 37" LCD-TV with a Vikuiti™ DBEF and 12 CCFLs produced brightness equal to the same LCD-TV with regular 16 CCFLs and no DBEF. The DBEF configured system also drew 35 Watts less power to produce the same brightness. In conclusion, the reflective polarizer film of 3M can increase the energy efficiency of LCD-BLU 30% to 50% which relates to a 20% to 30% power reduction of a LCD-TV.

Today, many TV-makers purchase already LCD panels with such high efficient polarizer films from 3M Electronics. However, it is important to understand that such polarizer films are proprietary technologies and are therefore an important cost factor.

6.1.2.2. LCD Panel Manufacturing

If trying to characterize the technical development in the field of LCD panels it could be said that improvement is focused on both enlargement and miniaturization.

Enlargement: The drive for larger screen sizes and higher production yield demands larger glass substrates. The 8^{th} generation in LCD panel manufacturing with glass substrates of 2160 x 2400 mm² stared in 2006. Extensive automation in production and the extremely competitive market situation makes LCD panel manufacturing costs and yield a key economical and environmental issue. There is a very simple correlation; improved production yield lowers the environmental footprint. Production yield – highest quality output – in LCD panel manufacturing is closely related to the level of miniaturization in the functional layers of the LCD.

Miniaturization: The drive for higher resolution (Full HD) demands finer color cell structures (red, green and blue filters separated by a black matrix) in order to generate a respectively higher number of pixels in the same space. With increasing number of pixels and corresponding color cells not only the amount of thin film transistors (TFT) will increase but they have to be miniaturized. Miniaturization demands a high degree of precision in manufacturing as well as cleanliness. Most LCD panel manufacturing steps have to be carried out in clean room environment (lithography and wet etching are commonly Class 10 whereas sputtering and plasma enhanced chemical vapor deposition [PECVD] is Class 100 and the rest Class 1000+). A considerable cost and yield factor are the multiple cleaning processes. According to a manufacturer around 80% of defects come from particles on the substrate. Therefore physical and chemical cleaning becomes a key factor for quality improvement. However, extensive cleaning processes are resource and potentially pollution intensive.

Resource conscious improvement of manufacturing yield: In conclusion, from an environmental point of view further development in LCD panel manufacturing should focus on an optimum break even point of yield (output quantity) to resource consumption (input quantity). The authors of the study are limited to this statement. A description of best practice examples or best available technology is not comprehensively possible due to the fast occurring changes from one manufacturing generation to the next, the specifics and complexity of applied LCD manufacturing equipment, as well as the protection of technologies on all levels by intellectual property rights.

The following example of the Toshiba Matsushita Display Technology Co., Ltd (TMD) Ishikawa Plant shows some strategies to reduce global warming potential in LCD panel manufacturing. There is a limiting factor to this example due to the fact that this particular plant does not produce large LCD panel for TV application. However it is an example that indicates best practice. We present the example in form of the original article which was taken from the JFS[20] Newsletter of February 2007. Japan for Sustainability (JFS) is a non-profit communication platform to disseminate environmental information from Japan. Check out website:

Example: LCD plant's efforts to tackle global warming

Towards a Sustainable Japan--Corporation at Work Article Series No.58 An LCD Plant Tackles Global Warming (Toshiba Matsushita Display Technology Co., Ltd.) http://www.tmdisplay.com/tm_dsp/en/index.html

… compared to the final assembly of digital devices and home appliances, the manufacture of LCDs, semiconductors and other electronic device parts consumes massive amounts of energy, and the industry has been called upon to promote in-house global warming measures. As a global corporation that produces digital and electronic devices, social infrastructure, and home appliances, the Toshiba Group is committed to tackling global warming, and is focusing its efforts on its electronic device business because this sector accounts for about 70 percent of the group's total energy consumption (CO2 equivalent), while accounting for only 20 percent of total sales. This article introduces Toshiba Matsushita Display Technology Co. (TMD), part of Toshiba Group's electronic device manufacturing team, focusing on its LCD plant's efforts to tackle global warming. […] The company enjoys a reputation for its technological excellence in the area of small- and medium-sized mobile displays. […] TMD incorporated a wide range of anti-global warming initiatives in a new LCD manufacturing line that was installed in its Ishikawa Plant in November 2005 and started operations in April 2006. Compared with conventional manufacturing lines, the new line is expected to achieve a 53 percent reduction in greenhouse gas emissions.

The new line incorporates three types of anti-global warming strategies, including one that was introduced into LCD manufacturing for the first time. The first strategy was to conserve energy in cooling water used in air conditioning. The LCD manufacturing process requires a highly clean environment in order to maintain product quality, and air conditioning is always used to control cleanliness, temperature and humidity in clean rooms. To regulate room temperature, 14-degree C (Celsius) water suffices, but 6-degree C water is needed to regulate humidity. Formerly, 6-degree water was used to regulate both room temperature and humidity, but the new line uses two systems with different water temperatures: 6-degree water for controlling humidity and 14-degree C water for controlling temperature to increase cooling efficiency with less energy input. Ishikawa Prefecture where the plant is located has severe winters, and another way the company attempts to reduce total energy consumption is to use cold air from outside to cool down the air conditioning coolant water from December to March.

Another strategy was to build a "ballroom" type clean room, and to make effective use of under-floor air-conditioning/recirculation passages. […] Conventional manufacturing lines consume a huge amount of energy because they consist of many small clean rooms for individual work processes. The new line improved space efficiency by eliminating room partitions and completing the manufacturing process in a single clean room. They also aimed to reduce power consumption by cleaning not the entire room but only individual pieces of manufacturing equipment and the transfer system that moves the substrate boards between machines. Ordinary clean rooms are two-storied: the second floor is used for production and the first floor for the passage of dirty air pulled down from the ceiling to the floor by the air conditioning system. The new line attempts to also use the first floor for production. If this idea can be realized, they

[20] http://www.japanfs.org/

can substantially reduce clean room floor space, allowing for further reductions in electricity consumption by air-conditioners, etc.

Ballroom-type clean rooms have been adopted at some semi-conductor plants. However, it was thought difficult to do so in LCD plants, because LCD manufacture uses substrate boards larger than those used for semiconductors. The unprecedented production design of these clean rooms, which incorporated less space for air recirculation passages, was the largest challenge in building the new line. […] The team completed a new clean room design that occupies about 44 percent less floor space compared with conventional designs by incorporating many innovations such as the installation of a cleaning unit on each piece of equipment, a system to control airflow during the transferring and loading of substrate boards, and cleanliness adjustment mechanisms for each process. As a result, the new design successfully reduced the use of building materials and cleaning units, minimizing initial construction cost as well as reducing the amount of energy consumed.

The third strategy was to reduce Perfluorocarbon (PFC) gas emissions. PFC gas, a kind of chlorofluorocarbon, has a greenhouse effect that is thousands to tens of thousands times greater than carbon's. PFC gasses, including CF_4, SF_6 and NF_3, are indispensable in manufacturing LCDs. However, the resulting exhaust gas is resistant to decomposition with water. This gas was emitted directly to the surrounding environment. In the new TMD line, PFC gas emissions were reduced by 90-95 percent by introducing cutting-edge equipment that renders PFC gas harmless by burning and decomposing the gas before adding water to it. TMD also decided to replace NF_3 gas with a type of fluorine that does not have greenhouse effect, and equipped the new line with Japan's first fluorine gas generator. The use of fluorine was known to reduce environmental impacts, but practical use of fluorine on a massive scale, as in mass production of LCDs, has been difficult due to constraints on the pressure and concentration of the fluorine in the process of putting it into a gas cylinder. TMD […] employed a method […] that applies electrolysis to fluorinated acid to generate the fluorine. […] The LCD industry set a worldwide goal to reduce PFC gas emissions to the year 2000's level by 2010. As LCD production is expected to experience a 3- to 5-fold increase by 2010, this target value appears extremely ambitious.

[…] According to preliminary calculations, the new line incorporating all these innovations will reduce greenhouse gas emissions to 28,258 tons of CO_2 equivalent annually, while a comparable conventional line would emit 60,082 tons annually. This achievement is imminent. The engineers who participated in launch of the new line are striving to solve issues in order to achieve further reduction of greenhouse gasses.

Written by Eriko Saijo

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http://www.japanfs.org

6.1.3. Back-Light Engines for Rear Projection Displays

There are currently different optoelectronic technologies for micro-display rear projection TVs in the market. The most commonly used technologies are branded under the names DLP™, 3LCD™, and LCOS. Rear projection TVs work on the principle of projecting a full-color image from a smaller screen through a projection lens on a larger display screen. The image is crated by a set of optics and electronics that illuminates and projects red, green and blue (RGB) light onto the smaller screen. All of these projection systems are currently using Ultra High Pressure (UHP) lamp as a light source. The UHP lamps contain mercury and are said to have a limited lifetime, making replacement a necessity. Power consumption of RP-TVs is mostly related to the UHP lamps. The power consumption in conjunction with the optoelectronic system is difficult to assess due to the variety of technology adaptation. The main systems are shortly introduced followed by an analysis of the backlight engines.

6.1.3.1. DLP System

DLP (Digital Light Processing) is the name for the optical system that uses DMD. DMD (Digital Micro-mirror Device) is a display technology where hundreds of thousands of carefully positioned micro-mirrors are arranged on a semiconductor substrate. Each mirror corresponds to a pixel and projects an image by reflecting the light from the source. 1-chip and 3-chip systems are available. DLP™ (Digital Light Processing) and DMD™ (Digital Micro-mirror Device) are trademarks of Texas Instruments Incorporated. For more information: http://www.dlp.com

6.1.3.2. 3LCD System

3LCD is the most widely used projection technology system. 3LCD technology employs three small high-temperature polysilicon active matrix liquid crystal displays (HTPS LCDs), hence the name 3LCD. In principle white light is divided into red, green, and blue using two dichroic mirrors, which are special mirrors that transmit light with a certain wavelength. Each color is then passed through a dedicated HTPS LCD, before being combined with the other colors in a prism. The prism is formed by combining four triangular poles to create one rectangular solid. High precision is required in the processing and adhesion of poles to avoid dark lines and double images caused by misaligned dichroic surfaces. The image is then ready to be projected via a lens onto the larger front screen. For more information: http://www.3lcd.com

6.1.3.3. LCoS System

LCoS (Liquid Crystal on Silicon) is a reflective LCD display panel with a high open area ratio. Since the wiring area and switching elements are under the reflection layer, it doesn't require a black matrix area, so images are seamless. 1-chip and 3-chip systems are available. 3-chip LCoS rear-projection TVs achieve high performance by utilizing the high resolution characteristics of this element avoiding a color wheel. 1-chip LCoS systems use a sequential optical drive system with a rotation prism mechanism that divides the light into red, green, and blue and projects the picture. LCoS is a reflective technology. Instead of a backlight, light from a projection lamp strikes the liquid crystal cells from the front, hits a mirrored pane behind them then bounces back out toward the screen. JVC calls its own LCoS technology D-ILA or in HD models HD-ILA. Sony's version of LCoS is dubbed SXRD for Silcon X-tal Reflective Display.

6.1.3.4. Ultra High Pressure (UHP) Lamps

UHP lamps are currently used for RP-TVs. Philips developed the high pressure mercury type UHP lamps. The UHP lamp was designed with the ability to maintain small arc gaps by virtue of the fact that its mercury fill operated at pressures over 200 bar as compared to operating pressures prevailing at the time in the vicinity of 50 bar. UHP lamps can reach lifetimes of more than 10.000 burning hours[21] enabled by the regenerative chemical cycle using a patented halogen filling. Adding a certain amount of oxygen and halogen to the lamp atmosphere prevents the tungsten evaporated from the lamp electrodes to condense on the wall, as in the colder regions the tungsten atoms react chemically to form oxyhalide molecules[22]. The need by the projection industry for more light on the screen for its imaging products and the requirements to illuminate ever smaller imaging apertures is not as yet satisfied. There is a demand for lamps that go beyond the performance limits of current UHP lamps in terms of total light output, efficacy, arc gap size and color. Dr. Holger Moench, Principal Scientist at Philips, said in an online interview: “We (Philips) are the innovators and we still innovate, year after year, new lamps. We started with a 100 Watt lamp of this size (holds a larger lamp) and now operate at more than 200 Watt that size (holds a smaller lamp), so miniaturization is one research issue aiming at portable projectors. Another thing is that we extend the lifetime up to 20.000 hours making consumer products realistic[23].

[21] Consumer tests indicate 5000 – 8000 hours as more realistic. DLP TV Review in the internet: http://www.dlptvreview.com/dlptvreviews/projection-lamp-replacement.html (03/2007)
[22] Pavel Pekarski et al: UHP Lamps for Projection Systems, Philips Research Laboratories, Aachen, Germany
[23] http://www.research.philips.com/profile/people/researchers/uhp.html

Environmental performance of UHP lamps are defined by power consumption and containing hazardous substances. Sony is utilizing a 120W UHP lamp (Model XL-5200) in the current LCoS-based (SXRD) 60” RR-TV (KDS-60A2000) which consumes according to catalogue value 210 Watt. Sony also provides a power saving option of this product reducing the luminescence output. Samsung also utilizes a 120W UHP lamp in the current 61” DLP-based RP-TV (SP61L6HX) with TV-set power consumption of 166 Watt. In the specification a lamp life of 8000 hours is given[24]. According to a product safety data sheet for a UHP lamp of Philips Lighting is the mercury content 0.01 – 0.023grams[25].

Issues related to UHP lamps:

- Improvement lifetime
- Miniaturization and lower mercury content
- Fair power consumption

6.1.3.5. Laser-based light sources for RP-TVs

Another controversial development in the field of RP-TV is the so called laser-projection TV. Their advocates claim a long lifetime (50.000 hours) and increased energy efficiency by using two-thirds less power than traditional RP-TV[26]. The Australian chipmaker Arasor International and America-based Novalux showcased first laser-projection TV prototypes based on a Mitsubishi RP-TV in Australia (2006) and at the 2007 Consumer Electronics Show (CES). There are currently legal and financial business disputes connected to the development and application of this technology. It is therefore out of the scope of this study to investigate the technical potential of this controversial technology. In conclusion, lased-based light sources for RP-TVs are not yet available technology.

[24] http://www.samsung.com/au/products/tv/rearprojectiontv/images/SP61L6H.pdf (03/2007)
[25] http://www.hp.com/hpinfo/globalcitizenship/environment/pdf/L1709A_PSDS.pdf (03/2007)
[26] http://en.wikipedia.org/wiki/Laser_TV (03/2007)

6.1.4. Plasma Display Panel (PDP)

PDP is a self-emissive display which generates ultraviolet radiation though a gas discharge and excites phosphor to convert this radiation in visible light. Therefore each plasma cell (pixel) has a controlled light emission depending on the required brightness of the image. As a result, the power consumption increases with a brighter image (high average picture level[27]) and decreases with a darker image (low average picture level). Improving the panel's luminescence efficiency is an important measure for reducing power consumption and only achievable through further PDP technology development.

6.1.4.1. Advanced PDP luminescence efficiency

The Advanced PDP Development Center Corporation (APDC), a joint venture of the three Japanese PDP manufacturers Pioneer, Panasonic, and Hitachi, aims to develop plasma display panels with cell pitch of 0.1mm and average luminescence efficiency of 3 lm/W that corresponds to 0,3mm cell pitch and 10 lm/W. Current PDP-TV cell pitch is 0.3mm and up to 2 lm/W[28]. For example APDC predicts that power consumption can be decreased to less than 70W with a 42" PDP when luminescence efficiency of 10 lm/W is materialized. APDC has demonstrated luminous efficiency of 5,7 lm/W at the CEBIT 2007 in Hannover, Germany (see Figure 3).

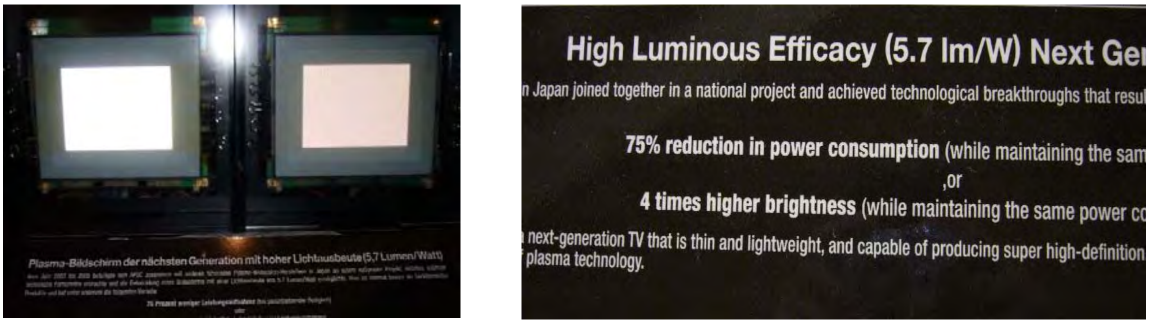

Figure 3: High luminous efficacy PDP at the CEBIT 2007

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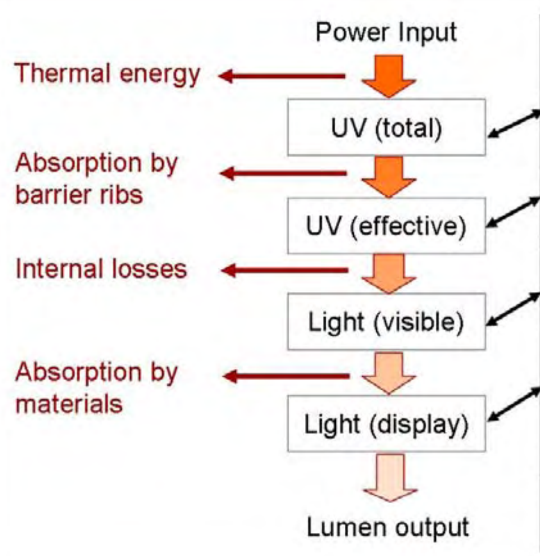
[27] Average Picture Level (APL) is the average luma (Y) level of the video input signal during active scanning time integrated over a frame period; defined as a percentage of the range between reference black and reference white level (Definition following draft version of revised IEC 62087 (2007-03-19).

[28] Advanced PDP Development Center Corporation (APDC) was established in July 2003 to co-develop basic technology for advanced PDPs in league with five PDP companies: http://www.advanced-pdp.jp/fpd/english.html#1 (02/2007)

The two Korean PDP manufacturers LG Electronics and Samsung SDI follow similar technology strategies to improve luminous efficiency. In the year 2005 SDI introduced the HEXA cell structure with a 30µm fine barrier rib that achieved a higher efficiency as a conventional panel design[29]. The Pioneer Corporation has announced on 9 January 2007 the launch of breakthrough new plasma display technology including a Crystal Emissive Layer that the company believes will change the competitive landscape in the flat-screen television market. The new technology premieres a completely re-engineered infrastructure, including a new panel, filter, electronics and drive sequence. Pioneer's exclusive Crystal Emissive Layer is sandwiched between the plasma glass and the individual light cells. This advanced layer helps conduct energy more efficiently so that each cell can be charged and discharged three times faster than before. This technology enables Pioneer displays to emit more light and it also increases contrast. Finally, the Crystal Emissive layer improves luminance efficiency by 22 percent compared to previous models by lowering power consumption. Pioneer is the first in the industry to include Crystal Emissive layer technology.[30]

From various discussions with major PDP manufacturers the following strategies regarding technological measures in conjunction with energy efficiency improvement can be drawn:

- Improvement of panel design and applied materials
- Improvement of drive sequence
- Improvement of drive voltage



Steps	Plasma Display	Florescent Lamp
1. UV Generation (gas discharge)	4%	65%
2. UV Transportation (utilization)	60%	98%
3. UV-Light Transition (phosphors)	20%	45%
4. Light Transportation (visible light)	80%	95%
Total Energy Efficiency	**0.4%**	**27%**
Luminescence Efficiency	**1.1 lm/W**	**76 lm/W**

Figure 4: PDP luminescence efficiency analysis (Source: JEITA 2004)[31]

[29] Displaybank (2005): FPD International 2005, LCD and PDP Panel Company Trends (by Luke Koo)
[30] http://www.pioneerelectronics.com/pna/v3/pg/enhanced/article/0,,2076_310069717_283578751,00.html
[31] http://it.jeita.or.jp/infosys/jeitakouza/kyouzai/waseda/05w_pdp_1.pdf (03/2007)

Figure 4 above shows an analysis of technical processes and resulting factors which determine the luminescence efficiency of PDP. The material was provided by industry with reference to a JEITA seminar on PDP from year 2003. The relatively low efficiency indicates already improvement strategies. According to major PDP manufacturers the general approaches to panel redesign are:

1. For better UV generation
    a. improved gas composition
    b. development of new MgO material for high secondary electron emission
2. For better UV transportation
    a. development of new cell structures for better UV irradiation
3. For better UV-visible light transition
    a. phosphor development and selection
    b. better processing of phosphor
4. For better light transportation
    a. improvement of aperture ratio
    b. ultra fine barrier rib formation under 50µm
    c. improved transparency
5. Improved driving scheme
    a. Improved electrodes control method
    b. New drive chip
6. Energy recovery circuitry for plasma panel
7. Lower drive voltage
    a. reduction of driver power consumption by lower voltage, currently 80 ~ 200 V, active power control

The actual energy saving potential of these measures can not exactly be assessed. It will depend individually from the generation and utilization of higher luminescence efficiency (deriving from new technological solutions) as well as the connected power management trade-offs (deriving from set-making [cp. task 6.2]). The energy saving potential will also depend on the power measurement test procedure. As explained before, energy consumption of PDP is directly related to the dynamic change of the average picture level (APL). A dynamic power measurement procedure, which is drafted for the revised edition of IEC 62087, will provide the best base for measuring the “on (average) mode” power consumption of the PDP. The power consumption data that we have received from manufacturers for their latest PDP-TV products (BAT) indicate the magnitude of energy consumption improvement over the past years.

The data in the following Table 1 indicates the improvement potential in power consumption for the three main PDP screen size segments over the past two years. The power consumption values are best available products in the year 2005, 2006 and 2007. The values for the 2005 and 2006 products are taken from catalogue. They are slightly rounded due to the fact that it is unknown if there were even better performing products at that time. It was not possible to determine the test procedures for these data. We assume however that the values are not rated power consumption values but average on-mode values. The 2007 data have been received from EICTA member and have been tested based on JEITA standard.

Table 1: Power consumption of PDP Best Available Product in 2005, 2006 and 2007

PDP power consumption	37-inch	42-inch	50-inch
2005	300 W	330 W	430 W
2006	240 W	260 W	330 W
2007	191 W	204 W	257 W

The power consumption values in Table 1 indicate a considerable improvement for PDP. However, it is still not possible to determine exactly how much improvement is related to technological measures on the one hand and how much improvement might be related to the measurements procedure. We advise to make comprehensive measurements of TVs (all display technologies) as a first option with the new dynamic video signal under the revised IEC 62087 test standard or – as a second option – with the static 4-bar video signal (former JEITA standard which is integrated into the revised IEC 62087).

In order to indicate the power consumption improvement potential related to the increase of luminous efficiency we discussed the issue with leading PDP manufacturers and asked them to provide an estimate. We like to thank Hitachi, Panasonic and Pioneer for providing an estimate of the improvement potential of PDP. According to this estimate, the average on-mode power consumption of a current (HD-ready) 42” PDP-TV with a luminous efficiency of 1.8 lm/W is approximately 200 Watt. The three Japanese manufacturers expressed their opinion that luminous efficiency for HD-ready PDP could be technically increase to a level of 3 lm/W or (at an absolute maximum) to 5 lm/W by the year 2010. According to Figure 5 could a 42” HD-ready PDP-TV in standard mode (at APL 40%) consume approximately 150W with 3 lm/W technology and only 110 Watt with 5 lm/W technology. The power consumption of the receiver is dropping respectively with the improvement of the luminous efficiency. Further improvement potential derives from improved driver, power supply efficiency and power management. For general approaches see Task 6.2 on set-making.

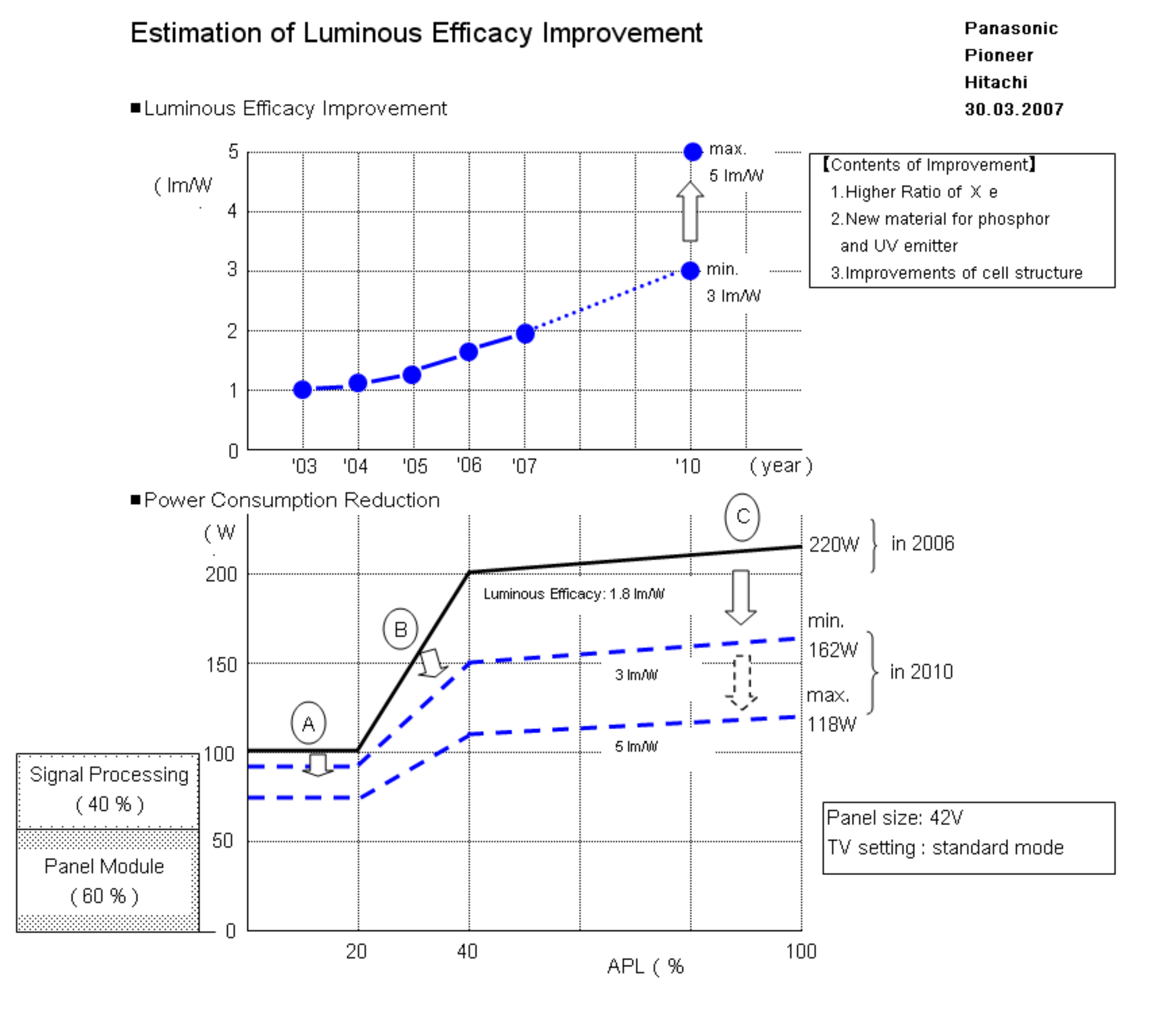


Figure 5: Estimation of luminous efficacy improvement for 42” PDP

Following the stakeholder meeting on May 3rd 2007 a review of the provided data were suggested by the two Korean manufacturers LG Electronics and Samsung. Both companies stated their opinion that the provided assumptions on the improvement potential of luminous efficiency and related power consumption are to high. As a more realistic figure LG Electronics suggested 2 to 3 lm/W for HD-ready PDP-TV and considerably lower efficiency of full HD products. Furthermore, it was indicated that the integration of digital tuners, HDD as well as the enhancement of picture quality will result in increasing power consumption on the receiver side.

In conclusion, the improvement of luminescence efficiency still has the best potential for reducing the overall power consumption of PDP-TVs. However, the improvement estimates provided by Japanese PDP manufacturers have been critically reviewed. The PDP manufacturers agreed that it t seems feasible that HD-ready TVs could achieve a luminous efficiency of up to 3 lm/W by the year 2010. It was also clearly stated that full HD TVs could not achieve 3 lm/W by the year 2010 due to the fine cell structure that is required. The novelty of the full HD PDP technology makes it difficult to estimate the improvement potential. At the present moment full HD products would require considerably more power than similar HD-ready products.

6.1.4.2. Lead free PDP

In November 2006 the Panasonic Corporation of North America announced that they achieved a proprietary lead-free plasma display panel. Lead in PDP is current exempted from the RoHS Directive 2002/95/EC (see Task 1). Lead-oxide glass is used in the dielectric layer, electrodes, glass sealant and other structural elements, primarily because of its capability to stabilize production yield and quality. According to the press release Panasonic has eliminated all of the roughly 70 grams of lead used in a 37” PDP[32].

[32] Online News of Green Supply Line from 27 November 2006: http://www.greensupplyline.com (11/2006)

6.1.5. Slim Cathode Ray Tube (CRT)

CRT is the most mature TV-display technology with no significant improvement potential. One recent development by mainly Korean TV-maker are so called "slim CRTs," which have significantly lower depths than conventional CRTs. One 32-inch slim CRT, for example has a depth of about 35cm, as compared to a conventional 32-inch tube's depth of 50cm. This is a reduction of about 30 percent, and it puts it into a size category that is competitive with a microdisplay RP-TV of similar screen size, at a significantly lower price.[33] The reduction in CRT depth requires a commensurate increase in deflection angle, which in turn requires higher deflection currents to swing the electron beam over the wider angle. Higher currents cause greater heat buildup in deflection coils and their driving electronics. Traditional CRT deflection amplifiers are analog class AB amplifiers, but another innovation is the use of Class D amplification, which employs pulse width modulation rather than traditional analog amplification. Class D amplification significantly increases efficiency and reduces heat buildup in the amplifier circuitry.

Product examples: A new ultra slim 21" CRT-TV was introduced by LG Electronics with a deflection angle of 120 degree[34]. Concerning power consumption limited information are available. For example the rated power consumption of the Samsung WS-32Z429T Slim Fit HD Ready CRT-TV is 160 Watt.[35] According to LG Electronics slim CRT-TVs are highly price competitive up to 32-inch TV market and expected to enter developing markets in Asia, the Middle East and Eastern Europe.

Improvement potential of slim CRT results from:

- Material weight reduction from smaller form factor
- Potentially lower power consumption due to Class D amplification

[33] Randy Hoffner article from 12.07.2005: http://www.tvtechnology.com/features/Tech-Corner/f_randy.shtml (02/2007)
[34] http://www.gizmosinsight.com/2007/03/08/LG-brings-the-world-slimmest-CRT-TV.html (03/2007)
[35] http://www.sdsdigital.co.uk/Samsung-WS-32Z409T-Slim-Fit-HD-Ready-CRT-Television-pr-737.html

6.1.6. Surface-conduction Electron-emitter Display (SED)

FED (field emissive display) is the effort to create a flat panel display based on the CRT principle. There are several companies in Japan, Korea, and the USA which hold patents in FED technology. SED (Surface-conduction Electron-emitter Display) a formerly joint development of Canon and Toshiba seems to be the most promising FED technology with commercial potential[36].

SED is a flat panel display technology that uses surface conduction electron emitters for every individual display pixel. The surface conduction electron emitter emits electrons that excite a phosphor coating on the display panel, the same basic concept found in traditional cathode ray tube (CRT) televisions. This means that SED can combine the slim form factor of LCDs with the high contrast ratios, refresh rates and overall better picture quality of CRTs[37]. The surface conduction electron emitter apparatus consists of a thin slit across which electrons tunnel when excited by moderate voltages (tens of volts). When the electrons cross electric poles across the thin slit, some are scattered at the receiving pole and are accelerated toward the display surface by a large voltage gradient (tens of kV) between the display panel and the surface conduction electron emitter apparatus.

The SED technology has been developed by Canon since 1987[38]. Although market introduction was announced continuously since 2005, the promising SED technology seems still not to be mature enough for mass TV manufacturing. According to a January 2007 press statement from Canon: “SED television sets are to be introduced in Japan in the fourth quarter of this year (2007) as originally scheduled, although Canon will reassess its future mass-production plans for SED panels”. SED panel prototypes (50” and 36”) have been showcased in the past with very good picture properties, small form factor, and low power consumption. These properties were observed during a visit of SED Inc. in June 2006[39]. SED Inc. however did not provide technical specifications and power consumption data for the SED-TV prototypes at the present state of development.

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[36] Canon Inc. and Toshiba Corporation announced an agreement by which Canon will purchase from Toshiba all of Toshiba's outstanding shares of SED Inc., which was jointly established by both companies. On completion of the purchase, SED Inc. will become a wholly owned subsidiary of Canon, effective January 29, 2007. Canon Press Release: http://www.canon.com/press/2007/sed2007jan12.html (02/2007)

[37] http://www.sed-fernseher.eu/what-means-sed-tv (03/2007)

[38] Ibid.

[39] During a demonstration at SED Corporation in Japan the author observed power consumption for a 36 Inch SED prototype panel in a range of 80 to 120 Watts while replaying a high definition video.

Improvement potential of SED results from:

- Potentially very low power consumption
- Good form and weight factor
- No known hazardous substances (except lead in glass frits)

Limiting factors:

- High yield technology/processes for mass-manufacturing seems not mature yet
- Highly competitive market situation (product costs/price pressure)

6.1.7. Organic Light Emitting Diodes (OLED)

OLED was first discovered by Kodak in 1987. Three years later, a research group at Cambridge University, UK, observed similar properties in conjugated polymers, consisting of long carbon chains with alternating single and double or triple bonds. Meanwhile, oligomers and dendrimers are also utilized as OLED materials[40]. OLEDs are self-emissive, highly efficient displays with good optical properties. The OELD electrically excites fluorescent organic compounds to emit light, and performs voltage driving or current driving on a number of organic luminescent cells so as to display images. It has a structure in which a luminescent layer made of an organic compound is put between an anode and a cathode. The OLED for TV application is an active matrix-type, featuring two thin film transistors (TFTs). An OLED has advantages that visibility is high by self color development, an all-solid display superior in impact resistance is provided different from a liquid crystal display, a speed of response is high, little influence of a temperature change is exerted, and a visual field angle is large. In recent years, use as a light emitting device in an image display apparatus has been noticed. The OLED devices may be driven by low voltage direct current (DC), and have short microsecond response times. OLED devices have wide viewing angles and excellent contrast ratios because of their self-luminescence.[41]

However, for mid and large screen applications with long life time (in the case of television displays it is an average of 60.000 hours) technology development is reported to be problematic. Material deterioration and stability are two key issues in that respect. Even though the red and green LEDs have shown long lifetimes of 10,000 to 40,000 hours, the blue component suffered high failure rates after about 3,000 to 5,000 hours. With the current R&D focus on a refinement in

[40] German Flat Panel Display Forum (2004): European Technology Flat Panel Displays, 4th Edition.
[41] Technical discription from: http://www.electronics-manufacturers.com/info/monitors-and-displays/flat-panel-monitor.html

material composition and manufacturing technology for blue LED, this limitation should be overcome soon. Another issue is sealing of the OLED. Without some way to seal the display in a waterproof outer covering the matrix can easily be damaged. These issues add to still high costs of the manufacturing processes[42]. Against that background market research institutions such as MEKO concluded that OLED-TVs will not appear in the market soon.

Somewhat surprising are recent developments indicating that OLED technology is likely to be introduced for small size TVs (under 27 inches). At the "2007 International CES", the trade show of the Consumer Electronics Association on January 8-11 in Las Vegas, OLED prototypes were exhibited. A press statement at the JCN Newswire showed Sony a 27-inch OLED-TV with Full HD panel and an 11 Inch OLED-TV with wide-SVGA panel. The statement reads: "The prospect of mass production of the panels for smaller size OLED-TVs is close to being cleared, and development on the panel for middle / larger-sized is currently under development"[43]. According to media report connected to the 2007 International CES it is assumed that Sony will mass produce small OLED-TVs by 2008[44]. Seiko Epson developed with a 40-inch the so far largest full-colored OLED display with the help of conventional ink printing[45]. Although these prototypes and press statements do not allow us to revise the previous conclusion that OLED-TVs are not "around the corner", it indicates once again the dynamics of the TV display market.

Improvement potential of OLED-TVs results from:

- Potentially very low power consumption
- Potentially low weight and small factor
- Potentially efficient manufacturing processes

Limiting factors:

- High yield technology/processes for mass-manufacturing unclear
- Highly competitive market situation (product costs/price pressure)

[42] Information on the prospect of OLED technology for television display application derives from talks with individual companies.
[43] http://www.japancorp.net/Article.Asp?Art_ID=13958 (03/2007)
[44] http://www.golem.de/showhigh2.php?file=/0701/49819.html&wort[]=OLED (03/2007)
[45] http://www.oled-display.net/amoled-oledtv.htm (03/2007)

6.2. State-of-the art in TV-set making

6.2.1. Power Supply Efficiency

Most TVs feature an internal power supply unit (PSU) as the display or backlight – the main source of power consumption – requires up to couple of hundred Watts for operation. But also video signal processing, display driver, audio components and interfaces need in sum a considerable amount of energy. Power consumption however is not only related to the power draw of single components. The amount of required voltage levels and power conversion steps contribute significantly to the total power consumption due to conversion losses. An efficient PSU and improved power management can safe a high amount of energy. The PSU has to be compliant with IEC 1000-3-2 Class D standard and therefore need an active Power Factor Correction (PFC) to limit the variation of the input voltage in front of the main PSU.

6.2.1.1. Reference Design for PSU η +80% and <1W Standby

As an example, On Semiconductor published in March 2006 the reference design documentation (TND316/D) for a built-in and tested GreenPoint™ solution for a 200W LCD-TV power supply with following specifications:

- Universal input voltage; $90V_{ac}$ to 265 V_{ac}, 47 – 63 Hz
- Main power supply output voltage; 24V/6A, 12V/3A, 30V/1A
- Standby power supply output voltage; 5V/2A, P_{in} <1W when the consumption on the 5V is <80mA.
- PFC compliant with IEC 1000-3-2

According to the reference design performance summary the power supply efficiency for 230 V_{ac} is η 80% at 20% load and η 90% at 80% load. The standby power consumption for 230 Vac (U_{in}) and P_{load} 300mW is given with 800mW and for P_{load} 400mW is 900mW. Regarding the architecture selected for this reference design On Semiconductor makes the statement that "this reference design allows design optimization so that the desired performance is achieved without increasing the component costs and circuit complexity too much"[46]. In conclusion, the reference design demonstrates a high efficient PSU solution and low standby.

[46] On Semiconductor TND316/D (reference design documentation package), page 9, March, 2006 – Rev 0.

6.2.1.2. Miniaturization and System Integration

Particular for medium and large flat panel display TV a high amount of power is required. Thermal management is an issue due to the small form factor of flat panel TVs. The utilization of fans is limited because they are audible. Large heat sinks made of aluminum or copper are expensive and add weight to the whole structure. A further aspect is electromagnetic interference (EMI). As the trend TV design incorporates more electronic components in order to improve functionality. High level of system integration becomes necessary. Higher system integration aiming on a reduction of board surface area and number of electronic components in conjunction with lower voltage and more efficient (low loss) power conversion is the key to improvement.

6.2.2. Housing Materials and Chassis Design

Eco-design measures regarding the housing and chassis of TVs are mostly material related. But also a reduced number of parts (e.g. screws), the methods for fastening components and easiness of assembly and disassembly are good measures to improve the eco-efficiency of a TV-set. In terms of housing and chassis materials there are following trends:

- Utilization of high-value plastics (e.g. PC/ABS which uses phosphorus flame retardants)[47]
- Utilization of recycled plastics (e.g. PC/ABS which is readily recyclable)
- Utilization of renewable materials (bio-plastics and bio-paint)
- Use of chlorine and bromine-free flame retardants (today already mostly phosphor based).
- Substitution of multi-layered or painted plastics
- Substitution of chromium-based protective coatings

Halogen-free PE housing and bio-painted stand
(Eco-Products 2006, Tokyo, Japan)

Chromium-free back side and screws
(Eco-Products 2006, Tokyo, Japan)

Figure 6: Examples of BAT in housing materials

6.2.2.1. Trend towards bio-plastics

Research is under way to develop plastics that use plants (bio) as feedstock. Engineering versions of these bio-plastics are hybrids of oil- and plant-based feedstock preserve property benefits of existing polymers such as PBT or nylon in order to maintain stiffness, durability and other

[47] Stakeholder commentary added. Dr. David Harrison of Bayer Material Science (25 April 2007): "A change relates to your inclusion of ABS as a high value plastic. Unfortunately, phosphorus flame retardants cannot be used with ABS, and instead brominated flame retardants are usually used. For this reason, we would propose using PC/ABS blend (polycarbonate/ABS) as an example of a high value plastic which uses phosphorus flame retardants and is readily recyclable."

properties needed for technical applications, and actually provide some improvements, particularly in surface finish. Bio-plastics for consumer electronics are usually based on modified polylactic acid (PLA) or corn starch. An example for TV application is not known. However, bio-plastics have a considerable improvement potential as the following example of Fujitsu shows. According to a recent article at the design news for mechanical and design engineers, one metric ton of bio-plastics generates between 0.8 and 3.2 fewer metric tons of carbon dioxide than one metric ton of petroleum-based plastics[48].

Fujitsu Push Bioplastics

Design News: http://designnews.com/article/CA6426809.html?nid=2334&rid= (03/2007)

One of the leading players is Fujitsu, which is using a PLA hybrid developed by Toray Industries to make the housing for its FMV-BIBLO notebook PC series Introduced two years ago. The Toray material, called Ecodear, is aimed at fibers, textiles, molded parts and films. Fujitsu and Toray first attacked the problem in 2002 with a pure PLA. The material, however, lacked adequate flame retardance and was not moldable because of its low temperature resistance. They decided to combine PLA (50 percent) with a proprietary amorphous oil-based plastic to achieve the required properties. Toray is now bringing on line a $9-million plant in South Korea to produce PLA. Annual capacity is 5,000 metric tons a year. Korean packaging converter Saehan is a 10 percent investor. Packaging in South Korea is now being rapidly converted to biodegradable PLA, a trend still in its nascent stage in the United States. Toray is also developing nano additives to use in PLA film. One interesting note: until recently PLA was only used because it is biodegradable. The Fujitsu hybrid material is not biodegradable. In fact, Fujitsu does not want the notebooks placed in landfills, where toxic metals could cause pollution. The goal is to increase recycling of the plastic components. Just recently, Fujitsu announced another turn. The company is now developing with French chemical producer Arkema a bioplastic based on castor oil that provides more flexibility than can be achieved with corn-derived plastics. The goal is to expand use of bioplastics in notebook computers. Castor oil is used because it is a source of nylon (polyamide) 11. A Fujitsu spokesman commented: “By weakening the interaction of the chain molecule in PA-11 and relaxing the stereoregularity of their organization, the resulting new material has sufficient flexibility to withstand repeated bending without causing the whitening that often occurs when such materials are strained.” Prototypes of PC cover components consist of 60-80 percent of the new bioplastic, an unparalleled achievement to date. High-density fillers are added to increase strength. Fujitsu’s goal is to use the materials for notebook covers, and other applications requiring high impact resistance. Fujitsu also hopes to begin using the material in mobile phone covers too. The new material cuts carbon dioxide emissions 42 percent compared to oil-based nylon 6/6, according to Thomas Grimaud, Arkema’s technical polymers business manager.

[48] Doug Smock, Design News 3/22/2007 6:38:00 AM: Toyota, Sony, Fujitsu Push Bioplastics; in the Internet: http://designnews.com/article/CA6426809.html?nid=2334&rid= (03/2007)

6.3. State-of-the art in TV power consumption

6.3.1. Standard On-Mode Power Consumption

BAT for on-mode power consumption is difficult to determine due to the variety of benchmark criteria and measurement methods (standards) that could be applied. The on-mode power consumption is directly related to the pictures brightness and quality (e.g. color gamut, motion blur, contrast). Furthermore increase integrated features such as additional tuners, picture improvement, and video recording technologies the power consumption. The differences in power consumption measurement standards also contribute to the resulting values. The rated power consumption does not reflect real use. Therefore standard on-mode power consumption as it is newly defined by IEC 62087 applies much better. But at this moment there are only few comparable BAT values available. Table 2 provides a compilation of best available TVs with a distinction by technology and screen size as well as values from different sources for comparison. As a reference value we use the average power consumption per segment based on 2006 HD-ready TV catalogue values.

Table 2: Best available products regarding power consumption

Technology	Size	26/27"	32/33"	36/37"	42/43"	50/52"
CRT-TV	Average CRT	100 W	130 W			
	EcoTopTen 2006 (DE)	84 W	94 W	xx	xx	xx
	MPT Testing 2006 (UK)	xx	xx	xx	xx	xx
	METI TopRunner 2006 (JP)	xx	xx	xx	xx	xx
	EICTA Member 2007 (EU)	xx	78 W	xx	xx	xx
	Company Catalogue 2006 (EU)	65 W	100 W	xx	xx	xx
LCD-TV	Average LCD	120 W	150 W	180 W	220 W	275 W
EcoTopTen 2006 (DE)		70 W	85W/ 124W	159 W	xx	xx
MPT Testing 2006 (UK)		xx	112 W	xx	xx	xx
METI TopRunner 2006 (JP)		105 W	104 W	160 W	246 W	322 W
EICTA Member 2007 (EU)		104 W	109 W	168 W	203 W	280 W
Company Catalogue 2006 (EU)		70 W	85 W	100 W	140 W	230 W
PDP-TV	Average PDP			250 W	330 W	410 W
EcoTopTen 2006 (DE)		xx	xx	xx	240 W	xx
MPT Testing 2006 (UK)		xx	xx	xx	285 W	xx
METI TopRunner 2006 (JP)		xx	xx	270 W	288 W	343 W
EICTA Member 2007 (EU)		xx	xx	191 W	204 W	281 W
Company Catalogue 2006 (EU)		xx	xx	241 W	251 W	257 W
RP-TV	Average RP				175 W	190 W
EcoTopTen 2006 (DE)		xx	xx	xx	xx	xx
MPT Testing 2006 (UK)		xx	xx	xx	xx	173 W
METI TopRunner 2006 (JP)		xx	xx	xx	xx	xx
EICTA Member 2007 (EU)		xx	xx	xx	xx	xx
Company Catalogue 2006 (EU)		xx	xx	xx	175 W	175 W

6.3.2. Standby Mode Power Consumption

6.3.2.1. Passive Standby

BAT regarding low standby power under 1 Watt are in the market already. Existing products from brand name manufacturers show that passive standby functions (timer, remote control, soft switch and network activation) can be accomplished with less than 1 Watt. According to our own compilation of power consumption data for 274 HD-ready TVs from product catalogues of the year 2006, over 30% of the devices had 1W standby power or less. Panasonic is currently promoting 300mW standby power for their 2006 products[49]. Philips aims to lower standby below 200mW in televisions by 2008[50]. A passive standby of 100mW for TVs was reported for the CRT-TV prototype that has been designed in the German “Green TV project” in the late 1990s. Mr. Siderius of SenterNovem confirmed this information at the stakeholder meeting on 3 May 2007 in Brussels.

6.3.2.2. Active Standby low

BAT regarding active standby low was provided by Loewe AG (Germany) in a statement form 27 April 2007 addressed to the authors of this report. According to this statement has Loewe AG achieved a power consumption in standby-active-low of only about 1,8 Watt in spite of the additional functions and the integrated Sat-Receiver, DVB-Tuner and Hard Disk Recorder. Loewe confirmed that a further reduction would be technically possible although: “from the actual point of view a value of 0,7 Watt (meaning < 1 Watt) is hard to reach with a high development expenditure and with a reduction of function for the user. A value of < 1 Watt means also a concept revision but can be reached within a period of 2 years a BNAT.

6.3.2.3. Active Standby high

BAT for active standby high can not be provided due to uncertainties regarding the functional spectrum which is covered by this mode. Stakeholder comments however indicated that channel, program and software updates require approximately 20 Watts.

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[49] This information was given at a meeting with Panasonic on Match 19th 2007.
[50] Philips Sustainability Report 2006, page 19.

EuP Preparatory Studies "Televisions" (Lot 5)

Final Report on Task 7 "Improvement Potential"

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Berlin, 2nd August 2007

Content

Introduction

This is the final report on Task 7 “Improvement Potential” for the EuP Preparatory Studies on televisions (lot 5). The findings presented in this report are results of the research conducted by the IZM consortium and the continuous feedback from a wide range of stakeholders. The statements and recommendations presented in the final report however are not to be perceived as the opinion of the European Commission.

We like to acknowledge the fruitful collaboration and trustful working relationship with various industry partners, non-industry stakeholders, and the European Commission throughout the study. We like to thank all stakeholders for their contributions and critical reviews of our reports.

2nd August 2007

7 Improvement Potential

7.1. Options

The identification and description of individual design options for environmental improvement is the given task of this chapter. In accordance with the interim results of the study the main focus of improvement and therefore the identification of improvement options are placed on the reduction of power consumption in the use phase as well as for standby. The second aspect is the identification of improvement options regarding material composition including the reduction of substances that bear a health, safety or environmental risk factor, physical design and recycling with the goal of improving the resource efficiency of TVs over the whole life cycle. In reference to the specific technological differences of the 32” LCD-TV and 42” PDP-TV bases cases and the outlined key environmental aspects (energy and resource efficiency), the following structure of analysis is proposed:

- Power consumption improvement options for LCD
- Power consumption improvement options for PDP
- General eco-design improvement options for all TVs

As for the identified technical improvement options the analysis provides a qualitative assessment of the environmental impact reduction (excellent [+ + +] >25% improvement, very good [+ +] 10 to 25% improvement, good [+] 5 to 10% improvement, and marginal or less than 5%) status of proliferation or limitations to availability (e.g. proprietary technology) as well as a qualitative cost estimate. Based on this assessment a set of options will be clustered in order to estimate the actual improvement potential for products.

7.1.1. Power Consumption Improvement Options for LCD

The following Table 1 summarizes LCD specific power consumption improvement options. The details of new technologies and technical measures have been already described in Task 6.1. The table provides a qualitative or if possible quantitative description of the improvement potential. These evaluations derive from comparisons of conventional technologies/products with best available technologies, discussions with industry partners and other sources. It is important to recognize that a precise evaluation of the improvement potential of single measures as well as related cost factors is very difficult. The improvement potential depends on the maturity and availability (proprietary technologies) of a solution. It also depends on the particular application or realization. In order to provide a reference value we have based the evaluation on a 32” LCD-TV.

Table 1: Power Consumption Improvement Options for LCD

Option	Specification of improvement	Improvement potential	Cost factor / availability
BLU driver / inverter circuitry improvement	Advanced BLU driver / inverter circuitry with electrical efficiency of η 80 to 85%.	Good (+)	Cost neutral electronic components and board design (cost trade-off possible)
Complete dimming of BLU	Scaling of the complete backlight is state of the art and results in an increase of the energy efficiency of the LCD. The effective reduction in power consumption depends on the whites point (APL) of the shown video image.	Good (+)	Cost neutral electronic components and board design (cost trade-off possible)
Partial dimming of BLU	Advanced BLU dimming reduces power consumption of single lamps selectively (e.g. the black strips on top and bottom of a picture that occur when displaying wide screen movies).	Very Good (+ +)	Cost increase electronic components and board design (cost trade-off possible)
Ambient brightness related dimming of BLU	Advanced BLU dimming (complete and partial) in relation to the ambient brightness conditions. Light-sensor with controller board necessary. Further improvement of energy efficiency possible if consumer utilizes this feature.	Good (+)	Cost increase sensor integration and controller board
EEFL-BLU	New - commercially available - BLU type with lower rated power consumption and simpler circuitry design. In combination with BLU dimming technology very good energy saving potential. Lower mercury content (<4 mg) than CCFL.	Very Good (+ +)	Cost neutral or down limited availability for larger size LCD-BLU (cost trade-off possible)
LED-BLU	Very new – not yet mature – BLU type allegedly very high power saving potential due to low power requirements and capability of image controlled selective dimming. No known hazardous substances (however, material composition diverse, manufacturing and electronic packaging unknown).	Excellent (+ + +)	Cost increase (+ +) currently very limited availability, could improve with mass application within next five years, IP issues unknown
LCD panel design	General improvement of optical properties of functional layers, color filter and pixel design (e.g. RGB + White pixel), electrical driving scheme resulting in higher light utilization. This in turn can reduce the number of necessary lamps and power consumption accordingly.	Unknown	Unknown proprietary technology
Efficient polarizer / fewer lamps	Reflective polarizer (e.g. marketed by 3M) or prismatic film achieves a higher utilization of the lamp's randomly emitted light. This in turn can reduce the number of necessary lamps and power consumption accordingly.	Excellent (+ + +)	Cost increase (+ +) proprietary technology
Efficient switched power supply unit	The improvement of the electrical efficiency of the main PSU up to 85% or 90%	Very good (+ +)	Unknown electronic components and board design, (cost trade-off possible)
Direct power supply for BLU	Direct power conversion from mains input to BLU. Avoid lower voltage intermediate steps. Very good potential for electrical efficiency improvement.	Very Good (+ +)	Unknown BLU supplier relation issues, power board design

7.1.2. Power Consumption Improvement Options for PDP

The improvement of power consumption of PDP-TVs is mostly related to the technological improvement of the plasma display panel’s luminescence efficiency. Advanced panel technologies contain improvements of cell structures (shape, pitch, deepness, etc.), functional materials (phosphors, gas composition, etc.) and improvements in the electrical driving schemes (see task 6.1.4). The Japanese PDP manufacturers Panasonic, Pioneer, and Hitachi provided estimates on the expected luminous efficiency development for HD-ready PDP-TVs. In 2007 the best available technology (BAT) for a HD-ready PDP-TV features 1.8 lm/W. This luminous efficiency relates to a maximum power consumption value of 120 Watt for a 42” PDP (panel with driver but without receiver, signal processing, etc.). Until 2010 these Japanese manufacturers forecasts to achieve for HD-ready plasma panels 3 lm/W luminous efficiency, which would be equivalent to a maximum power consumption value of 80 Watt for a 42” PDP (panel with driver but without receiver, signal processing, etc.). If this technology is achieved it would be an excellent improvement. The target for long-term development is set on 5 lm/W for HD-ready. The details of such technology development have been already described in Task 6.1.4.

During the stakeholder meeting on 3 May 2007 in Brussels the two Korean PDP manufacturers, LG Electronics and Samsung, have raised concern regarding the possible improvements for PDP. They indicated that 2 to 3 lm/W luminous efficiency is a more realistic assumption for the reference year 2010. In this context the industry also pointed to the fact that these improvements only apply to HD-ready products and not to full HD products. Full HD is considered a completely new technology due to the required finer cell structure. Against that background are the improvement potentials described at this point only relevant for HD-ready PDP-TVs.

Table 2 provides a qualitative or if possible quantitative description of the improvement potential for HD-ready PDP-TVs. As in the case of LCD-TVs it is very difficult to make precise evaluation of the improvement potential due to the unknown technical specifications and other market relevant factors (e.g. the introduction of new full HD technology). In order to provide a reference value we have based the evaluation on a HD-ready 42” PDP-TV.

Table 2: Power Consumption Improvement Options for PDP

Option	Specification of improvement	Improvement potential	Cost factor / availability
PDP design for 3 lm/W luminescence efficiency	Technology specific improvement of the cell structure, material composition, electrical and optical design, and integrated energy recovery circuitry resulting in higher luminescence efficiency. (full HD need attention)	Excellent (+ + +)	Cost neutral or decrease Decrease in power consumption makes costs for circuitry and heat sinks decrease (proprietary technology)
PDP driving scheme improvement	Active brightness / power control Driving scheme improvement is achieved by improved signal processing algorithm (chip design and software)	Good (+)	Cost neutral (proprietary technology)
Thermal management without fans	Improved luminance and power supply efficiency could make cooling fans obsolete.	Good (+)	Cost decrease
Efficient switched power supply unit	The improvement of the electrical efficiency of the main PSU up to 85% or 90%	Very good (+ +) potential 10% to 20% decrease in power	Unknown electronic components and board design, (cost trade-off possible)
Lead-free PDP design	Substitution of Lead in glass frits etc.	Good (+)	Unknown (proprietary technology)

7.1.3. General eco-design improvement options for all TVs

Eco-design improvement in TV-set-making derives from further improvement of power supply efficiency (see schematic designs of LCD-TV and PDP-TV in Figure 1), targeting lowest standby power, miniaturization of electronic boards, general material and weight reduction, the utilization of environmentally benign materials for housing, and other general design measures.

Figure 1: Schematic Design of TV

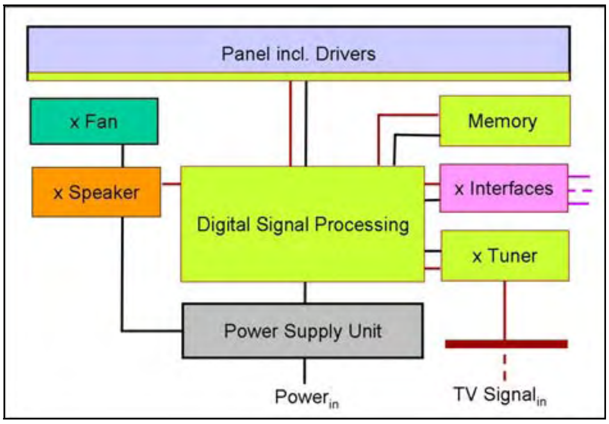


Table 3 provides a qualitative or if possible quantitative description of the technical options for improved energy efficiency.

Table 3: Energy Efficiency Improvement Options for TVs

Option	Specification of improvement	Improvement potential	Cost factor / availability
High Efficient PSU (η 85% - 90%)	Optimized power supply architecture (dimension) with specific electronic components choice and board design.	Very good (+ +)	Cost increase or neutral Possible utilization of proprietary technology
Fewer Voltage conversion stages	Multiple power conversion increases losses. A reduction of power conversion steps has a very good potential to reduce power consumption.	Very good (+ +)	Cost neutral or down (difficult to achieve)
Reduced power consumption of tuner and DSP, non-volatile memory	Utilization of low power components and improved power management. Non-volatile memory is mainly used already. Signal and picture processing power increases with full HD.	Very good (+ +)	Cost increase or neutral (Possible utilization of proprietary technology)
Passive Standby reduction under 1W	Related to PSU design. State of the art is ≤1W, lowest standby down to 0.3W is BAT. In standby all unnecessary components (functions) should be disabled (processor)	Good (+)	Cost increase or neutral
Active (network) Standby reduction	Active standby for downloading programs and information should be time limited. Tuner /DSP function is critical point of improvement (use of timer)	Good (+)	Cost increase or neutral
Alternative power supply for remote control	e.g. solar powered	Marginal	Cost increase

Table 4 provides a description of technical options for improved resource efficiency and low toxic potential. Some of the improvement potentials (particularly regarding material choice and related resource efficiency) only materialize under certain frame work conditions such as matching supply conditions or recycling schemes.

Table 4: Material and Design Improvement Options for TVs

Option	Specification of improvement	Improvement potential	Cost factor / availability
Miniaturization of electronic boards	Higher system integration aiming on a reduction of board surface area and number of electronic components	Good (+)	Unknown (cost trade-off possible)
Reduction of the number of parts	Amount of screws, cable, metal or plastic parts, etc.	Good (+)	Cost down
Reduction of product weight	Physical design of frames, chassis, thermal management elements (heat sinks, fans), etc.	Good (+)	Cost down
Reduction of parts or materials that need special treatment at product end-of-life	Reduction of Hg containing LCD-BLU. Reduction of lead in display panels. Reduction of PVC in cables. Use of bromine and chlorine -free flame retardants (today mostly phosphor based).	Good (+)	Cost increase or neutral
Utilization of hybrid or full bio-plastics	Modified Poly Lactic Acid (PLA), corn starch based polymers, etc. Only eco-friendly when energy efficient material supply (e.g. transport and processing) is realized.	Good (+)	Cost increase (long-term cost trade-off possible)
Utilization of recycled materials	Recycled polymers (e.g. PC/ABS) for housing.	Marginal	Unknown (cost trade-off possible)
Avoidance of color layered (painted) or sandwiched plastics	Composite materials and surface finished (painted) plastics increases the treatment efforts during recycling. Homogenously dyed plastics are the better option.	Marginal	Unknown
Component lifetime improvement and repair friendliness	Quality of power supply unit and main components such as the display. However be aware that continuous power efficiency improvement could make faster exchange of product feasible	Marginal	Cost increase However, advantage could be generated trough life cycle cost reduction
Design for Recycling	Easy disassembly of main components: Display (if applicable mercury containing BLU), electronic boards, steel frames and chassis, large heat sinks, etc.	Marginal Depending on actual recycling schemes	Cost increase Optimized recycling scheme could provide cost incentive
Reduction of packaging material and volume	Optimum utilization of space, use of recycled materials or materials that is easy to recycle.	Marginal / Good (+)	Cost neutral

7.2. Impacts

This task focuses on a quantitative assessment of the environmental improvement options. The given methodology (MEEuP) requires making this assessment by utilizing the VHK EcoReport. As a matter of fact not all possible improvement options can be assessed sufficiently due to the limited availability of material or component specifications. Some improvement options are proprietary technologies but assumed to be widely implemented (e.g. high efficient polarizer). Such options will of cause add to the overall improvement potential. The reduction of power consumption in on-mode is the main target of improvement, followed by other measures to improve energy and resource efficiency. The improvement of resource efficiency through means of miniaturization (incl. weight reduction), the utilization of renewable or efficiently recyclable materials (easiness of end-of-life treatment), and physical design (easiness of assembly and disassembly) are important aspects that have to be promoted but difficult to assess individually. The improvement options that will be assessed in this task follow this priority list. Regarding the display specific options for the reduction of power consumption it seems necessary to assess two alternatives:

- BAT: Best Available technology with assumed fast implementation, low cost factor and high proliferation potential
- BNAT: Best Not yet Available Technology with assumed long-term implementation and higher costs

The formulated improvement options are only in one case – the backlights – a specific technology. For all other improvement options we refer to an unspecific set of technology measures. This approach is necessary due to the complexity of some technical solutions (e.g. power supply design). It is impossible to describe each and every design option with technical specifications. However, it is possible to formulate an improvement target – such as standby power consumption or the average electrical efficiency of a power supply unit – based on best available technology. It is also important to understand that an adaptation of a single technology not necessarily means that a certain improvement is achieved. In most cases additional design measures have to be taken, in order to realize (integrated) a new technology into an overall design. This combination of measures (options) has to be simplified in order to make an impact assessment. The assumed target values will provide that base for the impact assessment. In order to indicate the improvement potential in more details the study provides also a comparison of standard technology with the best available technology (option).

7.2.1. Impact assessment of BAT improvement option for TV

Table 5 summarizes a set of BAT (and BNAT) improvement options with comments for the 32" LCD-TV and 42" PDP-TV base case. The BNAT options will be discussed in task 7.5

Table 5: Improvement options for TV base cases

No	BAT Improvement Option	BNAT Improvement Option	Comments
1 LCD specific	EEFL backlight unit (BLU) for LCD-TV (with the potential of full or single lamp backlight dimming) EEFL-BLU has <4mg mercury	LED backlight unit (BLU) for LCD-TV (with the potential of area specific backlight dimming) LED-BLU is mercury-free	Efficient reflectors and polarizer could reduce the dimension of the BLU (number of lamps, etc.). Power supply efficiency & BLU driving scheme adds improvement potential. Full HD and picture improvement technology (e.g. wide color gamut) is potentially increasing power demand. This issue has to be addressed in set-making.
2 PDP specific	Unspecific set of measures to achieve 2 - 3 lm/W luminescence efficiency for HD-ready PDP-TV Panasonic introduced proprietary Lead-free PDP in late 2006.	Unspecific set of measures to achieve 3 - 5 lm/W luminescence efficiency for HD-ready PDP-TV	Full HD technology is in an early stage and can not achieve such high luminescence efficiency yet. Fast improvement of full HD plasma panels is necessary.
3	Unspecific set of PSU design measures to achieve η 85% efficiency of power supply	Unspecific set of PSU design measures to achieve η >90% efficiency of power supply	Fewer voltage steps and optimize PSU dimension adds improvement potential. Thermal management without cooling fans.
4	Unspecific set of standby power supply design measures to achieve ≤1 Watt passive standby Unspecific set of standby power supply design measures to achieve ≤2 Watt active standby low (current BAT is 1,8W)	Unspecific set of standby power supply design measures to achieve ≤0,5 Watt passive standby Unspecific set of standby power supply design measures to achieve ≤1 Watt active standby low	Active standby modes potentially increase power consumption. TVs with active standby low mode should supply option to set the TV in a lower power mode (passive standby or off-mode) via remote control or switch on the device Standardization necessary for active standby functionality and measurement (test) procedure.
5 → →	Utilization of bromine and chlorine-free recycling specific plastics for housing 5.1 Plastic housing optimized for thermal energy recovery (e.g. PE) 5.2 Plastic housing optimized for material recycling (e.g. PC/ABS)	Utilization of bromine and chlorine-free hybrid or full bio-plastics for housing 5.1 Plastic housing optimized for thermal energy recovery (e.g. PE) 5.2 Plastic housing optimized for material recycling (e.g. PC/ABS)	The recycling infrastructure and technology 15 to 20 years from now is not predictable. As a trend, (bio-)plastics should be utilized that contain no or very low admixtures of sulfur or nitrogen which is better for thermal energy recovery (thermal recycling). The use of dyed plastics (avoid coatings) and bromine and chlorine-free flame retardants is suggested.

7.2.1.1. BAT Option 1: EEFL Backlight with Dimming Technology for LCD

The BAT improvement option 1 for the reduction of on-mode power consumption of HD-ready LCD-TVs is the utilization of an EEFL (External Electrode Fluorescent Lamp) backlight unit (BLU). EEFL is an energy-saving fluorescent lamp technology with possible limits in availability for LCDs of 40-inch and larger. We assume that an EEFL-BLU consumes approximately 10% to 15% less power that a conventional CCFL-BLU of the same size. This improvement potential is related to the approximately 2 or 3 Watt lower power consumption of a single EEFL lamp (although 20% more lamps are necessary) as well as an optimized inverter design. The magnitude of the environmental improvement potential for this option can be increased through further measures related to the backlight and panel design as well as higher power supply efficiency and active dimming. The utilization of efficient reflectors and polarizer could reduce the number of lamps in the backlight unit. Such measures have a very good improvement potential and are highly recommended. Due to the high voltage requirement of the EEFL backlight it should also be considered to improve the power conversion efficiency through optimized (direct) supply architecture. Finally, the active dimming of the EEFL-BLU could improve the overall energy efficiency. All of these measures are state of the art and have been implemented by industry to some extent.

In summary, it is feasible to assume that a combination of these measures could improve the average on-mode power consumption of a 32” LCD-TV by 15% to 30%. The BAT improvement option should be achievable within one or two redesign cycles. As for full HD LCD-TVs power consumption is expected to increase. The improvement potential for full HD LCD-TVs can not be assessed at this point of time due to the novelty of this technology.

7.2.1.2. BAT Option 2: 3 lm/W technology for PDP

The BAT improvement option 2 for the reduction of on-mode power consumption of PDP-TVs can only be specified by the target of the improvement. This is a 2 - 3 lm/W technology for HD-ready PDP, expected by manufacturers to be available in 2010. The improvement of luminescence efficiency through a continuous development of PDP technology (see task 6.1.4) is the key to the reduction in power consumption. Further contributions are power management measures such as ambient brightness control and optimized driving circuitry. If a 3 lm/W is realized manufacturers assume that the panel consumes 40% less power which result in an overall reduction of power consumption for a 42” PDP-TV of 25% 30%. This improvement potential for PDP-TVs in general is realistic due to the fact that only five manufacturers of PDP (panels) are in the market (worldwide). Although competition is strong the mutual interest of all manufacturers is to establish PDP as a mature and efficient technology for large TVs. This motivation becomes obvious when comparing the improvement in power consumption over the past years of products from all PDP manufacturers. A further aspect related to an improved panel design is lead-free, as it was demonstrated as a proprietary technology by Panasonic in 2006.

The improvement potential for full HD PDP-TVs can not be assessed at this point of time due to the novelty of this technology.

7.2.1.3. BAT Option 3: 85% average efficiency of power supply (PSU)

The BAT improvement option 3 regarding the reduction of on-mode power consumption is universal for all TV display technologies. It comprises an unspecific set power supply design measures with the target of improving average power supply efficiency towards η 85%. The measures that can be taken for reducing the power conversion losses are ranging from the power supply architecture design (dimensioning) to the application of advanced components and circuitry designs. The PSU efficiency varies in accordance to the power conversion requirements. Fewer voltage levels and smaller magnitudes of voltage steps are preferable. As supply voltage levels drop and currents rise, the task of powering analogue and digital tuners, DSPs, and other elements in the system is becoming more difficult. Multiple power conversion on very low voltage levels is also not efficient. The improvement potential is of this option is related to the reduction of power losses. An assumed PSU efficiency improvement of η 85% would reduce power conversion losses by a maximum of 40% which results in approximately 10% reduction in average on-mode power consumption of a TV.

7.2.1.4. BAT Option 4: Passive Standby under 1 Watt

The BAT improvement option 4 focuses on the reduction of standby power consumption. The reduction of passive standby power to a level of ≤1W is best available technology. Passive standby functions are defined according to EuP Preparatory Studies Lot 6 as:

- Active control circuits: memory, microcontroller, power management, setup
- IR sensor, or remote control receiver
- Status displays, LEDs, clock
- Timer function possibly for recording, or for checking for updates at specified time

Technical measures for reducing passive standby power are related to a reduction of functions, an improved power supply efficiency in the low-load or no-load modes (η >75%), partial deactivation of main parts of the power supply, or the utilization of a separated standby power supply unit. The use of non-volatile memory (storage) is common. These measures are assumed to be cost neutral and feasible for immediate implementation. The improvement potential is relative depending on the initial situation. Based on the standby power scenarios (cp. task 5.4.2) a reduction of passive standby to ≤1W improves total power consumption ratio over the use life by 3% to 10% depending on the screen size of the TV.

A critical point in the discussion of standby power consumption is the trend towards active standby. Active standby is the capability to activate and operate components of the TV for receiving and storing broadcast signals (e.g. for program download). Active standby is currently an issue for TV peripherals such as set-top boxes and video recorder. It is feasible to expect that in the near-term future more TVs will feature integrated digital tuners/decoders, IPTV modems, and video recording/storage devices (DVD, HDD). In this case active standby power consumption becomes an issue.

Active standby low – the capability to recognize a broadcast signal – could require that an integrated tuner is continuous active. Active standby high – the capability to download and store a broadcast signal – demands a further activation of processors and recording/storage devices. Related power consumption is assumed to be at least 10 to 20 Watts. However, this active standby high functionality is according to EuP Preparatory Study Lot 6 (standby and off-mode losses) out of the standby definition scope, because the TV provides a main function. The Lot 5 study supports this standby definition. That keeps the aspect of active standby low as an issue of discussion with all stakeholders (incl. TV broadcast enterprises). Based on current technology active standby low can not be achieved with average <1W power consumption. The current BAT is 1.8 Watts.

Active standby high – the capability of receiving and downloading a broadcast signal – is a functionality that should not be considered standby but “time limited active mode”. A revised definition and standardization regarding framework conditions of active standby high should be considered under IEC 62087. It is also necessary to define the procedure for measuring active standby power consumption. The idea is to determine average active standby power consumption over a certain time period (e.g. as Wh/h, over a certain time period such as 20h per day). This would allow to incorporate shorter periods of active standby (some Watts over a period of a couple of minutes) and still achieve <1W in total over a 20 hours period in the mid-term.

A second aspect related to the standby issue is off-mode. Adding a primary side hard-off switch (Zero Watt) would be the ultimate measure for potentially reducing power consumption. This "potentially" indicates the pros and cons related to such a measure, because the power saving effect depends on the utilization behavior of the user. The integration of a primary side hard-off switch compensates standby functionality. As said before, the user is the critical link. If the user does not demand standby functionality and actively switches the TV off than it is possible to exploit an additional energy saving potential. This potential is considerable in case of avoiding continuous active standby power consumption. The assumed additional costs (switch plus mains voltage cable) are less than 3 Euro. If a TV only provides passive standby functionality with <1W or even 0,5W the energy saving potential is marginal and the integration of a hard-off switch might overcompensate (additional resources) the energy saving effect.

In conclusion, the integration of a primary side hard-off switch (0W) should not be considered mandatory for TVs. However, TVs with active standby modes should provide the user with the option to set the TV in a lower power mode such as passive standby or off-mode via switch/push button on the remote or on the front side of the TV.

7.2.1.5. BAT Option 5: Chlorine and bromine-free plastic housing optimized for recycling

The BAT improvement option 5 focuses on the topic of resource efficiency. In the long-term resource efficiency will grow in importance. Design measures that support the recovery of genuine material fractions at the product's end-of-life is a general requirement. Particular options for a Design for Recycling (DfR) however are not feasible to provide. Plastic material for housing (chassis) is one example. However it applies to main metal fractions as well.

The main requirements on plastic materials utilized for housing are long-term thermal and mechanical stability, easy processing, and the capability of being outfitted with flame retardants. Further requirements are surface related. One aspect is the capability to put an adhesive sticker on it. Another aspect is the coloring (dying) capability. Despite these functional design aspects, the environmental impact of plastic housing over the whole life cycle and the methods of end-of-life treatment are of concern. Material recycling and thermal recycling are the two main options for treatment at the product's end-of-life. It is difficult to promote a particular design option due to the unknown situation of the recycling infrastructure and technology 15 to 20 years from now. This would be the time when products (that fall under the EuP Directive) will come out of the market and have to be treated. Two options are taken into account. A broader stakeholder discussion might promote one or the other of the two options:

- BAT Option 5.1: Plastic housing optimized for thermal energy recovery (e.g. PE)
- BAT Option 5.2: Plastic housing optimized for material recycling (e.g. PC/ABS)

The first of the two options is favoring a cheaper material solution with the simple end-of-life strategy of direct recovery of the thermal energy. A lower grade plastic material such as PE could be utilized. This kind of plastic is usually not suitable for material recycling and thermal treatment under certain conditions (filter) could be an economically and ecologically feasible solution. One argument that promotes this solution is that recycling companies today often separate plastic housing materials of TVs as not fitted for recycling due to the unknown composition of the plastics and the assumed added halogenated flame retardants. With the ban of the flame retardants PBB and PBDE under the RoHS Directive the treatment of plastic housing will improve in the long-term.

The second option promotes a higher grade plastic material such as PC/ABS with the option of better material recycling. Material recycling and the reuse of the recycled material would keep to some extent the original energy value of the plastic. There are many pros and cons (different options) to the topic of plastics material recycling. A prolonged lifespan of a material has surely some advantages if the overall environmental and economical impact is positive. It is not in the scope of this study to investigate the latest status of expert discussion regarding the topic of plastics recycling. Both options are therefore up for discussion. A general requirement however is the use of dyed plastics (avoid coatings) and the use of chlorine and bromine-free flame retardants.

Stakeholder Comment by Dr. David Harrison of Bayer Material Science (25 April 2007):
“Phosphorus flame retardants are the main class of bromine-free flame retardants being used in TVs. However, these flame retardants are used in combination with a small amount (typically up to 0.5%) of fluoroorganic "anti-dripping agents" (e.g. PTFE), i.e. the plastic is perhaps chlorine and bromine free, but not "halogen free". As you may be aware, eco-labels such as the Blue Angel, or the Japanese Ecolabel which normally exclude halogenated flame retardants from IT housings such as computers specifically exclude the fluoroorganic anti-dripping agents from this specification. Other ecolabels for TVs and similar equipment specifically mention the exclusion of brominated and chlorinate flame retardants, rather than all halogenated flame retardants. To avoid confusion regarding the status of fluoriniated compounds and anti-dripping agents, it is therefore suggested changing the title and wording of section 7.2.1.5 (BAT Option 5) so that it is clear that fluoroorganic compounds would not be restricted”.

7.2.2. Impact Assessment of Improvement Options

The impact assessment of the improvement options will be provided separately for the two base cases in the following structure:

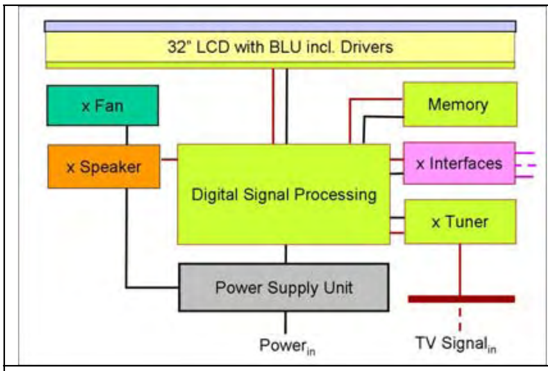
- BAT option 1 and 3 for 32” LCD-TV
- BAT option 2 and 3 for 42” PDP-TV
- BAT option 4 and 5 for all TVs

The calculation of the improvement potential (quantitative assessment) is based on the comparison of the conventional base case with the BAT option. The improvement option 5 could not yet be assessed quantitatively.

7.2.2.1. Calculation of improvement potential related to BAT option 1 and 3

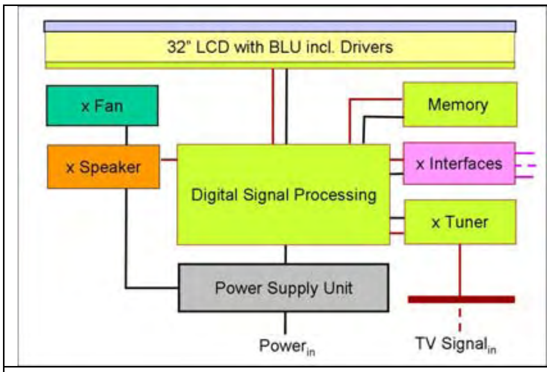
For the purpose of calculating the improvement potential of BAT option 1 and 3 a comparison of a conventional 32” LCD-TV (CCFL-BLU with a power supply unit efficiency of η 80%) with an improved 32” LCD-TV (EEFL-BLU with a power supply unit efficiency of η 85%) are shown in the following Table 6 and Table 7.

Table 6: Conventional 32” LCD-TV with CCFL-BLU and with a PSU efficiency of η 80%

	Rated “on-mode ” Power Consumption with 100% load (in W)	Average “on-mode” Power Consumption with 80% load (in W)	Power Supply Losses at PSU η 80% (in W)
32” LCD with CCFL-BLU incl. Drivers*	128 W	96 W	19,2 W
Digital Signal Processing	25 W	20 W	4,0 W
Digital Memory	4 W	3 W	0,6 W
Tuners	4 W	3 W	0,6 W
Interfaces	4 W	3 W	0,6 W
Audio/Speakers**	2 x 10 W	2 W	0,4 W
Total:			152,4 W

* For rated power consumption of the LCD the value relates to 16 CCFL at 8W (max). For the average power consumption of the LCD the value relates to 16 CCFL at 6W.
** Audio output are measured with 500mW

Table 7: Advanced 32” LCD-TV with EEFL-BLU and PSU efficiency of η 85%



	Rated “on-mode ” Power Consumption with 100% load (in W)	Average “on-mode” Power Consumption with 80% load (in W)	Power Supply Losses at PSU η 85% (in W)
32” LCD with EEFL-BLU incl. Drivers*	120 W	80 W	12 W
Digital Signal Processing	25 W	20 W	3 W
Digital Memory	4 W	3 W	0,4 W
Tuners	4 W	3 W	0,4 W
Interfaces	4 W	3 W	0,4 W
Speakers**	2 x 10 W	2 W	0,3 W
Total:			127,5 W

* For rated power consumption of the LCD the value relates to 20 EEFL at 6W (max). For the average power consumption of the LCD the value relates to 20 EEFL at 4W.
** Audio output are measured with 500mW

The assumptions for the power consumption of the integrated electronic devices (DSP, memory, tuner, etc) are based on various sources and reflect an average product in the market. Following the stakeholder meeting on 3 May 2007 in Brussels the assumed power consumption were slightly adjusted according to specifications given by industry. Particularly the assumed value of the tuner was adjusted to 4W on average. These adaptations however do not change the general proportion of the results.

As a result of BAT option 1 and 3 the power consumption was reduced from 152 Watt to 128 Watt. The combination of the two improvement options result in a 15% reduction in power consumption not calculating further reduction potential related to advanced polarizer technology, active dimming or other power management measures. In total such technologies may improve the energy efficiency of a HD-ready LCD-TV by 30%.

In relation to the 15% reduction in power consumption shows the impact assessment for the use phase based on VHK EcoReport the same reduction in the individual impact categories (see Table 8 and Table 9). An impact assessment regarding the manufacturing phase is not possible due to missing material and component specifications for the EEFL-BLU and for the improved power supply design. A slight reduction in the environmental impact is however feasible to assume. The reduction in mercury content for the EEFL-BLU (<4mg per lamp) is not visible.

Table 8: Life cycle impact for conventional and improved 32" LCD-TV

0 Products 0 vhk

	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	Total	BUTION		Disposal	Recycl.	Total	
	Materials	**unit**									
1	Bulk Plastics	g			0			0	0	0	0
2	TecPlastics	g			0			0	0	0	0
3	Ferro	g			0			0	0	0	0
4	Non-ferro	g			0			0	0	0	0
5	Coating	g			0			0	0	0	0
6	Electronics	g			0			0	0	0	0
7	Misc.	g			0			0	0	0	0
	Total weight	g			0			0	0	0	0
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	MJ	0	0	0	0	24988	0	0	0	24988
9	of which, electricity (in primary MJ)	MJ	0	0	0	0	24988	0	0	0	24988
10	Water (process)	ltr	0	0	0	0	1666	0	0	0	1666
11	Water (cooling)	ltr	0	0	0	0	66634	0	0	0	66634
12	Waste, non-haz./ landfill	g	0	0	0	0	28972	0	0	0	28972
13	Waste, hazardous/ incinerated	g	0	0	0	0	576	0	0	0	576
	Emissions (Air)										
14	Greenhouse Gases in GWP100	kg CO2 eq.	0	0	0	0	1090	0	0	0	1090
15	Ozone Depletion, emissions	mg R-11 eq					negligible				
16	Acidification, emissions	g SO2 eq.	0	0	0	0	6434	0	0	0	6434
17	Volatile Organic Compounds (VOC)	g	0	0	0	0	9	0	0	0	9
18	Persistent Organic Pollutants (POP)	ng i-Teq	0	0	0	0	164	0	0	0	164
19	Heavy Metals	mg Ni eq.	0	0	0	0	429	0	0	0	429
	PAHs	mg Ni eq.	0	0	0	0	49	0	0	0	49
20	Particulate Matter (PM, dust)	g	0	0	0	0	137	0	0	0	137
	Emissions (Water)										
21	Heavy Metals	mg Hg/20	0	0	0	0	161	0	0	0	161
22	Eutrophication	g PO4	0	0	0	0	1	0	0	0	1
23	Persistent Organic Pollutants (POP)	ng i-Teq					negligible				

Conventional 32" LCD-TV with 153W on-mode / 2W standby power consumption over 10 years use life

0 Products 0 vhk

	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	Total	BUTION		Disposal	Recycl.	Total	
	Materials	**unit**									
1	Bulk Plastics	g			0			0	0	0	0
2	TecPlastics	g			0			0	0	0	0
3	Ferro	g			0			0	0	0	0
4	Non-ferro	g			0			0	0	0	0
5	Coating	g			0			0	0	0	0
6	Electronics	g			0			0	0	0	0
7	Misc.	g			0			0	0	0	0
	Total weight	g			0			0	0	0	0
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	MJ	0	0	0	0	21922	0	0	0	21922
9	of which, electricity (in primary MJ)	MJ	0	0	0	0	21922	0	0	0	21922
10	Water (process)	ltr	0	0	0	0	1461	0	0	0	1461
11	Water (cooling)	ltr	0	0	0	0	58458	0	0	0	58458
12	Waste, non-haz./ landfill	g	0	0	0	0	25417	0	0	0	25417
13	Waste, hazardous/ incinerated	g	0	0	0	0	505	0	0	0	505
	Emissions (Air)										
14	Greenhouse Gases in GWP100	kg CO2 eq.	0	0	0	0	957	0	0	0	957
15	Ozone Depletion, emissions	mg R-11 eq					negligible				
16	Acidification, emissions	g SO2 eq.	0	0	0	0	5645	0	0	0	5645
17	Volatile Organic Compounds (VOC)	g	0	0	0	0	8	0	0	0	8
18	Persistent Organic Pollutants (POP)	ng i-Teq	0	0	0	0	144	0	0	0	144
19	Heavy Metals	mg Ni eq.	0	0	0	0	376	0	0	0	376
	PAHs	mg Ni eq.	0	0	0	0	43	0	0	0	43
20	Particulate Matter (PM, dust)	g	0	0	0	0	121	0	0	0	121
	Emissions (Water)										
21	Heavy Metals	mg Hg/20	0	0	0	0	141	0	0	0	141
22	Eutrophication	g PO4	0	0	0	0	1	0	0	0	1
23	Persistent Organic Pollutants (POP)	ng i-Teq					negligible				

Improved 32" LCD-TV with 133W on-mode / 2W standby power consumption over 10 years use life

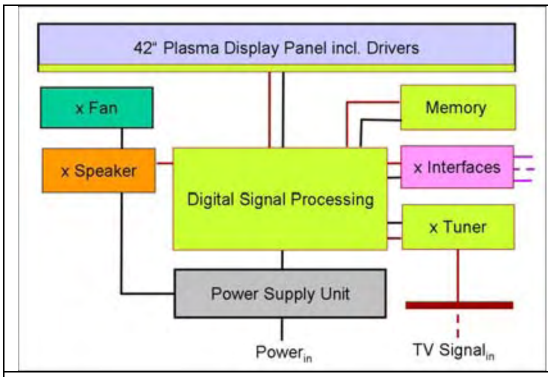
In conclusion it is feasible to assume that the application of common best available technology has the realistic potential to reduce total power consumption of a 32” LCD-TV by 15% and even more on average. Depending on the actual TV’s screen size this potential might be higher for larger screen size TVs or lower for smaller screen size TVs due to the more equal proportion of power consumption related to video signal and audio signal processing.

However, it is necessary to put the theoretical improvement potential into perspective with the power requirements of the current technical development. One aspect is the shift towards full HD in the larger screen size segments. In parallel focuses the technology development on improved picture quality such as higher color gamut, and contrast ratio. Regarding both aspects do we expect considerable increase in power consumption at least in the first product generations. Digital signal/data processing power, memory capacity, and high brightness backlights are essential requirements that directly relate to power consumption. Precise data are not available, but from latest discussions with industry it seems that measures for picture quality improvements easily increase power consumption of LCD-TVs by 20 to 40 Watts, which correlates with the indicated improvement potential.

7.2.2.2. Calculation of improvement potential related to BAT option 2 and 3

At the stakeholder meeting on 3 May 2007 in Brussels the two Korean PDP manufacturers LG Electronics and Samsung raised concerns regarding the general improvement potential of PDP and the 3 lm/W luminescence efficiency in particular, an assumed BAT which was given by the Japanese PDP manufacturers Panasonic, Pioneer, and Hitachi as realistic for the year 2010 (see discussion of this issues in task 6.1.4 and 7.1.2). Against that background the calculation of the improvement potential regarding BAT option 2 and 3 becomes more difficult. In the interim report we have calculated the 42” PDP-TV base case (1,5 lm/W) with 312 Watt average on-mode power consumption and an (2010 BAT) improved 42” PDP-TV (3 lm/W) with 230 Watt. The assumed data for power consumption were corrected by the Japanese manufacturers to the following figures (see Table 9 and Table 10). The initial product is a 2006 state-of-the-art HD-ready 42” PDP-TV with an assumed 1.8 lm/W and power supply unit efficiency of η 80%. The improved model is an assumed 2010 BAT. This (improved) HD-ready 42” PDP-TV features 3 lm/W with a power supply unit efficiency of η 85%. In comparison to the interim report we have also corrected the assumptions for the power consumption of the single components such as the digital signal processor, tuner, fans and audio system. These changes do not change the general proportion of the results, although the particular power consumption is considerably lower. As a result of BAT option 2 and 3 the power consumption was reduced from 230 Watt (1.8 lm/W) to 175 Watt (3 lm/W). The combination of the two improvement options result in a 24% reduction in power consumption not calculating further reduction potential related to power management measures.

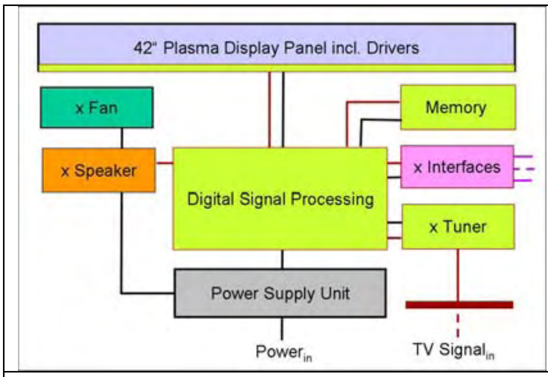
Table 9: State of the art 42" PDP-TV (1.8 lm/W) with PSU efficiency of η 80%



	Rated "on-mode" Power Consumption with 100% load (in W)	Average "on-mode" Power Consumption with 80% load (in W)	Power Supply Losses at PSU η 80% (in W)
PDP*	180 W	160 W	32,0 W
Digital Signal Processing	25 W	20 W	4,0 W
Digital Memory	4 W	3 W	0,6 W
Tuners	4 W	3 W	0,6 W
Interfaces	4 W	3 W	0,6 W
Audio/Speakers**	2 x 10 W	2 W	0,4 W
Fans	1 W	1 W	0,2 W
Total:			230,4 W

* For average power consumption correlated data were provided by industry.
** Audio output are measured with 500mW

Table 10: Improved 42" PDP-TV (3 lm/W) with PSU efficiency of η 85%



	Rated "on-mode" Power Consumption with 100% load (in W)	Average "on-mode" Power Consumption with 80% load (in W)	Power Supply Losses at PSU η 85% (in W)
PDP*	132 W	120 W	18,0 W
Digital Signal Processing	25 W	20 W	3,0 W
Digital Memory	4 W	3 W	0,4 W
Tuners	4 W	3 W	0,4 W
Interfaces	4 W	3 W	0,4 W
Speakers**	2 x 10 W	2 W	0,3 W
Fans	1 W	1 W	0,1 W
Total:			175,4 W

* For average power consumption correlated data were provided by industry. Panel improvement approx. 30%.
** Audio output are measured with 500mW

If we take the concerns of the two Korean manufacturers into consideration and assume that the 2010 BAT is between 2 and 3 lm/W (lets say 2,5 Im/W on average) and correct the initial product energy efficiency to 1,5 lm/W in order to reflect a more average 2006 PDP-TV we would still have a similar improvement potential of 25% until the year 2010. In conclusion it is feasible to assume that the application of common best available technology has the realistic potential to reduce total power consumption of a PDP-TV by 25% on average. Depending on the actual PDP's screen size this potential might be higher for larger screen size TVs. In relation to the 25% reduction in power consumption shows the impact assessment for the use phase based on VHK EcoReport the same reduction in the individual impact categories. An impact assessment regarding the manufacturing phase is not possible due to missing material and component specifications for the improved plasma panel technology and for the improved power supply design.

Table 11: Life cycle impact for state-of-the-art and improved 42" PDP-TV

Table . Life Cycle Impact (per unit) of Products

Nr	Life cycle Impact per product:							Date	Author		
0	Products							0	vhk		
	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	Total	BUTION		Disposal	Recycl.	Total	
	Materials	**unit**									
1	Bulk Plastics	g			**0**			0	0	**0**	**0**
2	TecPlastics	g			**0**			0	0	**0**	**0**
3	Ferro	g			**0**			0	0	**0**	**0**
4	Non-ferro	g			**0**			0	0	**0**	**0**
5	Coating	g			**0**			0	0	**0**	**0**
6	Electronics	g			**0**			0	0	**0**	**0**
7	Misc.	g			**0**			0	0	**0**	**0**
	Total weight	g			**0**			0	0	**0**	**0**
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	MJ	0	0	**0**	**0**	**37559**	0	0	**0**	**37559**
9	of which, electricity (in primary MJ)	MJ	0	0	**0**	**0**	**37559**	0	0	**0**	**37559**
10	Water (process)	ltr	0	0	**0**	**0**	**2504**	0	0	**0**	**2504**
11	Water (cooling)	ltr	0	0	**0**	**0**	**100156**	0	0	**0**	**100156**
12	Waste, non-haz./ landfill	g	0	0	**0**	**0**	**43547**	0	0	**0**	**43547**
13	Waste, hazardous/ incinerated	g	0	0	**0**	**0**	**865**	0	0	**0**	**865**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	kg CO2 eq.	0	0	**0**	**0**	**1639**	0	0	**0**	**1639**
15	Ozone Depletion, emissions	mg R-11 eq					negligible				
16	Acidification, emissions	g SO2 eq.	0	0	**0**	**0**	**9671**	0	0	**0**	**9671**
17	Volatile Organic Compounds (VOC)	g	0	0	**0**	**0**	**14**	0	0	**0**	**14**
18	Persistent Organic Pollutants (POP)	ng i-Teq	0	0	**0**	**0**	**246**	0	0	**0**	**246**
19	Heavy Metals	mg Ni eq.	0	0	**0**	**0**	**644**	0	0	**0**	**644**
	PAHs	mg Ni eq.	0	0	**0**	**0**	**74**	0	0	**0**	**74**
20	Particulate Matter (PM, dust)	g	0	0	**0**	**0**	**207**	0	0	**0**	**207**
	Emissions (Water)										
21	Heavy Metals	mg Hg/20	0	0	**0**	**0**	**242**	0	0	**0**	**242**
22	Eutrophication	g PO4	0	0	**0**	**0**	**1**	0	0	**0**	**1**
23	Persistent Organic Pollutants (POP)	ng i-Teq					negligible				

State of the art 42" PDP-TV (1.8 lm/W) with 230W on-mode / 3W standby power consumption over 10 years use life

Table . Life Cycle Impact (per unit) of Products

Nr	Life cycle Impact per product:	Date	Author
0	Products	0	vhk

Nr	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	Total	BUTION		Disposal	Recycl.	Total	
	Materials	**unit**									
1	Bulk Plastics	g			0			0	0	0	0
2	TecPlastics	g			0			0	0	0	0
3	Ferro	g			0			0	0	0	0
4	Non-ferro	g			0			0	0	0	0
5	Coating	g			0			0	0	0	0
6	Electronics	g			0			0	0	0	0
7	Misc.	g			0			0	0	0	0
	Total weight	g			0			0	0	0	0
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	MJ	0	0	0	0	27594	0	0	0	27594
9	of which, electricity (in primary MJ)	MJ	0	0	0	0	27594	0	0	0	27594
10	Water (process)	ltr	0	0	0	0	1840	0	0	0	1840
11	Water (cooling)	ltr	0	0	0	0	73584	0	0	0	73584
12	Waste, non-haz./ landfill	g	0	0	0	0	31994	0	0	0	31994
13	Waste, hazardous/ incinerated	g	0	0	0	0	636	0	0	0	636
	Emissions (Air)										
14	Greenhouse Gases in GWP100	kg CO2 eq.	0	0	0	0	1204	0	0	0	1204
15	Ozone Depletion, emissions	mg R-11 eq					negligible				
16	Acidification, emissions	g SO2 eq.	0	0	0	0	7105	0	0	0	7105
17	Volatile Organic Compounds (VOC)	g	0	0	0	0	10	0	0	0	10
18	Persistent Organic Pollutants (POP)	ng i-Teq	0	0	0	0	181	0	0	0	181
19	Heavy Metals	mg Ni eq.	0	0	0	0	473	0	0	0	473
	PAHs	mg Ni eq.	0	0	0	0	54	0	0	0	54
20	Particulate Matter (PM, dust)	g	0	0	0	0	152	0	0	0	152
	Emissions (Water)										
21	Heavy Metals	mg Hg/20	0	0	0	0	178	0	0	0	178
22	Eutrophication	g PO4	0	0	0	0	1	0	0	0	1
23	Persistent Organic Pollutants (POP)	ng i-Teq					negligible				

Improved 42" PDP-TV (3 lm/W) with 175W on-mode / 1W standby power consumption over 10 years use life

7.2.2.3. Calculation of improvement potential related to BAT option 4

The improvement potential of BAT option 4 has been calculated based on the studies previous results regarding use patterns, EU-25 product stock and an average of 3W standby as initial situation in 2005 (cp. Task 5.4.2). The total EU-25 stock for TVs in reference year 2005 is assumed to be 271 million units. An average of 20 hours per day (365 days per year) is assumed for maximum standby time. The results of the improvement in regards to electricity consumption and global warming potential, etc. are shown in Table 12.

Table 12: BAT option 4 improvement potential regarding 1W standby (10 year life time scenario)

Standby Scenario 20h/day 365d/year 10 years	Single TV GER (in MJ)	Single TV GWP (kg/CO_2)	Single TV Acidificat. (g SO2 eq.)	Single TV POP (ng i-Teq)	Single TV Power (in kWh)	Stock 2005 271 Mio TVs (in MWh)
3W Standby	2300	100	592	15	219	59349
1W Standby	767	33	197	5	73	19783

The reduction to 1 Watt standby power is considerable for TVs of all screen sizes. The actual reduction potential varies in relation to the screen sizes of a TV (see Table 13). Total power consumption of a large TV (>40”) in on-mode is considerably more dominant in relation to standby power consumption than it is the case of a small TV. The reduction from 3W to 1W standby has in this case a lower improvement potential than a considerable reduction in on-mode power consumption. Nevertheless, the reduction to 1W standby is an important step. Further reduction of standby power however shows only marginal improvement in comparison to the potential of the reduction in on-mode power consumption.

Table 13: Standby related reduction potential in percentage of total annual power consumption

TV Type	kWh/a	% of standby	TV Type	kWh/a	% of standby
CRT 23	124,10	15,8	CRT 23	124,10	5,9
LCD 23	138,70	14,3	LCD 23	138,70	5,3
CRT 26	153,30	13,0	CRT 26	153,30	4,8
LCD 26	182,50	11,1	LCD 26	182,50	4,0
CRT 32	197,10	10,3	CRT 32	197,10	3,7
LCD 32	226,30	9,1	LCD 32	226,30	3,2
PDP 37	357,70	5,9	PDP 37	357,70	2,0
LCD 37	270,10	7,7	LCD 37	270,10	2,7
PDP 42	489,10	4,3	PDP 42	489,10	1,5
LCD 42	357,70	5,9	LCD 42	357,70	2,0
RP 42	262,80	7,9	RP 42	262,80	2,8
PDP 50	605,90	3,5	PDP 50	605,90	1,2
LCD 46	408,80	5,2	LCD 46	408,80	1,8
RP 50	284,70	7,3	RP 50	284,70	2,6
PDP 65	897,90	2,4	PDP 65	897,90	0,8
LCD 65	795,70	2,7	LCD 65	795,70	0,9
RP 61	284,70	7,3	RP 61	284,70	2,6
Percentage of 3W standby in relation to annual power consumption of average TVs			Percentage of 1W standby in relation to annual power consumption of average TVs		

7.3. Costs

In this task the price increase due to the implementation of the BAT options has to be estimated. The current heavily competitive market conditions in conjunction with an unpredictable dynamic technology development make it very difficult to estimate realistic costs for the proposed BAT options. As a matter of fact product prices have dropped in some market segment by up to 50% or hundreds of Euros over the past years. This massive drop in product price seems to allow the simple conclusion that all proposed BAT options result in no additional costs. But, even if we take the competitive market situation out of the equation, the costs are assumed to be neutral (Table 14). Cost neutral means in the following plus/minus 10% of original costs.

Table 14: Costs for BAT options

No	BAT Option	BAT option costs	Conventional costs	Comments
1 LCD specific	EEFL backlight unit for 32” LCD-TV	Total costs for 32” EEFL-BLU: $ 92,4 Total costs incl. inverter $ 104,4 → cost reduction	Total costs for 32” CCFL-BLU: $ 89,4 Total costs incl. inverter $ 117,4	BAT option leads to a cost reduction if inverter costs are calculated too. Costs are based on DisplaySearch data from 4Q/2005.
2 PDP specific	Unspecific set of measures to achieve 3 lm/W luminescence efficiency for PDP-TV	Total costs for 42” plasma display panel € 500 – € 1.000 → cost neutral	Total costs for 42” plasma display panel: € 500 – € 1.000 42” PDP-TV lowest sales price € 1.200 (03/07) If panel costs are 60% of total PDP-TV than the lowest price is € 720	BAT option is part of incremental technical improvement process. With further maturity of technology costs should decrease. Costs are assumed to be neutral.
3	Unspecific set of design measures to achieve η 85% efficiency of power supply unit	Total costs for PSU: € 50 → cost neutral	Total costs for PSU: € 50 400W PSU retail price: € 50	BAT option could lead to design tradeoffs. Costs are assumed to be neutral.
4	Unspecific set of design measures to achieve <1W passive standby	Additional costs for standby improvement: € 2 → cost neutral	Costs for standby power supply is included in the costs for the PSU Costs for Hard-off switch € 3	BAT option could lead to design tradeoffs. Costs are assumed to be neutral.
5	5.1 Plastic housing optimized for thermal energy recovery (e.g. PE) 5.2 Plastic housing optimized for material recycling (e.g. ABS)	Total costs for plastic 5kg (32”LCD-TV): € 5,0 (PE) € 11,75 (ABS) → ABS would increase initial costs with possible payback at point of recycling	Total costs for plastic 5kg (32”LCD-TV): € 5,0 (PE) € 11,75 (ABS) € 1 pro kg/PE € 2,35 pro kg/ABS € 2 pro kg/PLA (bio) € 4 pro kg/PHB (bio)	Costs of plastics depend on the outfit with flame retardants, color, etc. As of total this cost factor is of minor significance. Bio-plastics such as PLA or PHB may become feasible in a few years

7.4. Analysis LLCC and BAT

This task requires summarizing the BAT options by ranking them according to least life cycle costs (LLCC). As the previous reports have indicated there are some limitations to this task. A ranking by LLCC is problematic due to following reasons:

- The TV market is unconsolidated due to the ongoing shift from CRT to Flat Panels. As an effect we have rapidly dropping product prices that do not reflect the actual value of the products components.
- Limited maturity of new display technologies (including manufacturing processes) with constant technological development in LCD, PDP and new display technologies lead to dynamic changing component costs.
- Unknown conditions regarding digital TV services and HDTV are changing the product concepts and the thereby the bill of materials.

These dynamic conditions which characterize the current TV market are limiting even for a short period of time an exact cost assessment and the direct linking of improvement costs to the product's sales price. There is another factor that has to be considered when ranking the improvement options.

As the previous environmental assessments have indicated, the power consumption in on-mode is the primary environmental improvement target. The BAT options 1, 2 and 3 with related design measures such as ambient brightness control have therefore already the highest priority. Alternative technology options on the other hand such as LED backlights or even new display technologies such as OLED or SED are from our point of view BNAT. These options are surely interesting in the next five years but the missing specifications do not allow at this point of time to assess the environmental performance or related mass application costs of these new technologies. For that reason they are not current options. At the same time our study indicated also the dynamics of the market and the related technology development. New technologies and solutions are entering the market constantly and what is expensive today can be cheap by tomorrow because of this fast mass market development.

A final aspect is related to the increasingly necessary improvement of resource efficiency over the whole life cycle. One important aspect in that respect is the recycling conditions and treatment options at the products end-of-life. Judging from the current situation, the WEEE provides only limited incentives to manufacturers for improving their product's design for recycling. In case that a material or design option for easy disassembly and effective recycling would payback initial costs than a more optimum situation would occur. The end-of-life costs are an important factor in the LLCC calculation. The uncertainties regarding these costs may lead to wrong conclusions when talking about a couple of Euros improvement costs.

The following Figure 2 provides a calculation matrix for the electricity costs saving potential in relation to the on-mode power consumption of TVs (4h/d and 365d/a). As an example, a reduction of average on-mode power consumption from 150 Watt to 125 Watt would result in an electricity cost saving over a 10 year period of 51,1 Euro. This matrix useful for a general check of additional cost factors which could occur when applying improvement options for the reduction of power consumption.

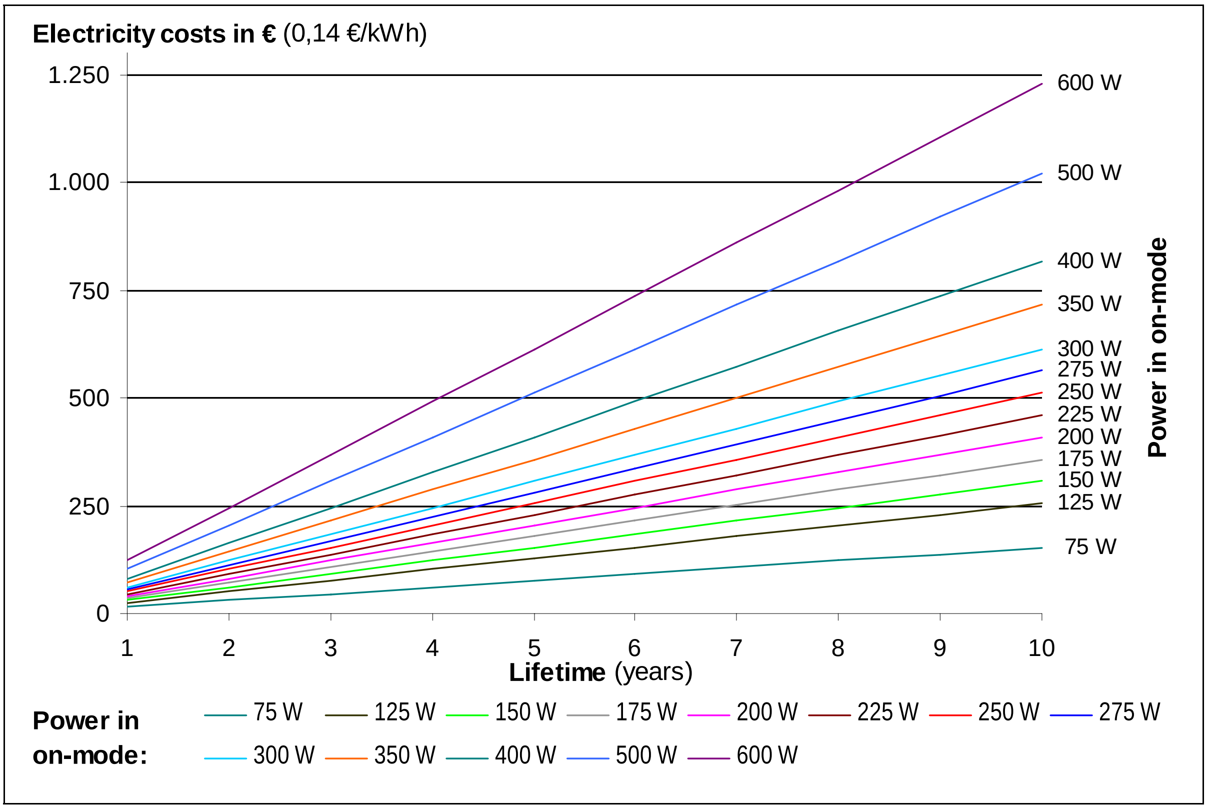


Figure 2: Electricity costs for on-mode power consumption over time

7.4.1. LCC analysis of BAT options

7.4.1.1. LCC analysis for BAT option 1 and 3

According to DisplaySearch, the EEFL-BLU had a cost factor of 1.0 in comparison to CCFL in the 4Q/2005[1]. At that moment they estimated the cost factor to decrease to 0.9 in the second half of 2006/first half of 2007 (approx. € 10). The lower price is based on the cheaper circuitry (e.g. inverter) design of EEFL compared to CCFL. Table 15 provides the energy consumption and life cycle costs results for the 32" LCD-TV base case when applying VHK EcoReport for BAT options 1 and 3.[2] In this case the on-mode power consumption of the TV is assumed to be 120 Watt (BAT) that is 20% improvement in comparison to the base case with an average 150 Watt. Standby power consumption is assumed to remain the same for both options (2W). Changes in the bill of material (BOM) could not be quantified, but they are expected to be insignificant and in the case of electronic components not detectable by the VHK EcoReport. Lower mercury content and potentially longer lifetime of the EEFL-BLU have not been taken into account. These factors however could further contribute to the improvement and related total LCC reduction.

Table 15: Energy and LCC results for the 32" LCD-TV with BAT options 1 and 3

32" LCD-TV (per unit)	32" LCD-TV base case	BAT Option 1 and 3	Improvement in %
Total energy over life cycle (GER in MJ)	28398	22607	-20%
Of which is electricity (in primary MJ)	25720	19929	-22,5%
Life Cycle Costs (LCC in €)	1897	1831	-3,5%

7.4.1.2. LCC analysis for BAT option 2 and 3

It was not possible to obtain cost estimates for the BAT option 2; the improvement of luminescence efficiency of PDP to a level of 2 or 3 lm/W. We therefore assume that the costs are neutral or rather decreasing with further maturity of technology and advanced manufacturing generations. Table 16 provides the energy consumption and life cycle costs results for the 42" PDP-TV base case when

[1] DisplaySearch Presentation on Backlight system Development (Slide 26), in the internet: http://www.displaysearch.com/free/sid_leds_in_displays_011306.pdf (03/2007)

[2] Please notice that VHK EcoReport automatically calculates a so call Present Worth Factor (PWF 7,72/a) and a discount rate of 5% (interest minus inflation). This results in a considerable reduction of energy costs over the 10 years period. It is questionable if this calculation is realistic under the condition of continuously increasing energy costs. Lot 7, 6, and 3 are currently applying a discount rate of 1,8% with an respective PWF of 9,08/a. We take the same values for the calculation.

applying VHK EcoReport to BAT options 2 and 3.[3] In this case the on-mode power consumption of the state-of-the-art HD-ready 42” PDP-TV is assumed to be 230 Watt that is 30% improvement in comparison to the base case with an average 330 Watt. Standby power consumption is assumed to remain the same for both options (3W). Changes in the bill of material (BOM) could not be quantified, but they are expected to be somewhat significant due to the changes in material composition and panel structure. Finally, sales prices for 42” PDP-TV have further dropped. For the base case an average sales price of 3500 € was assumed (12/2005). As of today (03/2007) the average sales price has dropped by 25% on average which results in 2625 €.

Table 16: Energy and LCC results for the 42” PDP-TV with BAT options 2 and 3

42” PDP-TV (per unit)	42” PDP-TV base case	BAT Option 2 and 3	Improvement in %
Total energy over life cycle (GER in MJ)	59382	44205	-25,6%
Of which is electricity (in primary MJ)	55775	40598	-27,3%
Life Cycle Costs (LCC in €)	4140	3956	-4,5%

7.4.1.3. LCC analysis for BAT option 4

The LCC calculation for BAT option 4 (passive standby under 1W) are based on 20 hours passive standby per day and an additional cost factor of 2 Euro for the 32” LCD-TV and 42” PDP-TV base case. The results of the VHK EcoReport assessment are shown in Table 17. Please notice again that VHK EcoReport automatically calculates a so call Present Worth Factor (PWF 7,72/a) and a discount rate of 5% (interest minus inflation). This results in a considerable reduction of energy costs over the 10 years period. It is questionable if this calculation is realistic under the condition of continuously increasing energy costs. Lot 7, 6, and 3 are currently applying a discount rate of 1,8% with an respective PWF of 9,08/a. We take the same values for the calculation.

[3] Please notice that VHK EcoReport automatically calculates a so call Present Worth Factor (PWF 7,72/a) and a discount rate of 5% (interest minus inflation). This results in a considerable reduction of energy costs over the 10 years period. It is questionable if this calculation is realistic under the condition of continuously increasing energy costs. Lot 7, 6, and 3 are currently applying a discount rate of 1,8% with an respective PWF of 9,08/a. We take the same values for the calculation.

Table 17: Energy and LCC results for BAT option 4

LCC Aspects	**32" LCD-TV base case**	**42" PDP-TV base case**
Total LCC of base case (in €)	1899	4140
Standby LCC of base case (in €)	19	28
Total LCC with option 4 (in €)	1890 (improvement) -0,48%	3940 (improvement) -4,8%
Standby LCC with option 4 (in €)	9 (improvement) -52,6%	9 (improvement) -67,9%

7.4.1.4. LCC analysis for BAT option 5

The LCC calculation for BAT option 5 is not applicable because both base cases feature already approximately 80% ABS for housing material. Alternative setting for bio-plastics of modulation of recycling options is with VHK EcoReport not possible. However, it is feasible to assume that BAT option 5 has no significant impact on the overall LCC.

7.4.2. Ranking of individual BAT options

The ranking of the individual BAT options regarding Total Energy (GER) in conjunction with resulting Life Cycle Costs (LCC) is given for the 32" LCD-TV base case in the following Figure 3. The combination of the three options shows the best result. An overall reduction of 9235 MJ (GER) in a ten year use life is a considerable improvement of 32,5%. The total cost reduction is 61 Euro or 3,8% of total.

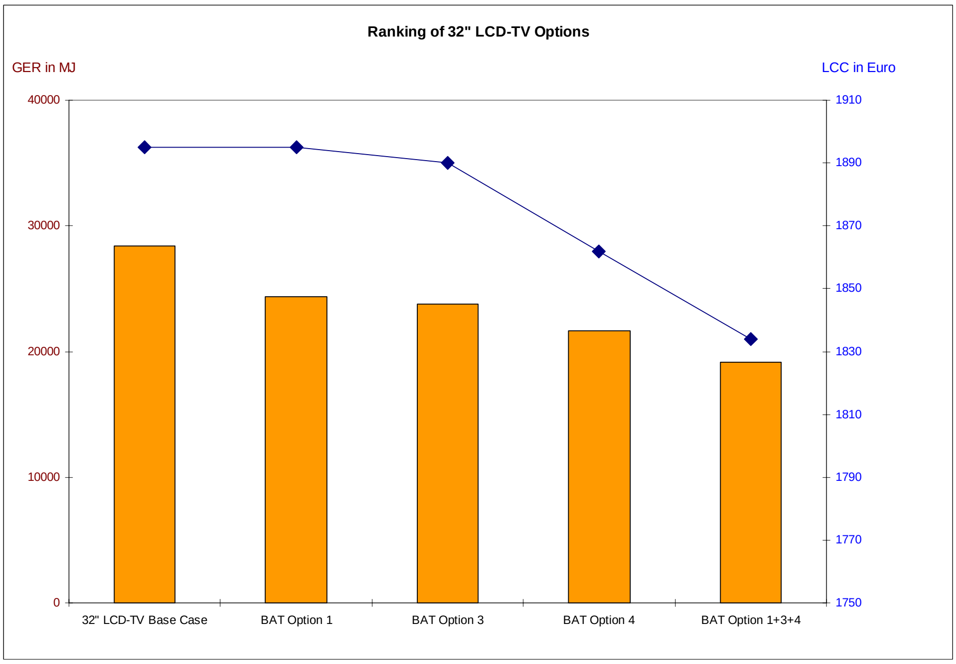


Figure 3: Ranking of 32" LCD-TV improvement options

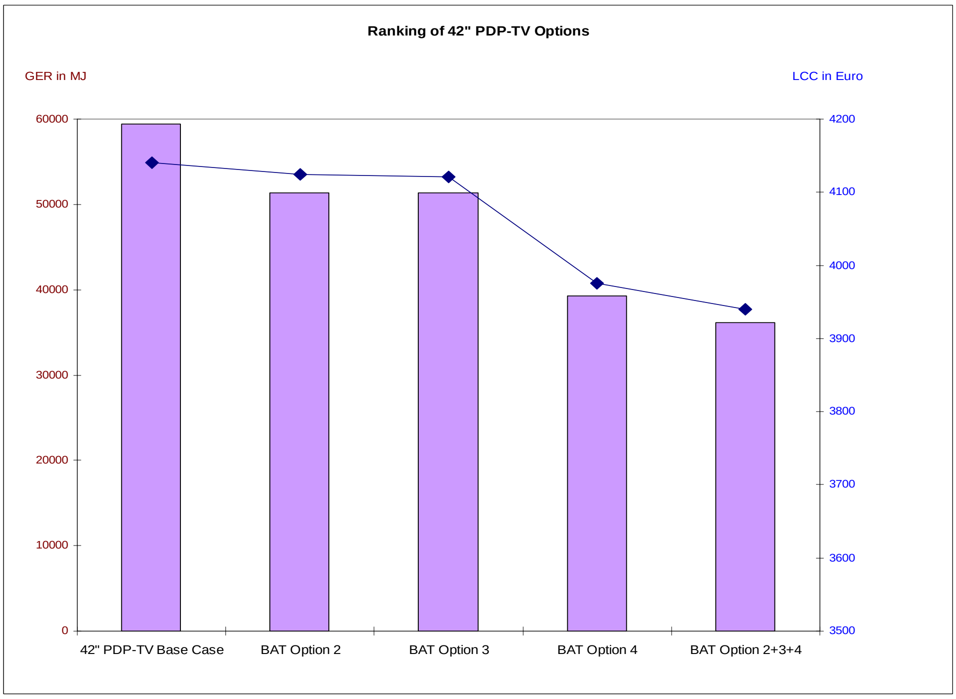


Figure 4: Ranking of 42" PDP-TV improvement options

The ranking of the individual BAT options regarding Total Energy (GER) in conjunction with resulting Life Cycle Costs (LCC) is given for the 42" PDP-TV base case in the following Figure 4. The combination of the three options shows the best result. An overall reduction of 23203 MJ (GER) in a ten year use life is a considerable improvement of 39%. The total cost reduction is 200 Euro or 4,9% of total.

7.5. Long-term Target (BNAT) and Systems Analysis

This final task provides a discussion of long-term technical potential on the base of BNAT (best not yet available technology) and the total system to which the product belongs.

7.5.1. Impact assessment of BNAT improvement options for TVs

Table 18 summarizes a set of BNAT improvement options with comments for the 32” LCD-TV and 42” PDP-TV base case.

Table 18: BNAT improvement options for TV base cases

No	BAT Improvement Option	BNAT Improvement Option	Comments
1 LCD specific	EEFL backlight unit (BLU) for LCD-TV (with the potential of full or single lamp backlight dimming) EEFL-BLU has <4mg mercury	LED backlight unit (BLU) for LCD-TV (with the potential of area specific backlight dimming) LED-BLU is mercury-free	Efficient reflectors and polarizer could reduce the dimension of the BLU (number of lamps, etc.). Power supply efficiency & BLU driving scheme adds improvement potential. Full HD and picture improvement technology (e.g. wide color gamut) is potentially increasing power demand. This issue has to be addressed in set-making.
2 PDP specific	Unspecific set of measures to achieve 2 - 3 lm/W luminescence efficiency for HD-ready PDP-TV Panasonic introduced proprietary Lead-free PDP in late 2006.	Unspecific set of measures to achieve 3 - 5 lm/W luminescence efficiency for HD-ready PDP-TV	Full HD technology is in an early stage and can not achieve such high luminescence efficiency yet. Fast improvement of full HD plasma panels is necessary.
3	Unspecific set of PSU design measures to achieve η 85% efficiency of power supply	Unspecific set of PSU design measures to achieve η >90% efficiency of power supply	Fewer voltage steps and optimize PSU dimension adds improvement potential. Thermal management without cooling fans.
4	Unspecific set of standby power supply design measures to achieve ≤1 Watt passive standby Unspecific set of standby power supply design measures to achieve ≤2 Watt active standby low (current BAT is 1,8W)	Unspecific set of standby power supply design measures to achieve ≤0,5 Watt passive standby Unspecific set of standby power supply design measures to achieve ≤1 Watt active standby low	Active standby modes potentially increase power consumption. TVs with active standby low mode should supply option to set the TV in a lower power mode (passive standby or off-mode) via remote control or switch on the device Standardization necessary for active standby functionality and measurement (test) procedure.
5 →	Utilization of bromine and chlorine-free recycling specific plastics for housing 5.1 Plastic housing optimized for thermal energy recovery (e.g. PE)	Utilization of bromine and chlorine-free hybrid or full bio-plastics for housing 5.1 Plastic housing optimized for thermal energy recovery (e.g. PE)	The recycling infrastructure and technology 15 to 20 years from now is not predictable. As a trend, (bio-)plastics should be utilized that contain no or very low admixtures of sulfur or nitrogen which is better for thermal energy

→	5.2 Plastic housing optimized for material recycling (e.g. PC/ABS)	5.2 Plastic housing optimized for material recycling (e.g. PC/ABS)	recovery (thermal recycling). The use of dyed plastics (avoid coatings) and bromine and chlorine-free flame retardants is suggested.

7.5.1.1. BNAT Option 1: LED backlight for LCD

The BNAT improvement option (option 1) regarding the reduction of on-mode power consumption of LCD-TV is the utilization of a LED-BLU with the potential of area specific backlight dimming. LED-BLU is assumed to be available for mass application within the next five years. The exact improvement potential and related costs can not be quantified. Based on the received information, it is feasible to assume, that average on-mode power consumption could be reduced by 30% to 50% in comparison to a current 32” LCD-TV. The magnitude of the improvement potential depends on the luminous efficiency of the LED system (color mixing, polarization etc.) and the realization of an area specific backlight dimming. The LED-BLU is mercury-free and will therefore reduce environmental and health hazards (and related costs for special treatment) in manufacturing and recycling processes. This improvement option is a mid- to long-term option.

7.5.1.2. BNAT Option 2: 5 lm/W technology for PDP

The BNAT improvement option (option 2) regarding the reduction of on-mode power consumption of PDP-TV is the realization of a 5 lm/W technology for PDP-TVs. If a 5 lm/W technology is realized manufacturers assume that a 42” PDP-TV consumes approximately 120 W with a panel power consumption of <75 W. This improvement is targeted by manufacturers in the mid-term an earliest possible by 2010. Specifications of such a technology are of cause unknown. Lead-free panel technology is expected which has a positive effect for end-of-life and during recycling.

7.5.1.3. BNAT Option 3: >90% average efficiency of power supply (PSU)

The BNAT improvement option 3 regarding the reduction of on-mode power consumption is the improvement of the power supply’s electrical efficiency towards an average of η >90%. Depending on the power requirements this excellent improvement would further reduce the power conversion losses and hence improve total energy efficiency of the TV in the use phase. This is insofar of importance due to the increasing low power design requirements in conjunction with added functionality.

7.5.1.4. BNAT Option 4: <0,3W passive standby / <0.7W average active standby low

The BNAT improvement option 4 focuses on a further reduction of standby power consumption. The reduction of passive standby power to a level of <0,3W and average active standby low to <1W intends to keep the focus of eco-design on the increasing problem of active standby.

7.5.1.5. BNAT Option 5: Utilization of hybrid or full bio-plastics for housing

The BNAT improvement option 5 focuses on further improvement of life cycle resource efficiency. Full or hybrid bio-plastics such as PLA (Poly Lactid Acid) or PHB (Polyhydroxybutyrat) should be utilized for housing due to their more neutral energy balance. With such biopolymers it would be easier to argue a low cost end-of-life option meaning energy recovery (thermal recycling). A precondition is that the used bio-plastic contain no or very low admixtures of sulfur or nitrogen in order to reduce the environmental impact of thermal recycling.

EuP Preparatory Studies “Televisions” (Lot 5)

Final Report on Task 8

“Scenario, Policy, Impact, and Sensitivity Analysis”

Compiled by Fraunhofer IZM

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Berlin, 6th August 2007

Content

Disclaimer and Acknowledgement

This is the final report on Task 8 “Scenario, Policy, Impact, and Sensitivity Analysis” for the EuP Preparatory Studies on televisions (lot 5). The findings presented in this report are results of the research conducted by the IZM consortium and the continuous feedback from a wide range of stakeholders. The statements and recommendations presented in the final report however are not to be perceived as the opinion of the European Commission.

We like to acknowledge the fruitful collaboration and trustful working relationship with various industry partners, non-industry stakeholders, and the European Commission throughout the study. We like to thank all stakeholders for their contributions and critical reviews of our reports.

6th August 2007

8 Scenario, Policy, Impact, and Sensitivity Analysis

Introduction to final report and stakeholder comments

The task 8 final report summarizes the results of the study, provides policy recommendations and impact scenarios for the reference years 2010 and 2020. Following the draft task 8 report from 18th June 2007 we received specific stakeholder comments from individual companies including Loewe, Sharp, Hitachi, Pioneer, and Panasonic, as well as an official statement from EICTA, the Danish Energy Authority, and SenterNovem. These stakeholder comments cover the full spectrum of topics addressed in the draft report. This includes:

- Application of revised IEC 62087 for Power Measurement
- Specifications regarding picture level setting in the revised IEC 62087
- Methodology and values for setting minimum and energy label requirements for average on-mode power consumption
- Differentiation of HD-ready and full HD requirements
- Differentiation of high functionality devices with e.g. integrated digital tuners (DVB-S/DVB-T) and integrated video storage (HDD/HDR), functional adder (**+ $P_{feature}$)**
- Further eco-design requirements including the mercury issue

These stakeholder comments will be discussed at the relevant places in the report. In some cases we have adopted stakeholder comments and have revised recommendations respectively.

At this point, we also like to draw your attention to three parallel proposals for TV power consumption requirements (labeling) that are currently under discussion:

- U.S. EPA draft 1 version 3.0 Energy Star for TV product specification from 29 June 2007
- AEAT 3rd discussion paper on revised Ecolabel Criteria for Televisions from 28 June 2007
- Hans-Paul Siderius & Bob Harrison "Energy Efficiency Index for TVs from 12 Feb. 2007

All three documents propose different metrics and respective values for the definition of power consumption requirements. It is out of scope of this study to discuss the differences and plausibility of these approaches in comparison to our own proposal. However, we have plotted the resulting values for the purpose of easy comparison (see in Figure 1). The following Table 1 provides the overview of the different schemes and Table 2 the respective on-mode power consumption requirements.

Table 1: Overview of current TV power consumption labeling schemes

Metric of Watt per screen area + offset (Pbasic)	Institution (Labeling Scheme)
0,2750W/in² + 40W	IZM (Minimum Requirement)
0,1372W/in² + 20W	IZM (Energy Label Class A)
0,3264W/in² + 15W	Siderius & Harrison (EEI for TVs)
0,2450W/in² + 11W	U.S. EPA Energy Star Program TV
0,2710W/in² + 0W	EU Eco-Label (AEAT)

Table 2: Resulting power consumption values from different metrics

Screen Surface (16:9)	in Inch²	96	171	223	289	438	585	684	754	904	1068	1805
Screen Size Diagonal	in Inch	15	20	23	26	32	37	40	42	46	50	65
0,2750W/in² + 40W	IZM (MR)	66	87	101	119	160	201	228	247	289	334	536
0,1925W/in² + 28W	IZM (Class C)	46	61	71	84	112	141	160	173	202	234	375
0,1650W/in² + 24W	IZM (Class B)	40	52	61	72	96	121	137	148	173	200	322
0,1372W/in² + 20W	IZM (Class A)	33	43	51	60	80	100	114	123	144	167	268
0,3264W/in² + 15W	Siderius/Harrison	46	71	88	109	158	206	238	261	310	364	604
0,2450W/in² + 11W	EPA EnergyStar	35	53	66	82	118	154	179	196	232	273	453
0,2710W/in² + 0W	EU Eco-Label	26	46	60	78	119	159	185	204	245	289	489

Figure 1 shows the power consumption requirements per screen surface area for the different schemes. An interpretation of Figure 1 has to consider the purpose (intention) of the different labeling schemes, the applicability of the metric over the whole screen size spectrum, and finally the actual values per screen size segment. As indicated before, we are not going to discuss this situation. We will however, discuss direct stakeholder comments regarding our own proposal at the respective part in the study.

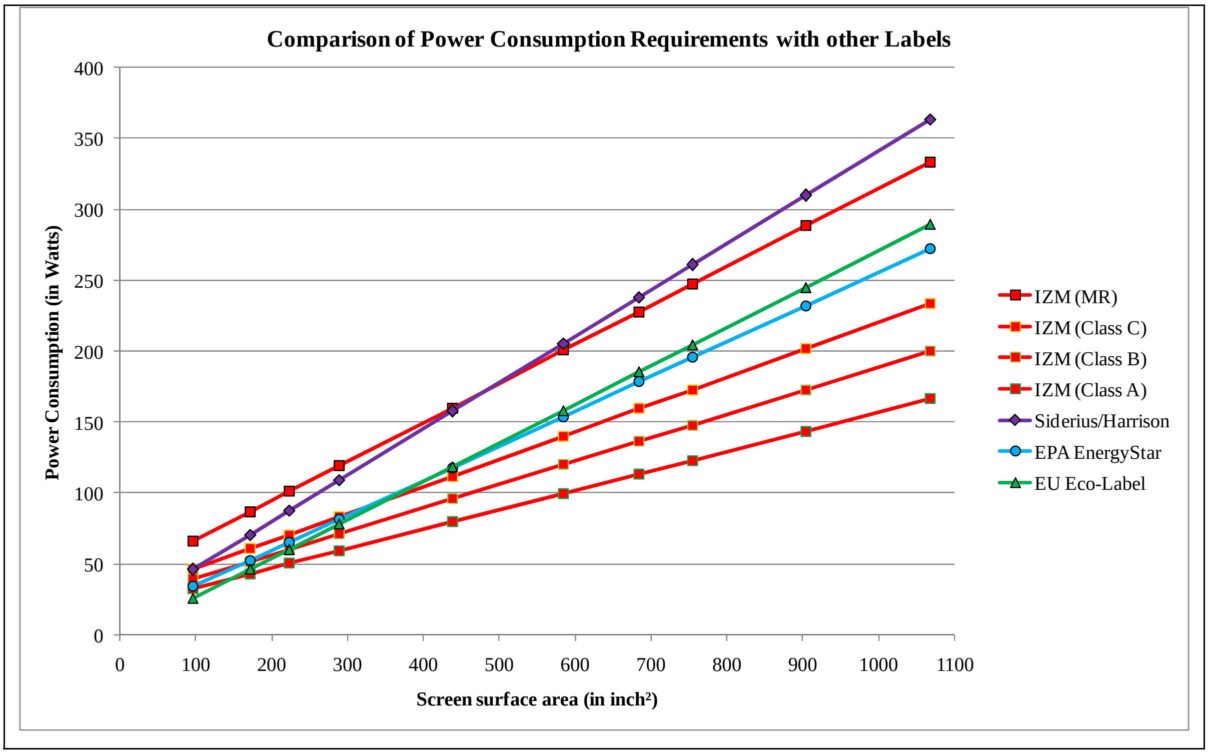

Figure 1: Comparison of power consumption requirements of different schemes

There is a second general aspect that should shortly be discussed at this point. Following the stakeholder meeting of lot 5 and lot 6 in early May 2007 a discussion regarding the priority of recommendations concerning standby and off-mode issues started. In our opinion, the lot 5 study has clearly the task of assessing and analyzing all environmentally relevant aspects of televisions. This includes the topic of standby and off-mode losses. We have therefore addressed this issue although clearly stated that the primary task is to improve on-mode power consumption. Nevertheless, we have analyzed best available technology (BAT) regarding standby and off-mode. We also pointed to the growing uncertainties regarding the aspect of active standby, which could lead to a further increase in total power consumption. Our recommendations are therefore including minimum requirements for active standby low, passive standby, and off-mode. These requirements are more strict that the lot 6 requirements. At the same time we like to emphasize that the lot 6 study provides a very thorough analysis and a deep understanding of the standby issue which applies to lot 5. The definition of modes and the “function cluster approach” was beneficial to the lot 5 study.

Against this background we suggest to give the findings and recommendations of product specific study lot 5 priority in the policy making process on televisions.

8.1. Policy and Scenario Analysis

8.1.1. Summary of Results

According to the results of the study (tasks 1 to 7) the primary environmental impact of TVs is related to the on-mode energy consumption in the use phase (see Tasks 4 and 5). The analysis has shown that energy consumption related to the use of TVs in European households increased over the past years and will continue to increase in the years to come. In the following a summary of the study results is presented. It combines elements from the technical and market analysis, and provides the background for policy recommendations. It should be noticed that the current assessment always focuses on mid-term developments in order to describe the actual situation by the reference year 2010 at which point implementing measures under the EuP framework may take effect.

8.1.1.1. Two TV-sets per household

The first reason for the increase in overall power consumption related to TVs is the utilization of more than one TV-set (including peripheral devices such as STB and video recording devices) in households. Based on current figures, it is feasible to assume that by the year 2010 two TVs on average are used in each European household. Although it is difficult to assess precisely to what extent a second TV is used – meaning the hours per day in on-mode – related power consumption still contributes considerably to the overall energy demand. Until the year 2015 most of these secondary devices will be conventional CRT-TVs with screen sizes under 33-inches. These CRT-TVs are of mature technology featuring an on-mode power consumption of 60W to 140W (averaging 100W) depending on the actual screen size. Standby power consumption in a range of 1W to 6W (averaging 3W) is an issue particularly for older models. However, policy measures in the framework of the EuP can hardly address these products, although they contribute to the total energy consumption of TVs on stock in the European Union. According to our market analysis (see Task 2), CRT-TVs are expected to phase out by 2015. Further improvement in CRT technology targeting even lower on-mode power consumption is very limited due to the high maturity of the technology and already low power consumption. Concerning passive standby power consumption however an improvement is still possible and a minimum standard of ≤1 Watt is recommended in general. For a discussion of active standby see paragraphs further below.

8.1.1.2. New display technologies and larger screen sizes

The second reason for the total increase of energy consumption of the TV stock in Europe is related to the introduction of new flat panel display technologies such as LCD and PDP in conjunction with a market shift towards larger screen sizes, higher resolution and better picture quality. These two flat panel display technologies first entered the market about ten years ago (with quite high power consumption), but have only recently reached significance (sales volume) in the market. With further maturity of these two technologies, market forecasts predict for the year 2010 a dominant sales position of LCD-TV in the screen size segments up to 37-inch and a highly competitive situation in the large screen size segment with a considerable share of PDP-TVs, LCD-TVs, and a smaller share of RP-TVs (DLP, 3LCD, LCoS).

The market potential of other innovative display technologies such as OLED-TVs and SED-TVs is difficult to assess. Research and development is ongoing for both technologies. Prototypes have shown excellent picture quality and their potential for lower power consumption, which is of interest for this study. But, as indicated before, OLED and SED are not yet mature technologies and hence they are not expected to have a considerable market impact in the short-term. However, against the background of dynamic technology development and unconsolidated market conditions disruptive technologies have always the potential to change the market situation within a period of five to ten years. It is therefore difficult to predict the market situation and the TV stock e.g. for the reference years 2015 or 2020. The following Figure 2 provides an overview on existing and potential display technologies for TV application with relevant screen size segments.

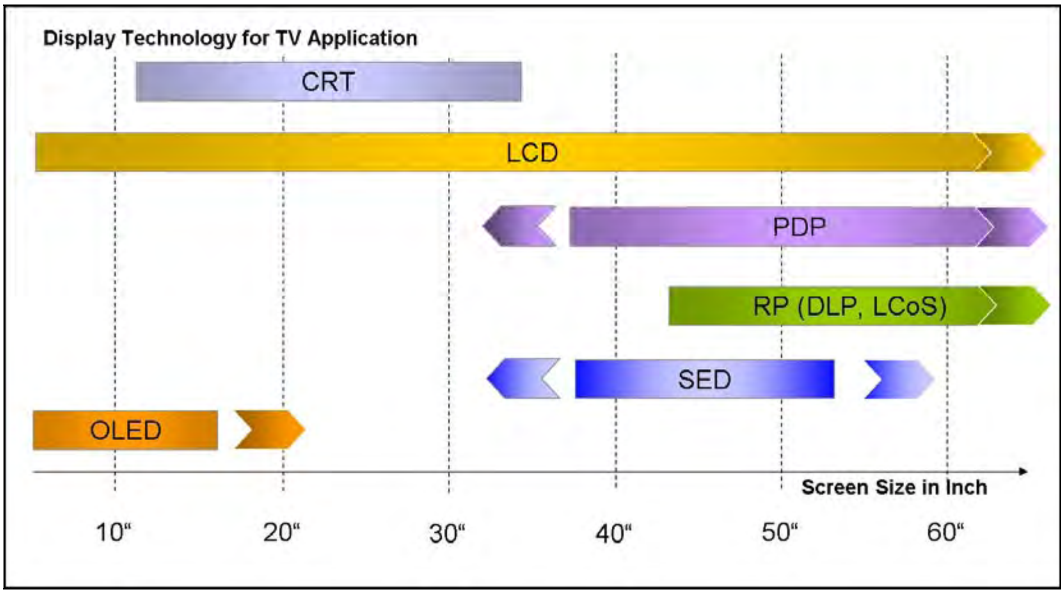

Figure 2: Display technology and TV screen size segments

For these reasons our analysis focused on a medium size 32” LCD-TV and large size 42” PDP-TV bases case. The selection of these particular product segments is related to their expected market significance in the mid- to long-term future. Industry confirmed current market forecasts according to which the screen size segments 32”/33”, 36”/37”, and 42”/43” will be the most strongest in future sales. Estimates indicate that approximately two thirds of the total European TV market will be almost equally shared by these three screen size segments. This ongoing market shift contributes in terms of energy consumption to the overall environmental impact of TVs in the next years, because TVs in these larger screen size segments are demanding on-mode power consumption of more than 100 W and up to 300 W on average. Following Figure 3 shows the market shift driven by the introduction of larger screen size flat panel display technology.

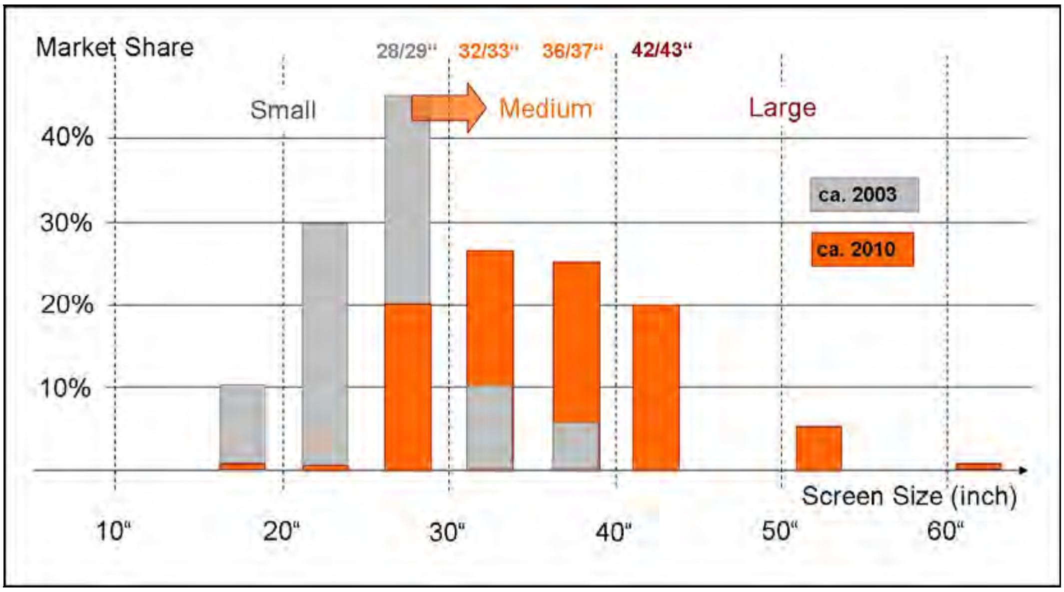

Figure 3: Shift in TV market screen size segments

A simplified comparison concerning average on-mode power consumption of conventional CRT-TVs with current HD-ready LCD-TVs and PDP-TVs indicates roughly the impact of the increase. More precise impact assessments and power consumption scenarios were already provided in previous reports on tasks 5 and 7.

8.1.1.3. Picture quality improvement and full HD

In the mid-term future the shift towards full HD (high definition resolution with 1.920 x 1.080 pixels) in conjunction with double frame rate (100Hz technology), wider color gamut, and other picture quality improvements will bring new challenges for advanced display technologies. There are clear indications that power demand will increase in order to realize full HD and other picture quality improvements. The required miniaturization in the cell structure, filters etc. of both LCD and PDP will have a negative effect on the panel's luminescence efficiency and is assumed to increase power consumption. Full HD broadcast and video content will also demand advanced video and audio encoding standards (MPEG-4/H-264) capable of providing good video quality at substantially lower bit rates. Digital signal processing capability and particularly memory capacity will have to increase in order to support HDTV content and extended image functionality. Multiple interfaces options and integrated digital tuners/receivers for maximum network comfort might also contribute to an increase in power consumption.

In conclusion, there are strong indications that the ongoing product development towards better picture quality and full HD (incl. HDTV content) will increase power consumption of TVs again. The technical improvement potential that has been discussed in the task 6 and 7 reports may not compensate the power demand of the current developments. In consequence it is questionable if the application of such energy efficient technologies even leads to an overall reduction or just maintains the current power consumption level.

8.1.1.4. Passive and active standby

The aspect of reducing standby power consumption, which has been a focus of environmental concern of the past, is still important. It is very positive to notice that passive standby power has been reduced by many manufacturers over the past years. The analysis and discussion of passive standby power consumption confirmed that ≤1 Watt is a feasible target which can be achieved on a broad scale by applying existing technologies. The reduction of environmental impacts through the application of ≤1 Watt passive standby is significant. Further reduction of passive standby is of course possible and highly recommended, however, the improvement potential is less significant in comparison to other issues. One of these issues is the potentially growing power consumption related to active standby as indicated in the study. The actual extent of related power consumption (the environmental impact) is difficult to assess at this point of time due to the few existing examples. Nevertheless, active standby functionality is definitely a trend and should be further studied. According to the provided analysis and in conjunction with the lot 6 results (definition of modes) we conclude that active standby low (networked standby) should be considered as a "real" standby mode, whereas active standby high (download standby) provides a functionality spectrum closer to active mode (main functionality) and therefore is not to be considered a "real" standby mode. Best available technology for active standby low is currently 1.8 Watt[1]. It has to be assumed that on average it is higher, when the tuner is always in on-mode. Due to the assumption that a consumer would use active standby low (if provided) in order to realize such functionalities as

[1] Example provided by Loewe AG, Germany.

digital program updates or recording, “real” standby power consumption must be assessed not on the basis of the passive standby value but on the active standby low value. Consequently, it is necessary to address the active standby low power consumption value in any policy measure as well.

8.1.1.5. Material utilization and recycling

Although the environmental impact of TVs is mainly determined by the power consumption in the use phase, applied materials and related manufacturing processes (production phase) contribute, on average, one seventh to the overall “life cycle” impact. Display manufacturing and electronic components are of growing environmental significance as we have indicated in the specific product analysis (task 5). The technological development which is focused on the improvement of the displays quality in combination with larger, high definition screens leads to resource intensive manufacturing processes and the increased utilization of precious material (cp. Tasks 4 and 5). The improvement of resource efficiency over the whole life cycle of the product is definitely an important task. However, such improvements are rather product specific, depending on the applied technologies and the particular product design. There is to some extent an intrinsic incentive to improve resource efficiency on the side of the manufacturer: the main incentive is reducing production costs by optimizing manufacturing processes and by improving production yield. A reduction in overall product weight shows also positive effects. Applying green procurement standards throughout the supply chain is a recommended strategy. Other, general recommendations regarding the utilization of materials and improvement of production processes, packaging and distribution are very difficult to state. General eco-design strategies are of course applicable.

8.1.2. Minimum requirement for on-mode power consumption

Resulting from the findings of the study the first recommendation is focusing on defining minimum power consumption requirements for on-mode and standby-modes. The recommendations are stressing methodical aspects for determining power consumption values (example calculations are provided) as well as aspects regarding the structure, test methods, and time horizon of measures.

8.1.2.1. General recommendations

In view of the dominating environmental impact related to the on-mode power consumption of TVs the definition of a mandatory minimum requirement for average (standard) on-mode power as part of the implementing measures of the EuP Directive should consider the following aspects:

- The method to determine the minimum requirement should be applicable to the scope of the lot 5 and reflect technical differences between smaller and larger TVs (14” - 65”).
- A particular distinction of different display technologies is unnecessary because the revised test standard IEC 62087 reflects this aspect already.[2]
- The method to determine the minimum requirement should be applicable over a long time period and therefore based on some constant factors as well as easy to determine (measurable) variables.
- An index value addressing the display surface area should be combined with a constant for the receiver in order to model actual power distribution more accurately.
- Power consumption data should be measured by existing test standards.

Recommendation: It is recommended to apply the new IEC 62087 dynamic broadcast-content video signal test method for the measurement of on-mode (average) power consumption. This test standard is already recognized by industry and the Energy Star Program[3]. The revised IEC 62087 test standard is expected to be finally published by 1st quarter 2008[4].

Please notice in that respect: The measurement of (average) on-mode power consumption may differ largely according to the test settings (IEC 62087: 11.3.6 Picture Level Adjustments). The

[2] Please note that the spectrum of integrated functionality (e.g. various recording or tuner/decoder capability) as well as picture quality (e.g. full HD) is directly linked to power consumption.
[3] http://www.energystar.gov/index.cfm?c=revisions.tv_vcr_spec
[4] According to Jon Fairhurst, IEC TC 100 TV power measurement project leader, at the IEA International workshop on “Energy Efficient Set-Top Boxes & Digital Networks” on 4th July 2007 in Paris, France.

revised IEC 62087 does not provide specifications regarding the adjustment of contrast and brightness of the television set and the backlight level. According to the current draft of the IEC 62087 the TV shall be measured in the mode as originally adjusted by the manufacturer to the end user. Further options are the adjustment to a “standard mode” or the first mode listed in the on-screen menus.

Industry sources have confirmed the problem of missing specifications for this aspect in the revised test standard. Depending on the chosen set-ups for brightness, contrast, and backlight level the power measurement results could differ 30% and more. If we take the 32” LCD-TV base case as an example and assume that the devices consumes in a maximum default-mode setting approximately 150W than the difference could be 45W and more.

Stakeholder Comments:

LOEWE had in that respect already referred in the draft report to the ongoing discussions for increasing the white level settings as a specification of the IEC 62087 picture level adjustment by adopting 130cd/m² from CISPR 32 Ed. 1.0 (Electromagnetic compatibility - multimedia equipment - radio disturbance - characteristics - limits and methods of measurements).[5] [6] In the meantime this scheme 130 cd/m² for white level (2cd/m² black) was also adopted in CRSPR 35. There are proposals to increase this value to 180cd/m² or even higher. The proposal to base a picture level adjustment specification in the revised IEC 62087 on 130cd/m² was made by the German manufacturer LOEWE and given to the relevant standardization body IEC TV 100.

EICTA member also commented this issue in their statement from 5th July 2007: We also believe that a measurement in the shipment mode (“out of the box”) is beneficial for the environment, as most consumers continue to run their sets in this factory setting”. This statement was confirmed as the reason for adopting the “out of the box” approach for the test settings by Jon Fairhurst, IEC TC 100 TV power measurement project leader, at the IEA International workshop on “Energy Efficient Set-Top Boxes & Digital Networks” on 4th July 2007 in Paris, France. EICTA furthermore stated that they are aware of “the necessity of a better definition of modes in IEC 62087” and that they “will transfer the concerns held regarding the report to the relevant standardization body IEC TC 100”.

SHARP as an individual company explained in their comments: “The factory default setting of display mode differs from each manufacturer. Therefore, we (Sharp) propose you that factory default mode should not be the measurement condition. Manufacturers recommend to consumers to

[5] CISPR: Special International Committee on Radio Interference.

[6] http://www.iec.ch/cgi-bin/procgi.pl/www/iecwww.p?wwwlang=e&wwwprog=pro-det.p&progdb=db1&He=CISPR&Pu=32&Pa=&Se=&Am=&Fr=&TR=&Ed=1.0

select “Standard mode” in general home, so we propose … the measurement condition should be “Standard mode” which each manufacturer adjust every picture level to suit general home’s room condition. Of course we know that picture level of “standard mode” is set by each manufacturer, so even “standard mode” the picture level is different from each manufacturer. Yet, as long as manufacturers recommend to consumers to select their “standard mode”, we assume that consumers use TV at “Standard mode” and measurement condition should be the same as the one of consumers’ usage”.

A joint comment of three Japanese PDP manufacturers PANASONIC, PIONEER and HITACHI addressed the issue of setting a fixed brightness value (white level 130cd/m²) in terms of technology differences. They stated: “PDP has a very advanced brightness control depending upon the bright area. For example, when the bright area in the screen is small, then that white part is displayed in high brightness. When white part is all over the screen, it will decrease brightness of white to 1/5. This is why PDP is gentle for eyes and minimizing the visual fatigue even after watching movie for a long time. Additionally, power saving is achieved by this technology as well. So, if the common fixed value of white level setting for measurement is adopted, then such environmental beneficial and human eyes gentle technology of PDP might be eliminated. In the case of 130 cd/m² of studio colour bar or three vertical bars, as the APL of these signals are 50%, PDP decreases its brightness to 2/5. On the other hand, LCD keeps always high brightness for white. The brightness of LCD is independent of the bright area. So, in this case, LCD need to decrease brightness to 2/5 to get the same brightness with PDP. … Our opinion is that fixed luminance condition should not be common for different technologies. This condition should be adopted "individually" for each technology”. PANASONIC, PIONEER and HITACHI therefore support the “out of the box” setting proposed by the IEC 62087.

Hans-Paul SIDERIUS (SenterNovem) also addressed this issue in his comments and acknowledge that the “out of the box” approach is not rigorous enough specification. He proposed a “middle setting” for contrast and brightness if a selection of different settings is possible.

The stakeholder comments reflect the full spectrum of opinions regarding a specification of picture level adjustment for the revised IEC 62087. It became clear that the standardization body IEC TC 100 is aware of this issue and possible consequences for the power measurement results. It also seems that most manufacturers prefer that a high picture quality is ensured in measurement settings of the IEC 62087. This does not mean that a specification reading brightness setting is necessary. It seems to be enough to ensure that a “standard mode” should be measured. It is assumed that this “standard mode” provides a good picture quality to the user.

Recommendation: From our perspective, IEC TC 100 should define "standard mode"[7] as the "out of the box setting" as well as the first mode appearing on the screen when activating the TV. IEC TC 100 should also consider proposing a recommendation for "standard mode" setting (specification) by reflecting on the current discussion regarding brightness and backlight settings. If no changes occur in the final version of the revised IEC 62087 (expected in 1stQ/2008) a definition of "standard mode" with technical specifications should be considered by the European Commission in order to ensure realistic power measurement conditions. However, we think that IEC TC 100 is thoroughly investigating this issue and will come up with a revised standard that is applicable for power consumption measurement under the framework of the EuP.

8.1.2.2. Determining an equation to extrapolate power consumption

Power consumption of TVs largely correlates with the specific (visible) screen surface area of the display. In consequence it is possible to calculate reference power consumption for a standard screen surface area (Watt per 1 inch² or 1 cm² screen), and then multiply the actual screen surface area with this index value. In order to determine an equation to extrapolate on-mode power consumption as a calculatory basis for setting minimum requirements (threshold value) and classes for energy efficiency labeling the study proposes however an approach that is not only based on one index value for the display power consumption, but which includes a constant for the receiver (non-display components) as well.

The preparatory study clearly shows that power consumption increases with screen size mainly independently of the display technology. It is this aspect on which the calculation of the index value is based. Please notice however that differences in power consumption also exist within the same screen size segment. These differences are related to advanced display technology and picture quality. It is no coincidence that today's technical development in the field of TV displays is focusing on these two aspects:

- The improvement of the picture quality for HD-ready TVs: This includes the technical realization of a high contrast, wide color gamut, fast response time, and reduced motion blur.
- The development of full HD TVs with a resolution of 1920x1080 pixels: This includes new panel technologies with finer structures and backlight designs as well as 100Hz technology.

[7] New proposal in IEC 62087 draft: "preset picture setting mode which is recommended by the manufacturer for the day to day or normal use by the customer".

The improvement of picture quality and resolution is directly related to the dimension and light utilization of the backlight unit in the case of LCD-TVs and the luminescence efficiency of the plasma panel in the case of PDP-TVs. In both cases power consumption will increase which could lead to considerable differences between products in the same screen size segment.

In order to put the power consumption related to the display into perspective to the whole TV it is possible to allocate a fixed power consumption value to the receiver or non-display components. As a matter of fact, the power consumption of the receiver (non-display components) does not correlate with the screen size to an extent as it is known for the display. The power consumption of the receiver is therefore relatively equal and depends more on the features or performance of the TV-set. The receiver or non-display components such as tuners, digital signal processors and memory, communication interfaces, video storage, audio components, as well as the power supply have an energy improvement potential which should be explored. Yet due to the potential integration of further functionality (e.g. digital tuners) and the still increasing performance requirements (e.g. full HD) it is feasible to assume that power consumption of the receiver side will remain constant or increase slightly. Against this background the study investigated the average power requirement of the receiver part. The feedback to the first results presented in task 7 interim report indicated following reference values (see Table 3).

Table 3: Basic Power Reference Values

Components	**Reference Power Consumption**	**Comments**
Digital signal processing	20W	DSP has improvement potential through system LSI development
Digital memory	4 W	Cache memory requirements will increase for full HD performance
Analogue tuner	4 W	Integration of multiple digital tuners might increase power demand in total
Interface components	4 W	Integration of modems might increase power demand in total
Audio components	1 W	Audio components are of less importance due to the volume control setting (50 mW) in the IEC 62087 test standard
Other (e.g. fans)	2 W	Fans, sensors, or other features require power which should find consideration
Power losses (85% PSU efficiency)	5 W	Power consumption of the components fluctuates with use intensity. The occurring power losses are accordingly. 85% PSU efficiency corresponds with the point of LLCC (see task 7)
Total:	**40 W**	

The study proposes using the following power consumption value as a constant for the receiver:

- 40W (P_{Basic})

The constant P_{Basic} should be considered an auxiliary tool which helps to put the power consumption per screen surface area approach particularly for small and medium screen sizes into a better perspective with the reality[8]. With the constant P_{Basic} the indicated improvement potential of the displays is now the foundation of setting a minimum requirement.

By subtracting the basic power constant P_{Basic} from the actual TV on-mode power consumption (P_{TVon}) a more realistic value for the display's power consumption ($P_{Display}$) is assumed. Based on this calculated display power consumption ($P_{Display}$) an index value for the power consumption of a 1 inch² screen surface area (Pa_{Screen}) can be calculated.

By multiplying Pa_{screen} with the actual screen surface area (a_{screen}) of the TV and adding P_{Basic} 40W the resulting P_{TVon} values per screen size form a linear ascent.

$$P_{TVon} = a_{Screen} \cdot Pa_{screen} + P_{Basic}$$

Taking this equation as the basis and Pa_{screen} and P_{Basic} as fixed, minimum requirements and energy efficiency classes can be defined by introducing factors b and c[9]:

$$P_{TVon} = a_{Screen} \cdot b \cdot Pa_{screen} + c \cdot P_{Basic}$$

The following calculation is an example of the method. It is based on a feasible data set and provides a basis for discussion of a minimum on-mode power consumption requirement.

8.1.2.3. P_{TVon} minimum requirement for HD-ready TVs

The outcome of the life cycle costing in task 7 leads to following points of least life cycle costs (LLCC) based on BAT assumptions:

- On-mode power consumption for the **32" LCD-TV** (option 1 + 3) of **127,5 W**
- On-mode power consumption for the **42" PDP-TV** (option 2 + 3) of **175,4 W**

Following MEEuP methodology, these values would qualify for a specific requirement (threshold value). However, the following constraints and uncertainties need to be addressed in that respect:

- The base cases represent two distinct technologies and screen sizes, extrapolation from these two points to other market (screen size) segments has to be done very cautiously,

[8] This aspect we show later in a calculation example.
[9] For additional integrated functionality (**+ $P_{feature}$**) see page 25 of this report.

- Picture quality improvements and full HD have currently an adverse effect on power consumption which needs consideration (see 8.1.1.3).
- Defining mandatory limit values (minimum requirements) should consider a safety margin. As discussed before, the test conditions of the power measurement standard (revision of the IEC 62087) influence the actual power consumption values.

Please notice: For these reasons we recommend in a first step to take the current market average as guidance to determine minimum requirements. With this conscious approach the methodology for defining threshold values can be introduced and experience gathered. With a certain time delay, more accurate power consumption data can be obtained and adjustments made for later requirements. In such a way we propose a two tier approach with the first tier setting the framework for a “phase-in” and a second tier setting “confirmed specific requirements”. The time frame for compliance with each tier should be at least two years in order to give industry enough time for redesign of their products.

Table 4: Calculation of average power consumption and scenario for HD-ready

Inch Scale	*Parameter*				*LCD BC*		*PDP BC*	
Screen size diagonal	Screen (inch)	20	23	26	**32**	37	**42**	50
Screen surface area	Screen (inch²)	172	223	289	**435**	585	**744**	1068
Minimum (market data, HD ready)	$P_{TV\ on}$ (W)		70,0	63,0	**75,0**	100,0	**140,0**	257,0
Maximum (market data, HD ready)	$P_{TV\ on}$ (W)		116,0	175,0	**210,0**	281,0	**380,0**	461,0
Average product (HD ready)	$P_{TV\ on}$ (W)	75,0	90,0	110,0	**150,0**	200,0	**275,0**	360,0
Adjusted display base	$P_{display}$ (W)	35,0	50,0	70,0	**110,0**	160,0	**235,0**	320,0
receiver factor c = 1	P_{basic} (W)	40,0	40,0	40,0	**40,0**	40,0	**40,0**	40,0
	$P\alpha_{Screen}$ (W/in²)	0,2035	0,2242	0,2422	**0,2529**	0,2735	**0,3159**	0,2996
Preferable Scenario								
Adjusted on-mode value	$P_{TV\ on}$ (W)	87,3	101,3	119,5	**159,6**	200,9	**244,6**	333,7
Adjusted display base	$P_{display}$ (W)	47,3	61,3	79,5	**119,6**	160,9	**204,6**	293,7
receiver factor c = 1	$c \cdot P_{basic}$ (W)	40,0	40,0	40,0	**40,0**	40,0	**40,0**	40,0
display factor b = 1	$b \cdot P\alpha_{Screen}$ (W/in²)	0,2750	0,2750	0,2750	0,2750	0,2750	0,2750	0,2750

Table 4 shows the exemplary calculation results for setting minimum on-mode power consumption requirements based on the year 2006 average power consumption data for **HD-ready** TVs. The example calculations are given in Inch. The power consumption data that have been used were introduced and discussed already in the Task 5.4.1 report of the preparatory study. Although these data are not fully transparent (which test standard has been used, is it average or rated power consumption, etc.) they are sufficient enough to demonstrate the methodical approach as well as to discuss actual minimum requirements.

Please notice: There have been stakeholder comments questioning the feasibility of the on-mode power consumption values which IZM used as a data base for this study. In order to show that our data are realistic, we made a comparison (graphical overlap) with the data currently used by the Energy Star Program and the UK Market Transformation Program[10]. The IZM values the light blue dots (CRT), the orange dots (LCD) the purple squares (PDP) and the green triangles (RP). The turquoise diamonds are the values of Energy Star and the dark purple diamonds that of the UK MTP. The comparison indicates that the range and calculated averages of IZM data are justified.

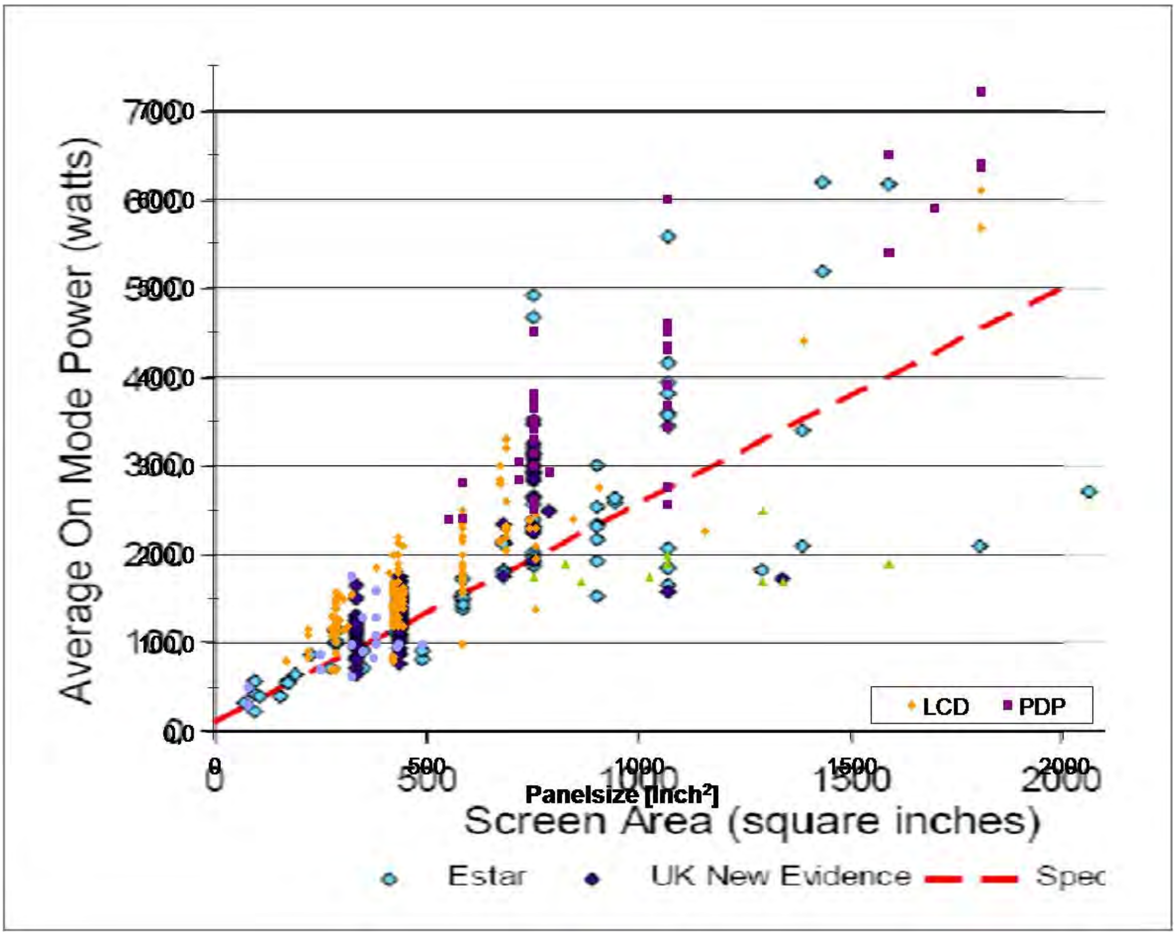

Figure 4: On-mode power consumption values according to IZM, Energy Star, and UK MTP

Keeping in mind that the identified improvement potential regarding power consumption of the 32" LCD-TV and 42" PDP-TV base cases is at least 20% (up to 40%) and that the revised test standard will result in more realistically measured power consumption values, the average power consumption of HD ready TVs from the year 2006 will describe the lower performance end in the year 2010. The focus for determining a realistic reference for the constant Pa_{screen} was laid on the base cases because they reflect the most significant technologies and the range of screen size

[10] Energy Star and UK data presented by Katharine Kaplan, U.S. EPA, at IEA workshop on energy efficient STB and digital networks on 4th July 2007 in Paris, France.

segments that are economically important in the next years. By taking the average on-mode power consumption (P_{TVon}) for each screen size segment (20"-50") and basic power constant P_{Basic} of 40W as a reference, an average screen constant Pa_{screen} of 0,258 W/in² was determined as an average over all screen size segments[11]. For screen sizes over 32-inch it is lower than the current average. This poses a problem and therefore a more moderate constant has been considered. If we only take the assumed most dominant screen size segments, the base cases (32" and 42") as a reference, than a constant Pa_{screen} of 0,284 W/in² results[12].

Recommendation: Against this background we propose as index value Pa_{screen} = 0,275 W/in² for the equation developed in 8.1.2.2. For setting minimum requirements for average (standard) on-mode power consumption (P_{TVon}) the considerations above leads to the recommendation to set factors b, c = 1:

$$\mathbf{P_{TVon,\ minimum\ req.\ HD\text{-}ready} = a_{Screen} \cdot 1 \cdot 0{,}275\ W/in^2 + 1 \cdot 40\ W + P_{feature}}$$ [13]

Resulting power consumption values for this equation are shown in the following Figure 5.

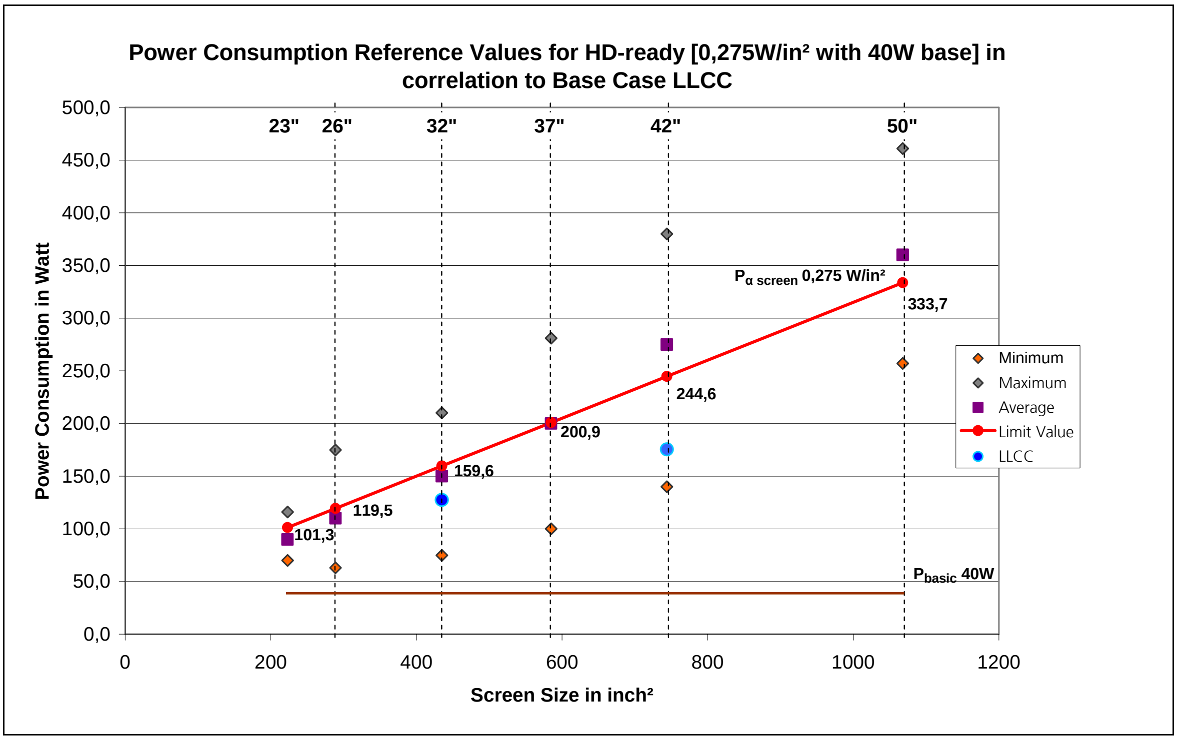

Figure 5: Examples for on-mode power consumption index value 0,275 W/in², and factors b, c = 1, in correlation to Base Case LLCC

[11] equal weighting for all 7 size segments in the above table (arithmetic average); based on statistical data used throughout the study

[12] arithmetic average of both base cases

[13] For additional integrated functionality (+ $\mathbf{P_{feature}}$) see page 25 of this report

The resulting P_{TVon} minimum requirements per screen size are reflecting future power demands of TVs with improved picture quality and integrated features realistically. For illustration, the Figure 5 compares the recommended threshold value and the points of LLCC for the two specific base cases. The recommended minimum requirement (red line) in comparison to our basic on-mode power consumption data set is plotted in the following Figure 6.

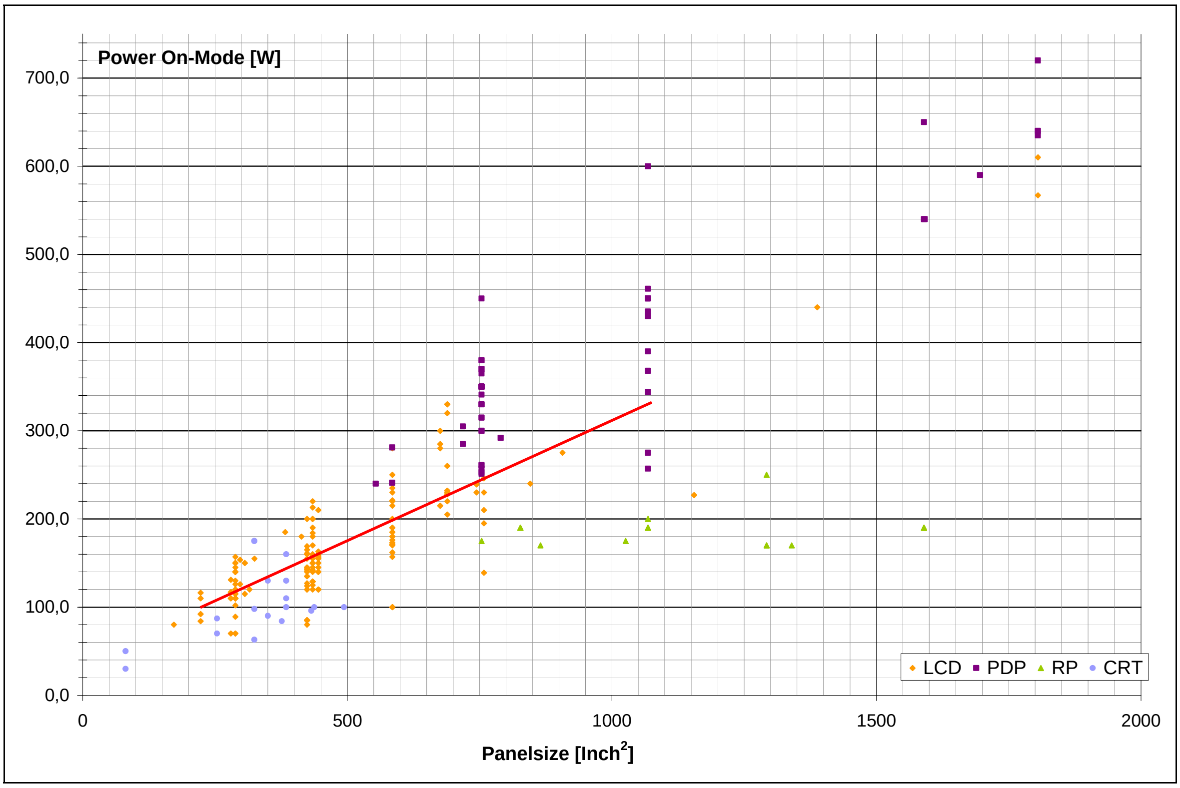

Figure 6: Illustration of minimum requirement versus catalogue data

This graph shows that the minimum requirement (0,275W/in² + 40W) would not mean a ban of any of the three technologies CRT, LCD, and RP up to 50" screen size (HD-ready). For large screen LCD and PDP the situation is different. Most of the on-mode power consumption values for large LCD and particular PDP that are plotted in the graph are over the minimum requirement. But according to our investigation (task 6 and 7) HD-ready LCD and PDP have a quite high improvement potential of up to 40% of current power consumption values. The new dynamic video test procedure (revised IEC 62087) will also provide more realistic (15% to 20% lower) power consumption values for PDPs. Both aspects should lead to considerably lower average on-mode power consumption. Against that background we have made the above recommendation for minimum requirement (0,275W/in² + 40W). This minimum requirement is surely demanding. But it is essential to keep in mind that the overall energy consumption related to TV (on-mode power) is a growing burden to the environment.

Stakeholder Comments:

Industry stakeholders such as EICTA has welcomed the general approach (metric) for setting minimum requirements based on $P_{TVon, minimum req.} = a_{Screen} \cdot 1 \cdot 0{,}275\ W/in^2 + 1 \cdot 40W$.

The Danish Energy Authority (DEA) and Hans-Paul Siderius propose that the equation derived in the paper "An Energy Efficiency Index for Televisions[14], is used to describe the power consumption in the on mode for TV's instead of the equation proposed in the lot 5 study. According to Mr. Siderius seems the factor of 40W far too high for the current average TV. Measurements with the revised standard (IEC 62087) of TVs now on the market suggest a constant between 15W and 20W. The setting of the constant (P_{basic}) at 40W has also consequences for the estimation of the screen index value. In Mr. Siderius and DEA's opinion the equation derived in their paper (0,3264W/in² + 15W) is more useful than the one described in the lot 5 report on task 8.

The IZM consortium is not in favor of Mr. Siderius metric (0,3264W7in² + 15W). The question what is a realistic off-set (P_{basic}) has been thoroughly investigated by the study and discussed with manufacturers. The value of 40W is realistic, and yes it is an auxiliary tool which helps to put power consumption into a realistic correlation to the screen area. A lower off-set (<40W) changes the ratio between modern display technology and necessary signal and picture processing, power supply to an unrealistic level. It would also limit the applicability of any kind of P_{screen}–based metric for small TVs (please see comparison in Figure 7). Furthermore, the 40W do not hamper the power consumption improvement on the receiver site. Manufacturers are aware of that potential. But as a matter of fact, picture quality improvement (as a key driver in current TV market) is currently achieved only by more digital processing power, memory capacity, and double frame rate (100Hz). This adds power demand on the receiver rather by tens of watts that further reducing power consumption.

[14] Hans-Paul Siderius & Bob Harrison, An Energy Efficiency Index for Televisions, 12 February 2007, http://www.ecotelevision.org/background_documents.php.

8.1.2.4. Critical review of the default values for Pa_{screen} and P_{Basic}

In comparison to the currently discussed metrics developed by the U.S. Energy Star (EPA), EU EcoLabel (AEAT), and Siderius & Harrison (UK MTP), the IZM approach with Pa_{screen} 0,275 W/in² and P_{Basic} 40W (off-set) shows the most moderate slope with more realistic power consumption values particularly in the smaller screen size segments and more ambitious values in the very large screen size segments which is from an environmental point of view beneficial. Table 5 and Figure 7 show the respective data in comparison.

Table 5: Resulting power consumption values from different metrics

Screen Surface (16:9)	in Inch²	96	171	223	289	438	585	684	754	904	1068	1805
Screen Size Diagonal	in Inch	15	20	23	26	32	37	40	42	46	50	65
0,2750W/in² + 40W	IZM (MR)	66	87	101	119	160	201	228	247	289	334	536
0,1925W/in² + 28W	IZM (Class C)	46	61	71	84	112	141	160	173	202	234	375
0,1650W/in² + 24W	IZM (Class B)	40	52	61	72	96	121	137	148	173	200	322
0,1372W/in² + 20W	IZM (Class A)	33	43	51	60	80	100	114	123	144	167	268
0,3264W/in² + 15W	Siderius/Harrison	46	71	88	109	158	206	238	261	310	364	604
0,2450W/in² + 11W	EPA EnergyStar	35	53	66	82	118	154	179	196	232	273	453
0,2710W/in² + 0W	EU Eco-Label	26	46	60	78	119	159	185	204	245	289	489

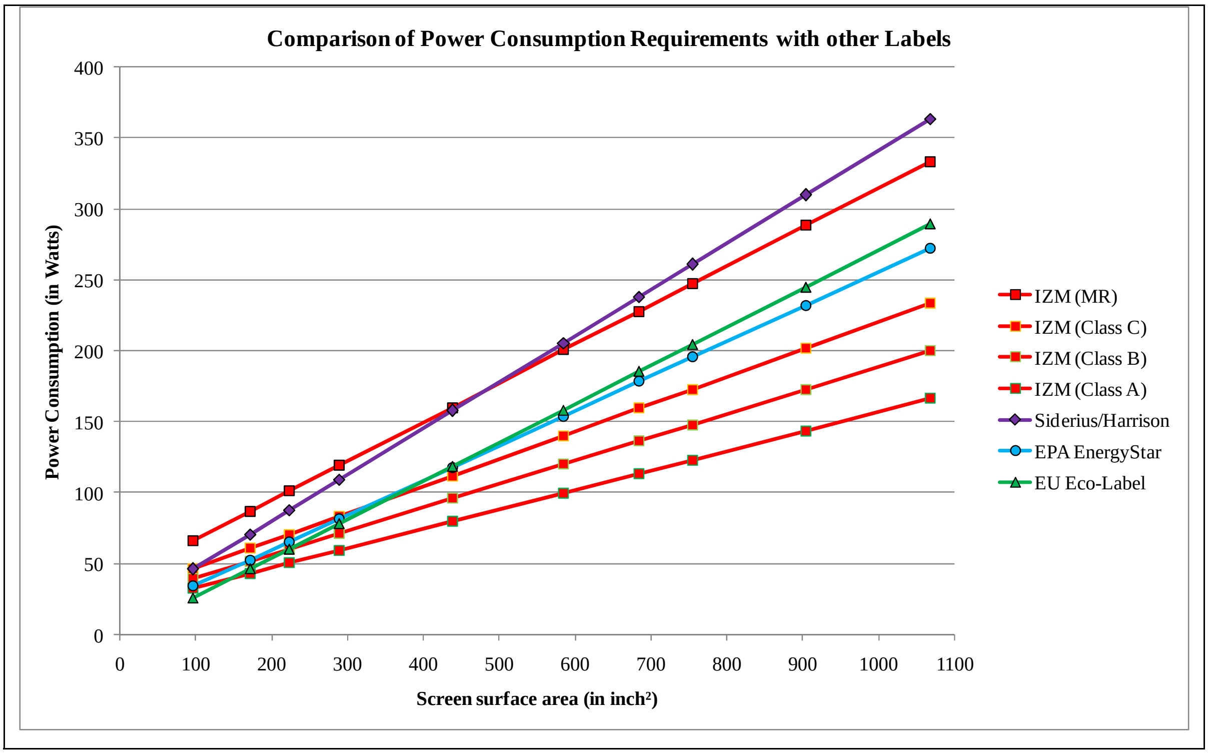

Figure 7: Comparison of power consumption requirements of different schemes

Recommendation: We propose using Pa_{screen} 0,275 W/in² (largest visible screen area[15]) with P_{Basic} 40W (factors b, c = 1) as the 1st tier minimum requirement for average on-mode power consumption (P_{TVon}) for HD-ready televisions. The related (average) on-mode power consumption should be measured based on the revised IEC 62087 test standard preferably in "standard mode" setting. We also recommend differentiating at this point of time a minimum requirement for HD ready from full HD (see next chapter) due to the novelty of this technology.

In view of future developments and more realistic benchmarking of energy efficiency in correlation with product performance we also recommend that industry, policy maker, and standardization bodies should investigate a benchmark system (value) for picture quality of TVs. Picture quality is the main distinction factor of TVs which more and more influences the consumer decision. But picture quality is perceived very differently by the consumer as well. Still, we assume that there are technical parameters available that could characterize a high picture quality. Picture quality criteria could be a combination of resolution, brightness, contrast, reaction speed, etc. Unfortunately, the study has not the scope to investigate a relevant scheme.

Further consideration should be given to the aspect of "integrated functionality".[16]

Stakeholder comments by EICTA, LOEWE, SHARP indicated that power consumption increase with more integrated functionality such as digital tuners (DVB-S/DVB-T) or video storage (DVD-R/HDR), however from a system point of view it decreases power consumption in case a stand-alone device (STB, HDR) would be substituted. Stand-alone devices consume on average more energy than comparable integrated features. This aspect is beneficial for the environment. LOEWE and SHARP recommend adding certain Power Budgets ($P_{feature}$) to the 40W P_{basic} by applying the following equation:

$P_{feature} = n_{feature}$ (number of additional functions) * P_{basic} / 10 (4W)

As an example:

$n_{feature}$ = 3 (DVB-S, HDR, W-LAN)

$P_{feature} = n_{feature}$ (3) * P_{basic} / 10 (4W)

$P_{feature}$ = 12 Watt

[15] EICTA et al had commented that a clear definition of screen surface should be given. For any calculation the largest visible screen area (picture ratio) should be the reference point.

[16] This particular aspect is new and derives from latest stakeholder feedback. It was not reflected in the base case assessments due to the novelty of the issue.

Comment by IZM: In general this is an appropriate scheme to address the possible tradeoffs from integrated functionality. The assumed 4W per feature is realistic. However, it seems necessary to set a scope for relevant features. The criteria must be the substitution of a stand-alone device with comparable performance. Regarding digital tuners (mostly double tuners for parallel TV viewing and separate recording) 2x4W should be the limit. If multiple double tuner (DVB-S, DVB-T, DVB-C) are integrated we assume that consumer will only utilize one option. Regarding video storage (DVD/DVD-R or HDD/HDR) we also see the necessity to set a limit with 2x4W. Other functionalities (features) such as Radio, W-LAN, Speaker, Ambient Light, etc. are not essential functions for watching TV. For instance, we reflect wireless interfaces in the provision of P_{basic} (40W). We therefore recommend, to consider (functional adder) adding $P_{feature}$ ($P_{feature} = n_{feature} *$ 4W) to P_{basic} for a (to be defined) set of integrated functions (features).

$$\mathbf{P_{TVon,\ minimum\ req.\ HD\text{-}ready} = a_{Screen} \cdot 1 \cdot 0{,}275\ W/in^2 + 1 \cdot 40\ W + P_{feature}}$$

8.1.2.5. P_{TVon} minimum requirement for full HD TVs

According to our study (see task 6), the shift towards full HD (in the medium and large screen sizes) will increase power demand at least in the field of PDPs. This aspect should be carefully reflected in order to set realistic targets. Due to the novelty of the full HD technology it is hardly possible to estimate power consumption values which could be achieved by 2010. However, in order to address this problem we suggest treating full HD products of the early generations (in the 1st tier requirement) with a separate value (see exemplary calculation below Table 6).

Table 6: Calculation of average power consumption (HD ready) and scenario for full HD

Inch Scale	Parameter				LCD BC		PDP BC	
Screen size diagonal	Screen (inch)	20	23	26	**32**	37	**42**	50
Screen surface area	Screen (inch²)	172	223	289	**435**	585	**744**	1068
Minimum (market data, HD ready)	$P_{TV\ on}$ (W)		70,0	63,0	**75,0**	100,0	**140,0**	257,0
Maximum (market data, HD ready)	$P_{TV\ on}$ (W)		116,0	175,0	**210,0**	281,0	**380,0**	461,0
Average product (HD ready)	$P_{TV\ on}$ (W)	75,0	90,0	110,0	**150,0**	200,0	**275,0**	360,0
Adjusted display base	$P_{display}$ (W)	35,0	50,0	70,0	**110,0**	160,0	**235,0**	320,0
receiver factor c = 1	P_{basic} (W)	40,0	40,0	40,0	**40,0**	40,0	**40,0**	40,0
	$P\alpha_{Screen}$ (W/in²)	0,2035	0,2242	0,2422	**0,2529**	0,2735	**0,3159**	0,2996
Preferable Scenario full HD								
Adjusted on-mode value	$P_{TV\ on}$ (W)	106,2	125,9	151,3	**207,5**	265,2	**326,4**	451,2
Adjusted display base	$P_{display}$ (W)	66,2	85,9	111,3	**167,5**	225,2	**286,4**	411,2
receiver factor c = 1	$c \cdot P_{basic}$ (W)	40,0	40,0	40,0	**40,0**	40,0	**40,0**	40,0
display factor b = 1,4	$b \cdot P\alpha_{Screen}$ (W/in²)	0,3850	0,3850	0,3850	0,3850	0,3850	0,3850	0,3850

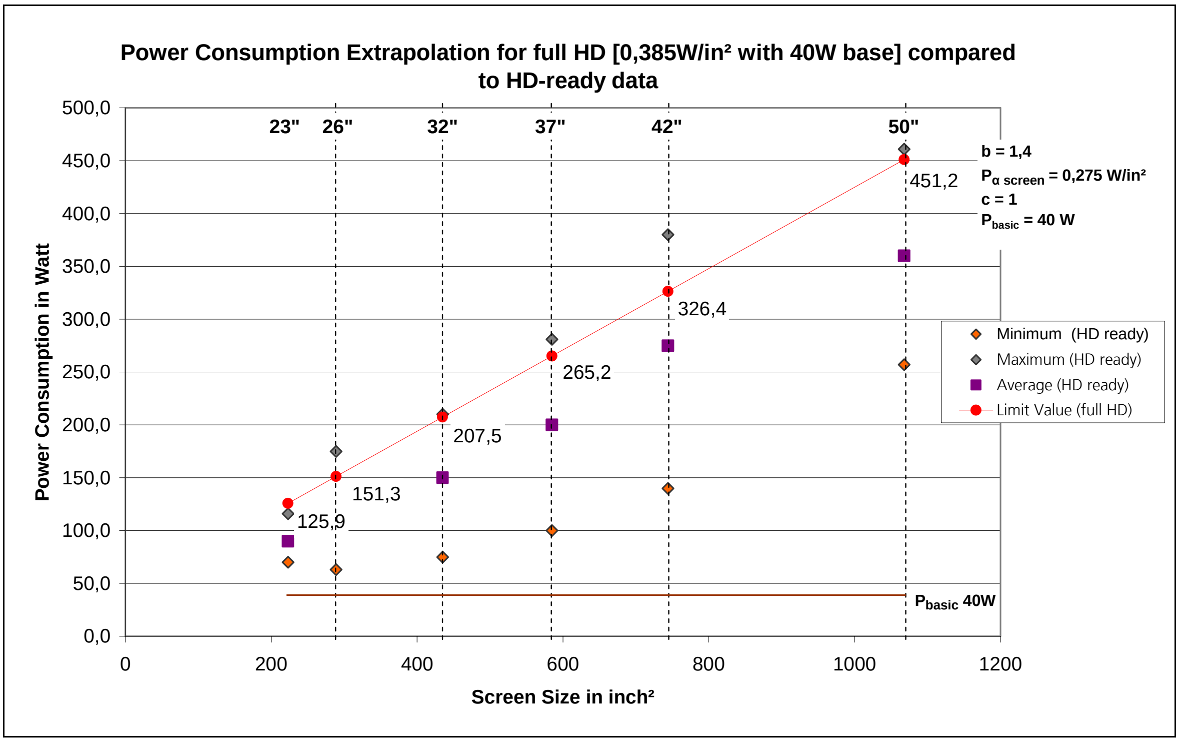

Figure 8: Exemplary power consumption extrapolation for full HD

Recommendation: The study recommends using a factor b = 1,4 (whereas c remains 1) as calculation basis for determining the minimum requirement for average on-mode power consumption (P_{TVon}) of full HD televisions:

$$\mathbf{P_{TVon,\ minimum\ req.\ full\ HD} = a_{Screen} \cdot 1{,}4 \cdot 0{,}275\ W/in^2 + 1 \cdot 40\ W + P_{feature}}$$

Information from industry indicate, that this is an ambitious target for **full HD PDP-TVs** and would require significant improvements compared to today's full HD PDP-TVs. For **full HD LCD-TVs** for technical reasons (see task 6) such a target (b = 1,4) is less ambitious. The power consumption values per screen size resulting from b = 1,4 are given in Table 6. The safety margin that has been incorporated reflects an additional power consumption of 30% in comparison to HD-ready products (percentage varies depending on screen size due to fixed P_{basic}). It is highly recommended to make comprehensive measurements based on the revised IEC 62087 in order to set more realistic threshold values for the 2nd tier. Again, we suggest using the 1st tier as a smooth "phase-in" during which experience can be gained and adjustment to the requirements made.

Stakeholder Comments:

Mr. Siderius and DEA do not agree with a separate minimum requirement for full HD. They argue that the report gives to little justification for the separate treatment of full HD. Some LCD manufacturer also raised concerns that this minimum requirement would open the market for very inefficient full HD LCD TVs. However, it is understood that full HD requires additional power at least in the current immature stadium of technology development and particular PDPs. In that respect we propose as a mid-term task to define performance characteristics such as picture quality which could than include the resolution of the display as well. However, as long as such a benchmark is not available we propose for the 1st tier a separate minimum requirement for full HD TVs. In that respect we like to indicate that the proposed energy label (see chapter 8.1.4) provides enough incentives for improving power consumption of full HD TVs.

8.1.3. Minimum requirements for passive and active standby

8.1.3.1. General remarks

The reduction of standby power consumption is an important task that needs continuous attention. With the shift towards digital TV new broadcast services such as coded Pay-TV are entering the market. Furthermore, the shift towards HDTV will also introduce advanced data compression and coding technology (MPEG-4) which will require periodical software updates in order to maintain interoperability and security. According to industry sources an important issue in that respect is the continuous update of code keys in order to reduce the risk of illegal copying from TV broadcasts. The TV broadcast industry is requiring that STBs or TVs with integrated digital tuner/decoder are remaining continuously in active standby modes in order to search and receive necessary security updates.

The lot 6 study on standby and off-mode losses investigated this growing issue and defined the term “networked standby” which can be equivalently used for the IEC 62087 term of “active standby low”. The investigation of lot 6 clearly indicates the technical status (power consumption requirements) of realizing network standby under certain network conditions (e.g. wired and wireless technologies). It also indicates the linkage to passive standby and shows the overruling potential of network standby in particular. Against this background we propose to set minimum power consumption requirements for **off-mode**, **passive standby,** and **active standby low** (networked standby) with a multi-tier approach.

In view of technical adaptation of such minimum requirements by the industry (redesign) the first tier should have at least two years time delay from the data of publication in the Official Journal. That would mean that if the implementing measure is published in 2008 the compliance should take effect in 2010. The second tier would than take effect in 2012. In the following we take this scenario for describing the time frame of the proposed requirements.

As with all recommendations given in this report the exact conditions of future implementing measures have to be discussed in the consultation forum. This includes conditions for the measurement procedure (applicable test standard is IEC 62301[17]) regarding the proposed minimum power consumption requirements of average standby modes. With regards to this aspect we

[17] IEC 62301 is currently under review.

recommend to measure "average" standby power consumption based on Wh/h approach (e.g. power consumption distributed over a 20h time period). The following Figure 9 summarizes the recommendations regarding minimum power consumption requirements. Details are given in the text below.

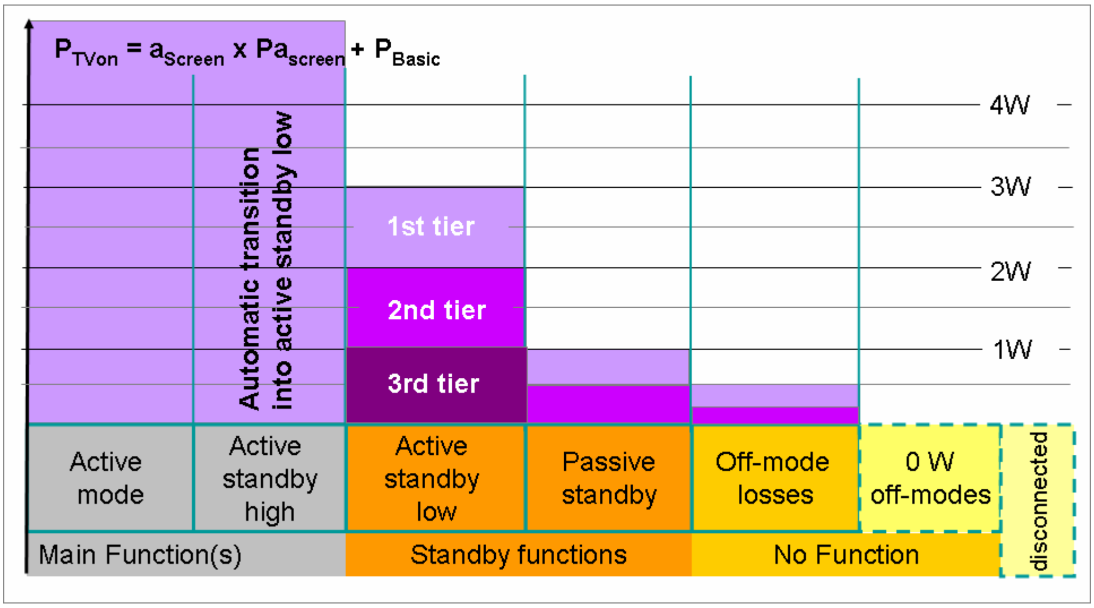

Figure 9: Summary of minimum requirements for power consumption

8.1.3.2. Minimum requirements for off-mode power consumption

A general recommendation is given to industry to keep possible off-mode losses to a minimum. The detailed analysis of this study did not focus on off-mode losses as this is usually less important under typical use patterns. However, to avoid loopholes, it is recommended to fix also off-mode power losses for TVs. A primary side hard-off switch (zero Watt) is optional. As minimum requirements the following values are recommended:

- 1st tier with compliance in 2010: ≤0,5W
- 2nd tier with compliance in 2012: ≤0,2W

Stakeholder Comments:

Most stakeholders appreciate the recommendation given above. SHARP however raised concern regarding the 2nd tier target: We (SHARP) agree with the 1st tier target (≤0,5W in 2010). However, regarding the 2nd tier target, design of hard switch, which can achieve ≤0,2W, has to be developed. It is quite difficult to realize by 2012. We believe that we have to put a priority on safety first, so we need to develop a technology which realizes both reducing remaining charge load at unplugging AC cord and reducing power consumption. At this moment, we cannot expect it by 2012. With considering typical use pattern, as you mentioned in your report, we think that its priority is lower than other stand-by modes. Therefore, SHARP propose you more moderate targets as below:

- 1st tier with compliance in 2010: ≤0,5W
- 2nd tier with compliance in 2012: ≤0,3W
- 3rd tier with compliance in 2015: ≤0,2W

The argumentation of SHARP is not fully transparent to the IZM. According to the knowledge is even passive standby possible with 0,2W. We could understand some economic reasons that the redesign of the whole product portfolio and secure supply of components might take more time. From a technical point of view the comment from SHARP would need further explanation.

8.1.3.3. Minimum requirements for passive standby power consumption

A general recommendation is given to industry to ensure that passive standby is kept to a minimum. Passive standby should be activated via remote control and clearly marked as such. As minimum requirements we recommend a two tier approach with the following average values:

- 1st tier with compliance in 2010: ≤1W
- 2nd tier with compliance in 2012: ≤0,5W

The target of ≤1W corresponds to the point of LLCC in task 7 (option 4 and option 1/2 + 3 + 4 respectively). Although calculations in task 7 are based on 1 W it is assumed that the real point of LLCC is below this value ("≤"). Confirmed achievable level within the near-term future is ≤0,5W (BNAT in task 7, individual manufacturers even claim 0,2W by 2008) and therefore is recommended as 2nd tier level.

Stakeholder Comments:

In general stakeholders appreciated the targets. Because of the same reason as "Off-mode" power consumption, SHARP again recommend the below targets for "passive standby" power consumption.

- 1st tier with compliance in 2010: ≤1W
- 2nd tier with compliance in 2012: ≤0,7W
- 3rd tier with compliance in 2015: ≤0,5W

The argumentation of SHARP is again not fully transparent to the IZM. From a technical point of view the comment from SHARP would need further explanation.

8.1.3.4. Minimum requirements for active standby low (networked) power consumption

In the light of upcoming network features in TVs it is recommended to cover active standby low in an implementing measure. As minimum requirements we recommend a three tier approach with the following average values:

- 1st tier with compliance in 2010: ≤3W
- 2nd tier with compliance in 2012: ≤2W
- 3rd tier with compliance in 2015: ≤1W

The 2nd tier level corresponds to a confirmed BAT. The minimum requirements of 3 and 1 W correspond with the findings and recommendations of the EuP Preparatory Study on Standby and Off-mode Losses[18], but with an additional intermediate tier due to specific complexity and redesign cycles of TV sets. A further requirement regarding active standby low is that a TV that features this functionality must provide the option to the consumer to easily switch the TV into a lower power mode which is passive standby or off-mode. This mandatory option should be provided on the remote control and clearly marked (identifiable) for the user.

Stakeholder Comments:

EICTA raises concern regarding the long timeline of target setting. EICTA argues: “As the timelines differ between the power modes, we strongly recommend not to propose or work upon any values which go beyond 2012. This applies specifically to the 1 Watt target for active standby low by 2015. This should be seen more as a subject for a future revision of a potential implementing measure and based on progress achieved in the market. With regards to the functionality of facilitating from active low into passive standby, solution should be menu driven instead of a mandatory option via the remote control.

The authors of the study appreciate a frequent revision of implementing measures based on new scientific insight. The proposal of a 3rd tier should be viewed as an orientation. It is important to investigate the issue of active standby in the future when more applications are in the market and real life surveys are possible. Regarding the requirement to enable the user to switch from active low into passive standby via remote control we are not following the EICTA opinion. On the one hand we understand that such switching might result in a loss of functionality and longer reactivation time. Users have to be made aware of this problem. They are accepting and planning already for longer reactivation times (to boot) in their use of PCs, Printer and Copiers. On the other

[18] Task 8 Draft Report, 19 June 2007

hand, passive standby is a required mode to ensure low power consumption. From our technical knowledge switching directly into passive standby on the remote is possible and should be facilitated as easy feature for the user to reduce energy consumption.

8.1.3.5. Minimum requirements for active standby high (transitional active)

Active standby high should not be considered “standby” but “transitional active” as it was again argued by the lot 6 study. Functionality that is provided under “active standby high” such as downloads and recording of TV programs is from our point of view considered a main function and therefore out of the standby scope. However, active standby high has an automatism which means that this functionality can be programmed and activated by user but does not have to be supervised by the user. In consequence, the only requirement towards active standby high is an automatic transition into active standby low after the main function (e.g. download) ended. Setting a particular time limit might have to be considered.

8.1.4. Mandatory energy efficiency label

8.1.4.1. General recommendations

Despite the setting of minimum requirements for power consumption the introduction of a mandatory energy efficiency label for TVs which promotes good and best performing products is recommended. As we have argued throughout the study, power consumption of TVs will likely increase than decrease in the coming years due to the technical realization of higher functionality and picture quality. The adoption of an energy label would stimulate the market and provide incentives to eco-conscious manufacturers. The introduction of an energy efficiency label in the white goods sector is a positive example in that respect. The mandatory energy efficiency label[19] should be based along the lines of the principles that were defined for the setting of the minimum power consumption requirements. This means that the setting of particular thresholds for the energy efficiency label (e.g. classes A, B, C, D, E, F, and G) should follow similar principles for determining a calculatory equation and measurement methods. In general the energy efficiency label should differentiate screen sizes (screen surface area) and should provide information on energy performance to the consumer. A differentiation of display technologies is not recommended. The energy label should only reflect on-mode (standard mode) power consumption and separate standby at the present time. The minimum requirements for standby power consumption are considered to be sufficient and, consequently, standby is not considered for the definition of efficiency classes (although standby could be included e.g. by defining a duty-cycle yielding a typical energy consumption).

[19] The legal frame for such an energy efficiency label could be Directive 92/75/EEC

8.1.4.2. Exemplary determination of class threshold values for energy efficiency label

In the following we exemplarily demonstrate an approach for determining class threshold values for a mandatory energy efficiency label. The basis of this exemplary calculation is an assumed 1st tier minimum requirement for HD-ready products with display and receiver factors b, c = 1. In order to determine a classification (A class, B class, C class, etc.) we suggest classes as outlined in the following Table 7. [20]

Table 7: Exemplary calculation of class thresholds for HD-ready TV

Class	On-mode power consumption (W)	Remarks
G	$a_{Screen} \cdot 1 \cdot Pa_{screen} + 1 \cdot P_{Basic} < P_{TV\ on}$	for full HD TVs only
F	$a_{Screen} \cdot 0{,}9 \cdot Pa_{screen} + 0{,}9 \cdot P_{Basic} < P_{TV\ on} \leq a_{Screen} \cdot 1 \cdot Pa_{screen} + 1 \cdot P_{Basic}$	Class F is min. requirement for HD ready TVs
E	$a_{Screen} \cdot 0{,}8 \cdot Pa_{screen} + 0{,}8 \cdot P_{Basic} < P_{TV\ on} \leq a_{Screen} \cdot 0{,}9 \cdot Pa_{screen} + 0{,}9 \cdot P_{Basic}$	
D	$a_{Screen} \cdot 0{,}7 \cdot Pa_{screen} + 0{,}7 \cdot P_{Basic} < P_{TV\ on} \leq a_{Screen} \cdot 0{,}8 \cdot Pa_{screen} + 0{,}8 \cdot P_{Basic}$	
C	$a_{Screen} \cdot 0{,}6 \cdot Pa_{screen} + 0{,}6 \cdot P_{Basic} < P_{TV\ on} \leq a_{Screen} \cdot 0{,}7 \cdot Pa_{screen} + 0{,}7 \cdot P_{Basic}$	
B	$a_{Screen} \cdot 0{,}5 \cdot Pa_{screen} + 0{,}5 \cdot P_{Basic} < P_{TV\ on} \leq a_{Screen} \cdot 0{,}6 \cdot Pa_{screen} + 0{,}6 \cdot P_{Basic}$	
A	$P_{TV\ on} \leq a_{screen} \cdot 0{,}5 \cdot Pa_{screen} + 0{,}5 \cdot P_{Basic}$	

This classification means every class stands for 10% improvement compared to the proposed tier 1 minimum requirement for HD ready TVs.

Table 8: Exemplary calculation of class thresholds

HD-ready TV	Screen Diagonal (inch)	23”	26”	32”	37”	42”	50”
	Screen Surface (inch²)	*223*	*289*	*435*	*585*	*744*	*1068*
min. 50% improvement (A class)	$b \cdot Pa_{Screen}$= 0,1372 W/in² $c \cdot P_{basic}$= 20W	51	60	80	100	122	167
min. 40% improvement (B class)	$b \cdot Pa_{Screen}$= 0,1650 W/in² $c \cdot P_{basic}$= 24W	61	72	96	121	147	200
min. 30% improvement (C class)	$b \cdot Pa_{Screen}$= 0,1925 W/in² $c \cdot P_{basic}$= 28W	71	84	112	141	171	234
100% minimum requirement	$b \cdot Pa_{Screen}$= 0,2750 W/in² $c \cdot P_{basic}$= 40W	101	119	160	201	245	334

Figure 10 below shows the threshold values again graphically. The orange rhombus indicates the 2006 BAT (HD-ready) as a reference. As we can see from this figure the current BAT is up to the 42-inch screen size segment within the assumed B class (40% improvement or 60% of minimum respectively). As for the 50-inch segment such a level cannot be reached by current LCD and PDP products except for RP-TVs which consume 175 Watts. Regarding smaller TVs under 23-inch we can notice some limits of the proposed approach. However, the exemplary calculation shows the

[20] For additional integrated functionality (+ $\mathbf{P_{feature}}$) see page 25 of this report.

feasibility of the values over the full scope of products. A further fine tuning is possible (see comments above).

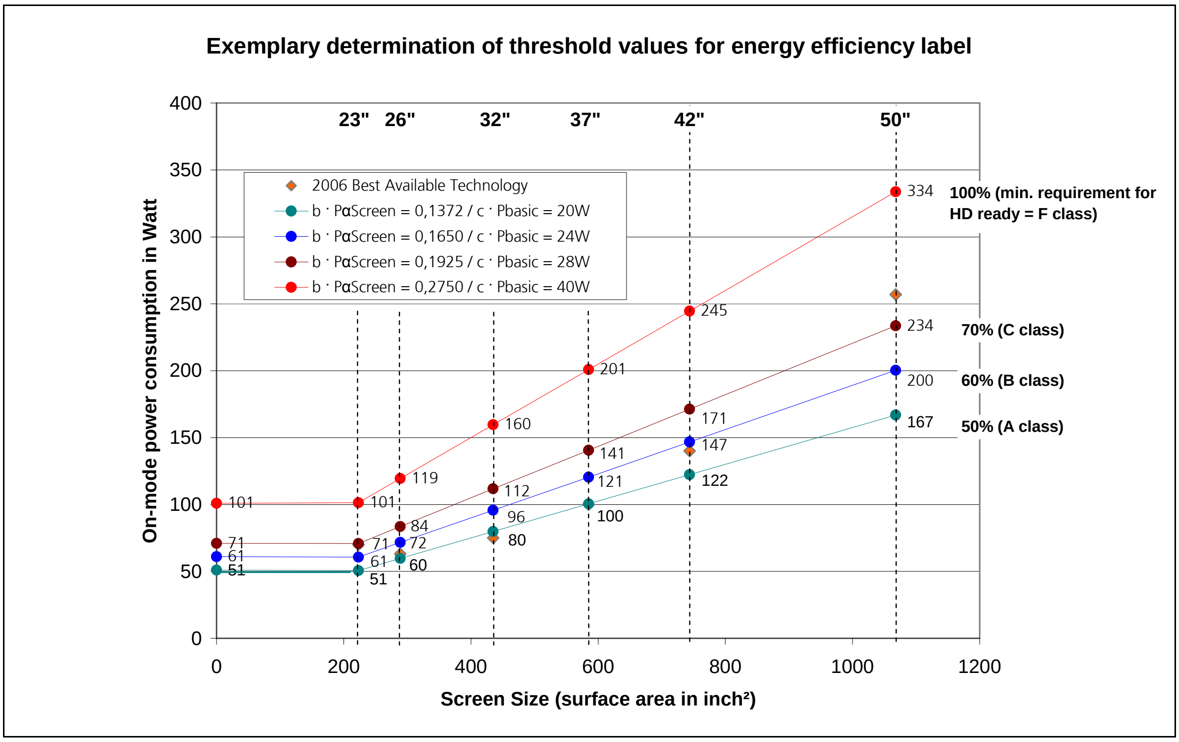

Figure 10: Exemplary determination of threshold values for energy efficiency label

The width of the proposed classes (steps of 10% improvement compared to the minimum requirement and for lower sizes an absolute delta of 10W) takes into account also likely measurement uncertainties under the coming IEC 62087 test standard, but with well defined settings. For the very minor market segment below 23” we recommend the rule, that values for 23” TVs are applicable (constant) also for all smaller TV sets. To apply this scheme of energy efficiency classes for both, HD ready and full HD gives an advantage for HD ready TVs as these can achieve a better class more easily. Especially full HD PDP-TVs are expected to achieve only the G class in the short-term.

Stakeholder Comments:

The DEA and Mr. Siderius recommend that an energy efficiency index (EEI) is used for the defining of labeling classes. The energy efficiency index could also be used for setting the minimum efficiency requirements. The index methodology is for instance used in the labeling scheme of refrigerators and freezers. A large advantage of the index methodology is that it makes the class boundaries independent from the screen size. According to Mr. Siderius can the energy efficiency index (EEI) be calculated in the following way:

$$EEI = P_{\text{on-mode measured}} / P_{\text{on-mode reference}}$$

The following class boundaries are proposed by Siderius et al:

A		EEI ≤	0,50
B	0,50	< EEI ≤	0,65
C	0,65	< EEI ≤	0,80
D	0,80	< EEI ≤	1,00
E	1,00	< EEI ≤	1,15
F	1,15	< EEI ≤	1,30
G	1,30	< EEI	

The IZM thinks that an Energy Efficiency Index (EEI) is a feasible approach that should be considered by the commission. We only recommend that the consumer is also provided with clearly understandable information on the actual power consumption of the device. The power consumption information could be provided as on-mode power (in Watt) based on a defined use pattern (in kWh).

Stakeholder Comments:

ECITA comments on the energy labeling included the following statement: "EICTA members are surprised that energy labeling has became a subject of EuP Lot 5; in our opinion, this should be a topic under the Energy Labeling Directive. Similar comment was made by Mr. Siderius indicating that mandatory energy efficiency labeling cannot be required under the EuP Directive. EICTA believes that the application of the A-G label for the white goods sector has moved the market positively. However, setting conditions for power labeling for televisions is premature, as there is no unified test standard given yet and the base line is therefore not known. We also believe that the fixed A-G label also proved to be extremely inflexible, which lead to the A+ and A++ ratings. In our eyes a rating should be more open-ended and offer a simple and transparent revision like the automobile emission classes EURO1, EURO 2 etc. A formula for the category calculation – as mentioned in the report - should also be in line with the improvement potentials given in Task 7. Focusing on a minimum 50 % improvement potential would mean that it is not consistent with the values proposed for the coming years. In this respect none of the TV producers could achieve an A class performance. Therefore we wish to repeat our request that a consistent approach be adopted, should labeling be seriously considered. It might be even helpful to adjust the steps of improvements. 10% might be too stringent, whereas 7.5 % might also be an option to support the need of the consumer for a real rating and for comparability".

Fraunhofer IZM agrees that "a minimum 50 % improvement potential" is not full consisted with the findings of task 6 and 7, where a maximum of 40% improvement was determined for both LCD and PDP technology as a maximum. We also confirm that there are almost no TVs in the market[21] that could today achieve an A Class. In that respect an adjustment of the A Class (e.g. 40% of minimum requirement) might be considered for future energy labeling. On the other hand, a very ambitious A Class will not lead to "extremely inflexible … A+ and A++ ratings". A reduction of the improvement steps from 10% to 7,5% should not be considered because it could lead to measurements inaccuracies for medium and small screen sizes.

Stakeholder Comments:

The PDP manufacturers HITACHI, PIONEER, and PANASONIC proposed to exclude full-HD products for labeling in the 1st tier: "In the case when the labeling is applied to full-HD products, please adopt the different standards from HD-ready (e.g. apply factor 1.4 to full-HD.) with the same efficiency class name as A to F (Excluding G). Please avoid giving class name G for full-HD as this class name may give impression to consumer that full-HD consumes power worst."

The authors of the report have indicated in the task report 6 the technical challenges for achieving full HD resolution in the case of PDP technology. Against that background full HD plasma displays in the first generations will consume considerably more energy than comparable liquid crystal displays. The separate minimum requirement for full HD TVs is reflecting this challenging situation. However, in order to give incentives to all market players for improving energy efficiency of their products, we would not consider a separate energy label for full HD. Again, it could be beneficial to combine the energy label in the midterm with picture quality criteria (label) that should consider high resolution as one aspect.

[21] Except view very small CRT and LCD as well as very large RP TVs.

8.1.5. Further eco-design requirements

8.1.5.1. Recommended standards for further eco-design requirements

We highly recommend considering the ECMA 341 Standard on "environmental design considerations for electronic products" or the new IEC 62430 Standard on "environmentally conscious design for electrical and electronic products and systems" (TC111/WG2) as base for generic eco-design requirements. For example, the ECMA 341 standard identifies general design practices for Information and Communication Technology (ICT) and Consumer Electronic (CE) products with a rated voltage not exceeding 1000 V r.m.s. This standard specifies requirements and recommendations for:

- Energy efficiency
- Material efficiency
- Consumables and batteries
- Chemical and noise emissions
- Extension of product lifetime and end of life considerations
- Substances and preparations needing special attention
- Product packaging
- Documentation

There is an overlap of the design aspects listed in the ECMA 341 and IEC 62430 standards and the identified aspects for TVs specifically (see listings in task 7.1.3). To make consideration of these standards mandatory for the design process would force the TV design teams to consider relevant environmental aspects, which cannot be addressed by specific requirements. Use and documentation of the design checklists provided in ECMA 341 plus detailed consideration of the design aspects listed in 7.1.3 can serve as evidence for consideration of main environmental aspects in the design process. As this ECMA checklist is a generic one for ICT & CE equipment it is recommended to initiate the development of a more detailed design guidance document based on the findings of this study, which can include also guidance on the mandatory requirements. Further information on the ECMA 341 standard is available on the internet[22]. A first draft of the IEC 62430 is under first review.

[22] http://www.ecma-international.org/publications/standards/Ecma-341.htm

Stakeholder Comments:

EICTA is generally pleased with the proposal on the recommendation to existing standards into consideration such as the ECMA 341 Standard or the new IEC 62430 Standard. EICTA however comments as well: "as Eco-Design requirements might potentially be subject to the CE approval process, EICTA would like to welcome a more systematic approach in order for companies to be in a position to provide evidence of eco-design aspects. Therefore it seems more appropriate to cover eco-design requirements within the various established management systems already embedded in companies Quality Assurance Processes. This procedure already has an excellent track record, bearing in mind experience with other Directives and proof provided to authorities on demand".

This comment by EICTA indicates the uncertainties regarding the documentation of eco-design measures and provision of test results. The scope of our study does not cover this question, however it is relevant. Furthermore, the EICTA comment might also addresses the nature of a possibly required "eco-profile" under the EuP-Directive.

8.1.5.2. RoHS compliance and further reduction of potential toxic materials

It is recommended that industry should facilitate green procurement procedures and continuously check the compliance of components with the RoHS Directive 2002/95/EC. The introduction and application of new technologies should focus on the further reduction of potentially hazardous materials. However such measures should not reduce energy efficiency as this is the primary environmental concern. Industry should also investigate design options to improve recycling or end-of-life treatment. This applies particularly to mercury containing LCD backlights and choice of flame retardants.

Mercury in LCD backlights is currently exempted from the RoHS substance ban. Due to the fact that the mercury content in LCD backlights provides long-term efficient light generation we agree with the RoHS exemption. But, mercury is a highly toxic substance which poses health dangers when treated not properly during the products end-of-life. We therefore recommend that on the cover of the backlight unit (BLU) a marking should indicate the contents of mercury. It is not necessary however to declare the exact amount of mercury.

Stakeholder Comments:

SHARP provided a correction regarding the quantity restriction of mercury in backlights: "Referring to the – RoHS Regulations Government Guidance Notes – issued by UK DTI in November 2005, mercury in LCD backlights is categorized as Annex C No. 3 of RoHS directive.

That means there is no restriction on the quantity of mercury in LCD backlights. We understand that DTI's interpretation is not applied to all EU member countries, but as long as there is a member country that has such interpretation officially, we ask you to delete the part in bracket "(up to 5 mg per lamp)" from the report. Further, there is a possibility of increase amount of mercury per lamp in order to achieve higher efficiency of backlights, to reduce material resources and power consumption. We are now studying the availability of more energy efficient lamp for LCD backlights. The mercury amount of that lamp increase compared to the current lamp type. However, total number of lamps per TV can be decreased. Even current type lamp, if amount of mercury per lamp increase, the life of lamp can be expanded. It is quite difficult to evaluate which contribute to reduce environmental impact "reducing mercury amount" or "increase energy efficiency". If consumers are given only mercury amount, they may judge the environmental performance by only that information. It may mislead customer understanding and it can be barrier of new energy efficient technology. In conclusion, we ask you to delete the description which recommends the declaration requirement to mercury amount."

The authors of the study approve this statement of SHARP and revised the text of the draft report respectively (see above).

Lead content in displays: The RoHS currently exempts Plasma Displays from the lead ban, although recently lead free panels have been introduced. As long as the exemption under RoHS is valid, it is recommended to require a declaration of the lead content in the Plasma Display. Same applies for CRTs.

The improvement of the end-of-life treatment of TV-sets and their materials with a high rate of material recovery and low pollutions are – as already indicated – increasingly important. The value of materials from discarded products is more and more recognized by a specialized electronics recycling industry. This potential should be explored and further improved by product design measures. This is an individual task which depends on certain product specifics (e.g. display technologies). It also depends on the link between manufacturers and the end-of-life infrastructure (technology) in a particular region. As we have indicated in the study the current WEEE scheme does not provide feasible incentives on the sides of the manufacturing industry to improve product design. Therefore, specific DfR recommendations (Design for Recycling) are not defined.

8.1.6. Data and information requirements

8.1.6.1. Data requirements

We recommend that manufacturers should provide following power consumption data referencing an approbation sample:

- On-mode (standard mode)
- Active standby low (networked standby)
- Passive standby
- Off-mode

The power consumption of on-mode should be measured according to the revised IEC 62087 test standard (which should be available by 2008). A test procedure for active standby low (networked standby) is necessary (or should be measured according to IEC 62301). We propose to measure respective active standby low power (without active standby high intervals) over a certain time period (e.g. 20h/day) as an average. Rated standby power (maximum levels) is an insufficient indicator and does not reflect energy efficiency. It would also limit functionality and may lead to constant active standby high.

8.1.6.2. Information requirements

We recommend that following information requirements:

- Mandatory energy efficiency labeling (no fee required)
- Mode-specific power consumption data (see task 8.1.6.1) should be provided to customers in sales advertisements and user manuals
- Rated power consumption in the user manual (necessary information for mains access)
- Explanations of power modes (particularly standby options) and energy saving options (eco-modes) in the user manuals
- Warning of mercury content in backlights (information to recycling industry on the backside of the BLU)

Stakeholder Comments:

The Danish Energy Agency (DEA) commented: “It is crucial that the technical documentation includes all information needed for compliance checks. You have listed important information to be included, but the information needed will have to be considered further when the final requirements in the implementing measure are known”.

The DEA further “agrees with the proposed information requirements (mandatory labeling, mode specific power consumption data in user manuals etc.). However mandatory labeling cannot be implementing in the framework of the eco-design directive”. A similar comment was given by Mr. Siderius indicated that “the EuP Directive cannot require a standard format (which is one of the essential elements of labeling)”.

The DEA finally stated: “The energy consumption of a TV varies according to the setting of the TV’s contrast and luminance levels. However consumers are not aware that set-ups of contrast etc. have a great influence on the actual energy consumption of the TV. Therefore the DEA recommends that information on the influence of the set-ups of contrast, luminance etc. is included in user manuals etc.”

The authors of the study approve these comments.

8.1.7. Energy Consumption Scenarios

8.1.7.1. Scenario models and variable factors

Regarding the development of annual energy consumption for the total TV stock in EU-25 the interim task 5 report provided an extrapolation scenario for the year 2010 based on market data and power consumption values of HD-ready TVs from the year 2006. The following scenarios are building on the same basis. The assumed power consumption averages, use patterns, and the stock data for the scenarios are resulting from the study's results of tasks 3 and 5. The scenarios are modeled on the basis of total EU-25 stock. Following variable factors have been considered.

Share of main screen size segments in the stock model. A distinction is made for small screen sizes (14"/15", 21"/23", 25"/26"), medium screen sizes (28"/29", 32"/33", 36"/37") and large screen sizes (42"/43", 50"/52", 61"/65"). Market shares and average power consumption value are allocated to all sub-segments in order to provide a finer tuning of the scenarios. For the scenarios we assume a certain distribution of market shares related to particular screen size segments. The assumed market shares for the reference years 2010 and 2020 are reflecting the shift form small screen sizes (80% share in 2005) towards medium and large screen sizes (80% share in 2020). To what extent this shift really occurs is of course unknown. However, the assumption of this shift influences the scenarios tremendously. If the amount of larger TVs that will be purchased over time increase, total energy consumption will increase respectively. The main stock data are summarized in Table 9 and Figure 11.

Table 9: Main stock and average power consumption data for the scenarios

TV Segment	Small Screen Size (14"-26")			Medium Screen Size (27"-29")			Large Screen Size (40"-65")			Total
TV Screen Size (inch)	14/15"	21/23"	25/26"	28/29"	32"/33"	36/37"	42/43"	50/52"	61/65"	
2005 Stock Scenario										
Stock (in %)	14%	30%	34%	10%	8%	2%	2%	0%	0%	100%
Stock (in Units)	38.629.080	82.776.600	93.813.480	27.592.200	22.073.760	5.518.440	5.518.440	0	0	275.922.000
Average on-mode (W)	70	90	110	130	150	200	275	360	575	
2010 Stock Scenario										
Stock (in %)	10%	20%	25%	10%	12%	10%	10%	2%	1%	100%
Stock (in Units)	39.151.200	78.302.400	97.878.000	39.151.200	46.981.440	39.151.200	39.151.200	7.830.240	3.915.120	391.512.000
2020 Stock Scenario										
Stock (in %)	2%	5%	15%	5%	25%	22%	20%	5%	1%	100%
Stock (in Units)	8.216.000	20.540.000	61.620.000	20.540.000	102.700.000	90.376.000	82.160.000	20.540.000	4.108.000	410.800.000

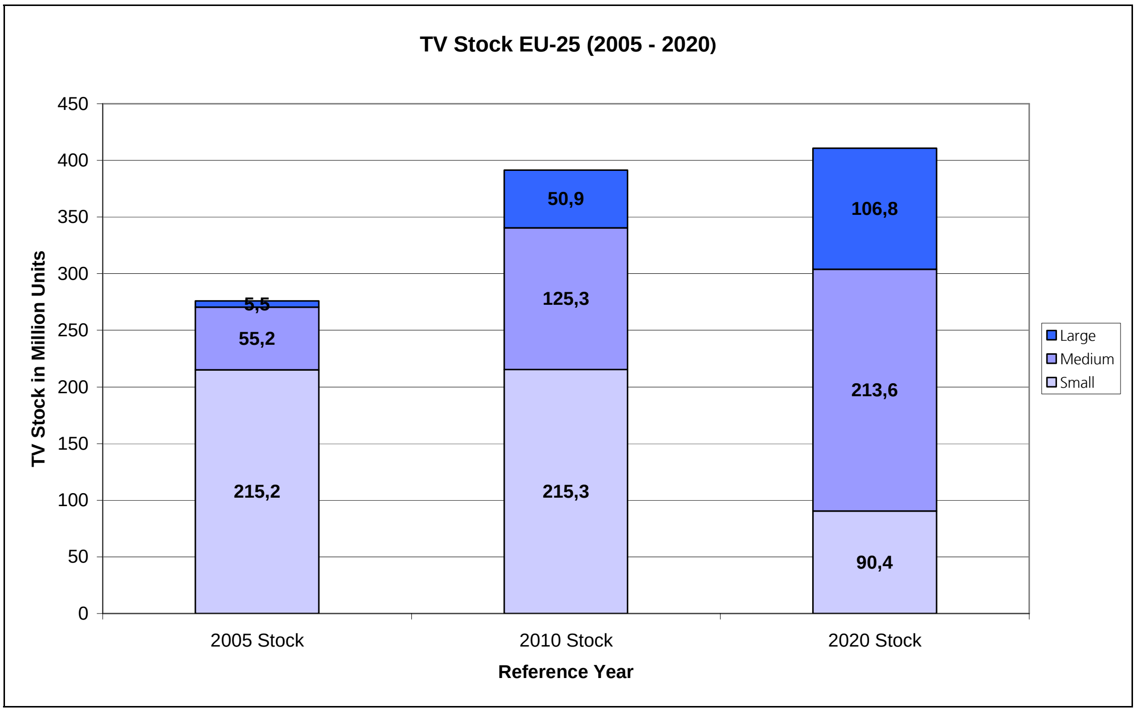

Figure 11: EU-25 TV stock development for reference years 2005, 2010, and 2020

Average on-mode power consumption values for all sub-segments. The data have been taken from the assessment in tasks 5.4.1.1 and 5.4.1.2. These are on-mode power consumption averages of HD-ready products of the year 2006. For the particular values see again Table 9 above. For the scenarios on-mode power averages have been changed according to the assumptions of values for minimum requirements and values of the proposed energy efficiency label. At this point of time it is not possible to provide a feasible outlook on full HD (1.920 x 1.080 pixels) products. Therefore all scenarios reflect the development of HD-ready products. However, from a technical perspective it is likely that power consumption of full HD products of the first generations will be considerably higher than average HD-ready products.

Average standby power consumption values have been fixed for purpose of the scenarios by the reference year. This is of course a simplification which has an impact on the long-term scenario. However, as the scenarios show, passive and active standby will not contribute to the overall energy consumption of TVs to such an extent that the main proportions of the scenarios will be affected. We therefore assume for the scenarios the following average values:

- 5W average standby for the reference year 2005
- 3W average standby for the reference year 2010
- 1W average standby for the reference year 2020

Daily use pattern and product lifetime have been fixed for the purpose of the scenarios. We have argued that 4 hours on-mode and 20 hours standby is an average daily use pattern. The annual power consumption is calculated on a daily use meaning 365 days a year.
However, due to the fact that more secondary TVs are utilized in European households and that by 2010 every household has two TVs we have reconsidered the average on-mode time per devices. In order to show the magnitude of this intensive TV use we also calculate a second scenario with a 3 hours daily on-mode and 21 hours daily standby for the reference year 2010 and 2020. Finally, we assume a 10 year average product life. In the past the utilization of a TV was approximately 15 years and still most households make use of a secondary TV even after such an extended time period. But with the introduction of new (and not yet fully mature) technologies and features, decreasing sales prices and availability of products, the product lifetime will drop and a faster exchange of devices is very likely. Out of these reasons we hold on to the assumption of 10 years product lifetime on average.

Four impact scenarios will be modeled. They reflect on the one hand worst case developments in order to indicate the magnitude of energy consumption related to the use of TVs in the long-term. Secondly they reflect the variables that influence to overall energy consumption of the TV stock in EU-25. Finally, they provide an outlook on the necessary improvement in order to reduce overall energy consumption of TVs in the EU. The following impact scenarios are modeled:

- **Scenario 1**: “Business as usual” with no improvement
- **Scenario 2**: “Business as usual” with 3h on-mode
- **Scenario 3**: “Minimum requirement” with assumed 1% annual improvement
- **Scenario 4**: “Best practice” with enforced B class energy efficiency label for all products

8.1.7.2. Scenario 1: “Business as usual” with 4h on-mode

The first scenario describes a “business as usual” situation in a sense of a worst case. We assume that due to picture improvement measures and the integration of functionality the current average will not be improved at all over until 2020. Figure 12 shows the **scenario 1** with 4 hours on-mode and 20 hours standby per day. The actual figures indicate a dramatic increase in TV related energy consumption. In the reference year 2005 annual energy consumption was 54 TWh. This figure sharply increases to 91 TWh in 2010 and 116 TWh in 2020. The main reasons for this situation are the increase in stock and impact from larger size TVs. The penetration rate increases from 1,5 TVs per household in 2005 to 2,0 TVs in 2010 (see also Figure 11). The shift towards larger size TVs is equally important. By 2020 the total power consumption of the large screen size segment is similar to the medium screen size segment although the large TVs are in number only half the amount of the medium segment. This scenario shows the impact of intensive utilization of TVs as well as the impact arising from the on-mode power consumption of medium and large TVs. In reality we should however assume that improvements will take place and not overcompensated by performance criteria.

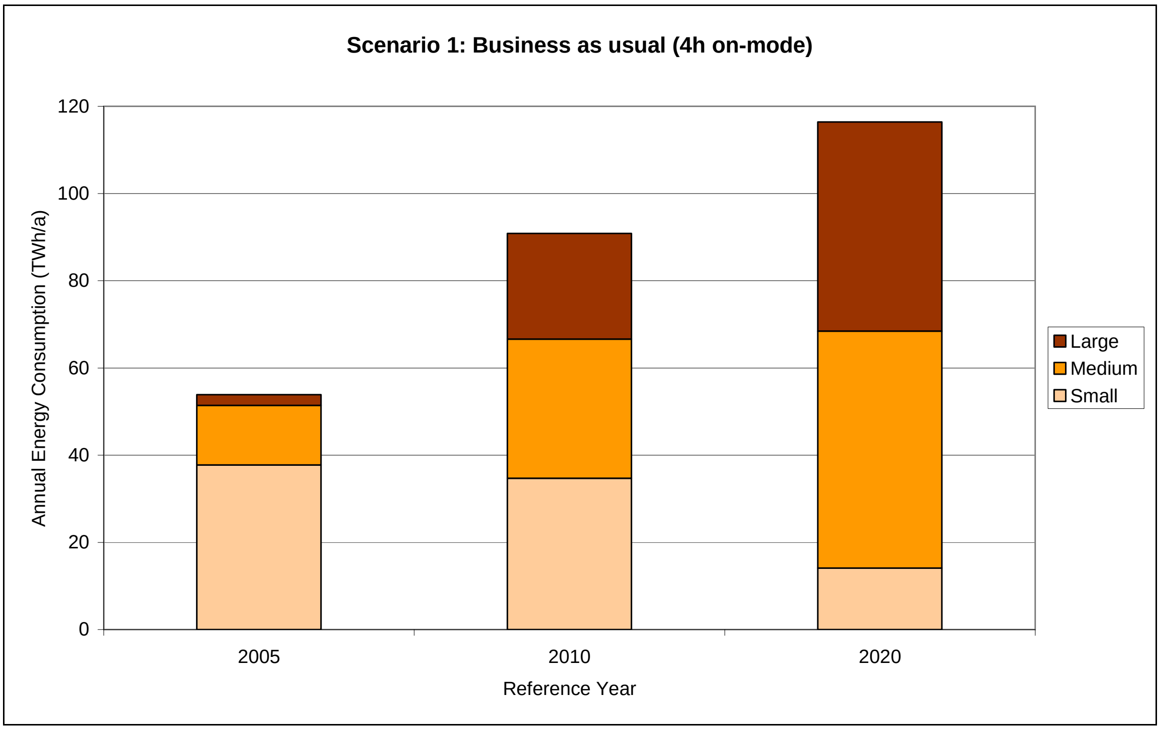

Figure 12: Scenario 1 "Business as usual" (4h on-mode)

Table 10: Main Data of Scenario 1 (4h on-mode / 20 h standby)

TV Screen Size (inch)	14/15"	21/23"	25/26"	28/29"	32"/33"	36/37"	42/43"	50/52"	61/65"	Total
2010 Stock Scenario										
Stock (in %)	10%	20%	25%	10%	12%	10%	10%	2%	1%	100%
Stock (in Units)	39.151.200	78.302.400	97.878.000	39.151.200	46.981.440	39.151.200	39.151.200	7.830.240	3.915.120	391.512.000
Power (W)	70	90	110	130	150	200	275	360	575	
Standby (W)	3	3	3	3	3	3	3	3	3	
4h on-mode (GWh/a)	4.001,25	10.288,94	15.719,21	7.430,90	10.288,94	11.432,15	15.719,21	4.115,57	3.286,74	82.282,90
20h standby (GWh/a)	857,41	1.714,82	2.143,53	857,41	1.028,89	857,41	857,41	171,48	85,74	8.574,11
Total Annual Power Consumption (GWh)										**90.857,02**
2010 Stock Scenario		**Small**			**Medium**			**Large**		**Total**
on-mode power		30.009,39			29.151,98			23.121,52		**82.282,90**
standby power		4.715,76			2.743,72			1.114,63		**8.574,11**
Annual power total (GWh/a)		34.725,16			31.895,70			24.236,16		**90.857,02**
2020 Stock Scenario										
Stock (in %)	2%	5%	15%	5%	25%	22%	20%	5%	1%	100%
Stock (in Units)	8.216.000	20.540.000	61.620.000	20.540.000	102.700.000	90.376.000	82.160.000	20.540.000	4.108.000	410.800.000
Power (W)	70	90	110	130	150	200	275	360	575	
Standby (W)	1	1	1	1	1	1	1	1	1	
4h on-mode (GWh/a)	839,68	2.698,96	9.896,17	3.898,49	22.491,30	26.389,79	32.987,24	10.795,82	3.448,67	113.446,12
20h standby (GWh/a)	59,98	149,94	449,83	149,94	749,71	659,74	599,77	149,94	29,99	2.998,84
Total Annual Power Consumption (GWh)										**116.444,96**
2020 Stock Scenario		**Small**			**Medium**			**Large**		**Total**
on-mode power		13.434,80			52.779,58			47.231,73		**113.446,12**
standby power		659,74			1.559,40			779,70		**2.998,84**
Annual power total (GWh/a)		14.094,55			54.338,98			48.011,43		**116.444,96**

8.1.7.3. Scenario 2: “Business as usual” with 3h on-mode

In order to show the impact of the use pattern on the total energy consumption of the TV stock the following scenario 2 describes a reduced viewing hour assumption. Figure 13 shows the **scenario 2** with a 3h on-mode and 21 hours standby per day. In this scenario the “business as usual” still shows a considerable increase in total energy consumption with 71 TWh in 2010 and 88 TWh in 2010. However, the magnitude of increase is lower in comparison to the scenario 1.

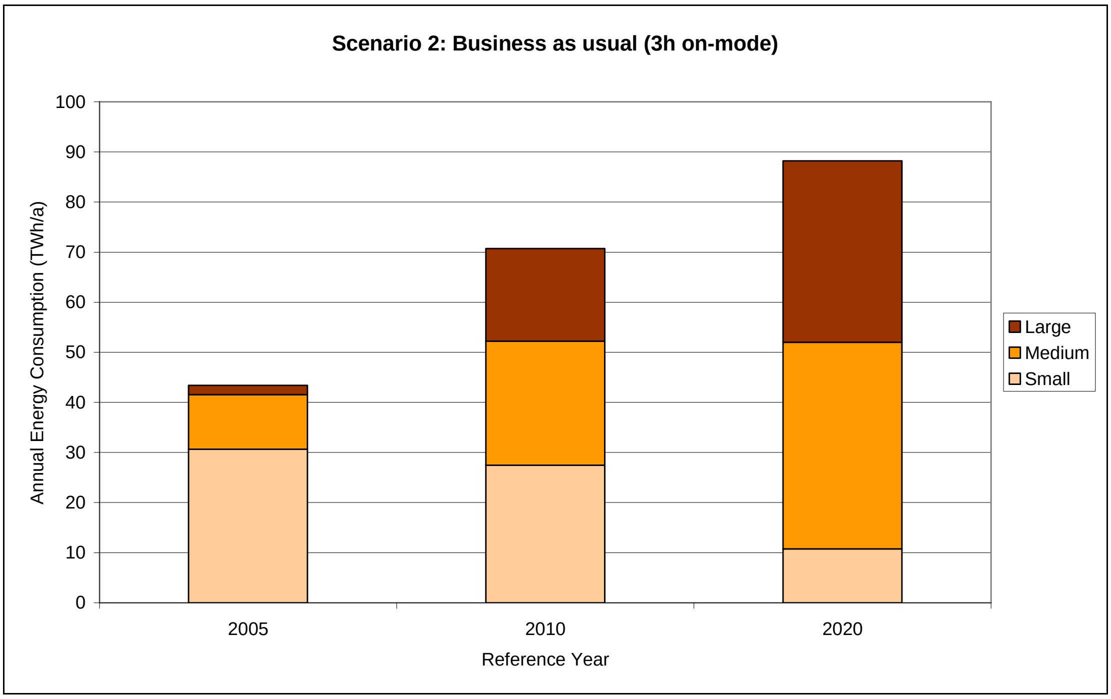

Figure 13: Scenario 2 “Business as usual” (3h on-mode)

Table 11: Main Data of Scenario 2 (3h on-mode / 21 h standby)

TV Screen Size (	14/15"	21/23"	25/26"	28/29"	32"/33"	36/37"	42/43"	50/52"	61/65"	
2010 Stock Scenario										
Stock (in %)	10%	20%	25%	10%	12%	10%	10%	2%	1%	100%
Stock (in Units)	39.151.200	78.302.400	97.878.000	39.151.200	46.981.440	39.151.200	39.151.200	7.830.240	3.915.120	391.512.000
Power (W)	70	90	110	130	150	200	275	360	575	
Standby (W)	3	3	3	3	3	3	3	3	3	
3h on-mode (GV	3.000,94	7.716,70	11.789,41	5.573,17	7.716,70	8.574,11	11.789,41	3.086,68	2.465,06	61.712,18
21h standby (G	900,28	1.800,56	2.250,70	900,28	1.080,34	900,28	900,28	180,06	90,03	9.002,82
Total Annual Power Consumption (GWh)										**70.715,00**
2010 Stock Scenario		**Small**			**Medium**			**Large**		**Total**
on-mode power		22.507,05			21.863,99			17.341,14		**61.712,18**
standby power		4.951,55			2.880,90			1.170,37		**9.002,82**
Annual power total (GWh/a)		27.458,60			24.744,89			18.511,51		**70.715,00**
2020 Stock Scenario										
Stock (in %)	2%	5%	15%	5%	25%	22%	20%	5%	1%	100%
Stock (in Units)	8.216.000	20.540.000	61.620.000	20.540.000	102.700.000	90.376.000	82.160.000	20.540.000	4.108.000	410.800.000
Power (W)	70	90	110	130	150	200	275	360	575	
Standby (W)	1	1	1	1	1	1	1	1	1	
3h on-mode (GV	629,76	2.024,22	7.422,13	2.923,87	16.868,48	19.792,34	24.740,43	8.096,87	2.586,50	85.084,59
21h standby (G	62,98	157,44	472,32	157,44	787,20	692,73	629,76	157,44	31,49	3.148,78
Total Annual Power Consumption (GWh)										**88.233,37**
2020 Stock Scenario		**Small**			**Medium**			**Large**		**Total**
on-mode power		10.076,10			39.584,69			35.423,80		**85.084,59**
standby power		692,73			1.637,37			818,68		**3.148,78**
Annual power total (GWh/a)		10.768,83			41.222,05			36.242,48		**88.233,37**

This scenario 2 clearly indicates the impact of the use pattern. The reduced assumption regarding the average on-mode duration shows a significant positive effect. Another reason behind the scenario 2 is to show how much impact the "on-mode" has in comparison to "standby". Table 10 and Table 11 provide the main data for the calculation. With an assumption of 3W average standby in 2010 the first scenario (20 hours standby) results in approximately 8,6 TWh standby whereas the second scenario (21 hours standby) results in 9,0 TWh standby. This ratio of the increase in standby does not correlate with the decrease in on-mode, from 91 TWh (scenario 1) to 71 TWh (scenario 2) for the same reference year 2010. Even more drastic is this kind of comparison for the reference year 2020.

8.1.7.4. Scenario 3: "Minimum requirement"

The scenario 3 describes a "minimum requirement" situation. The implementation of the 1st tier minimum requirements is in this scenario set for the reference year 2010. Until than we assume the "business as usual" scenario with no further improvement. Lacking precise data for a 2nd tier minimum requirement we assume also a 1% annual improvement until 2020. The following Figure 14 and Table 12 provide the main data of the minimum requirement scenario.

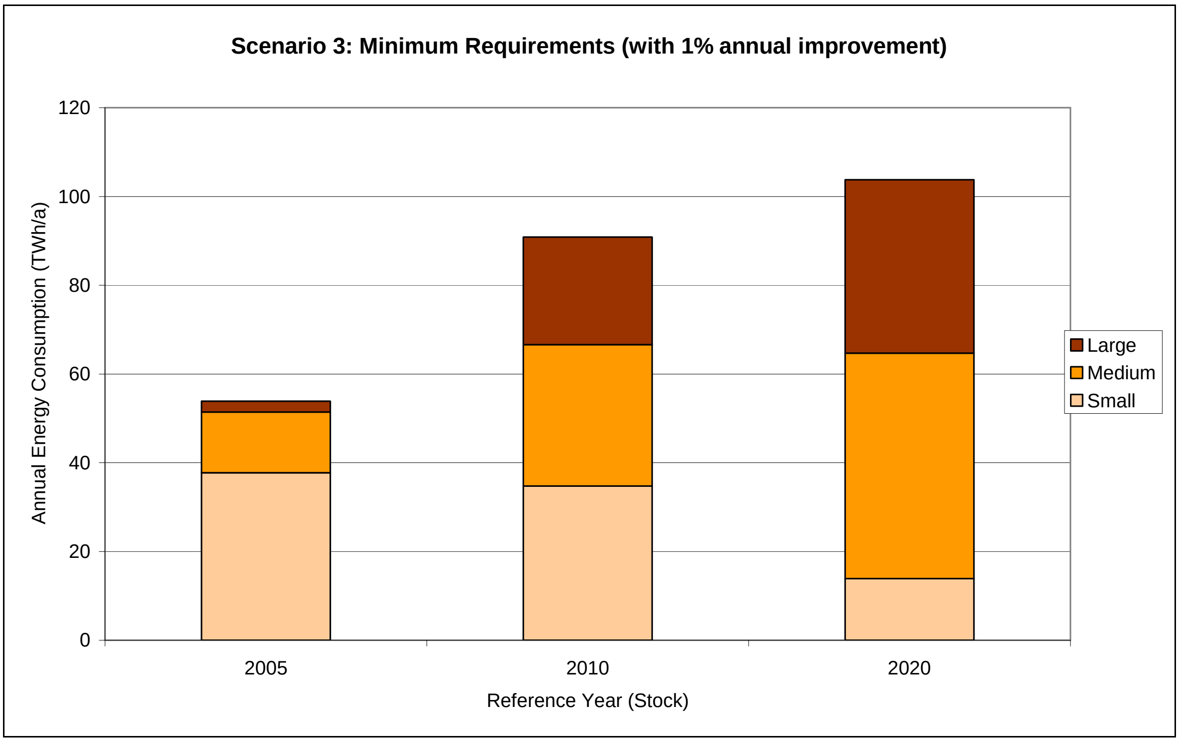

Figure 14: Scenario 3 "Minimum Requirements" (with 1% annual improvement)

Table 12: Main Data of Scenario 3 (4h on-mode / 20 h standby)

TV Screen Size (inch)	14/15"	21/23"	25/26"	28/29"	32"/33"	36/37"	42/43"	50/52"	61/65"	Total
2010 Stock Scenario										
Stock (in %)	10%	20%	25%	10%	12%	10%	10%	2%	1%	100%
Stock (in Units)	39.151.200	78.302.400	97.878.000	39.151.200	46.981.440	39.151.200	39.151.200	7.830.240	3.915.120	391.512.000
Power (W)	70	90	110	130	150	200	275	360	575	
Standby (W)	3	3	3	3	3	3	3	3	3	
4h on-mode (GWh/a)	4.001,25	10.288,94	15.719,21	7.430,90	10.288,94	11.432,15	15.719,21	4.115,57	3.286,74	82.282,90
20h standby (GWh/a)	857,41	1.714,82	2.143,53	857,41	1.028,89	857,41	857,41	171,48	85,74	8.574,11
Total Annual Power Consumption (GWh)										**90.857,02**
2010 Stock Scenario		**Small**			**Medium**			**Large**		**Total**
on-mode power		30.009,39			29.151,98			23.121,52		**82.282,90**
standby power		4.715,76			2.743,72			1.114,63		**8.574,11**
Annual power total (GWh/a)		34.725,16			31.895,70			24.236,16		**90.857,02**
2020 Stock Scenario										
Stock (in %)	2%	5%	15%	5%	25%	22%	20%	5%	1%	100%
Stock (in Units)	8.216.000	20.540.000	61.620.000	20.540.000	102.700.000	90.376.000	82.160.000	20.540.000	4.108.000	410.800.000
Power (W)	67	90	108	130	144	180	220	301	484	
Standby (W)	1	1	1	1	1	1	1	1	1	
4h on-mode (GWh/a)	803,69	2.698,96	9.716,24	3.898,49	21.591,65	23.750,81	26.389,79	9.026,51	2.902,88	100.779,02
20h standby (GWh/a)	59,98	149,94	449,83	149,94	749,71	659,74	599,77	149,94	29,99	2.998,84
Total Annual Power Consumption (GWh)										**103.777,86**
2020 Stock Scenario		**Small**			**Medium**			**Large**		**Total**
on-mode power		13.218,89			49.240,95			38.319,18		**100.779,02**
standby power		659,74			1.559,40			779,70		**2.998,84**
Annual power total (GWh/a)		13.878,63			50.800,35			39.098,88		**103.777,86**

According to this scenario, by 2020 the total energy consumption of the TV stock in EU-25 will increase to 103 TWh annually. This is considerably less in comparison to the business as usual scenario 1 which resulted in 116TWh annually by 2020. It is interesting to notice that the power consumption averages in the "business as usual" scenario are in the small and medium segments are mostly comparable to the minimum requirements. Therefore, the reduction in energy consumption is mainly related to large screen size segments. It shows the importance of these segments. As the magnitude of total increase in TV related energy consumption still indicates, it is absolutely necessary to enforce further improvement in order to reduce environmental impact in the long-term. In order to show the magnitude of necessary improvement we provide the following best practice scenario.

8.1.7.5. Scenario 4: "Best Practice" with B class energy efficiency label enforced

The third scenario describes a "best practice" situation in which all products achieve a 40% improvement which means the power consumption values of the "B class" energy efficiency label. The impacts for the reference years 2005 and 2010 are again identical to the previews "business as usual" scenario. The enforcement of the "B class" label by 2010 is of course not full realistic. We have to assume that smaller and medium screen sizes can achieve such values more easily whereas the large screen sizes will need a longer time period in order to reach such values. The following Figure 15 and Table 13 provide the main data of the scenario. There are based on assumptions and do not reflect current reality. A lot of efforts are necessary by the industry to achieve this scenario.

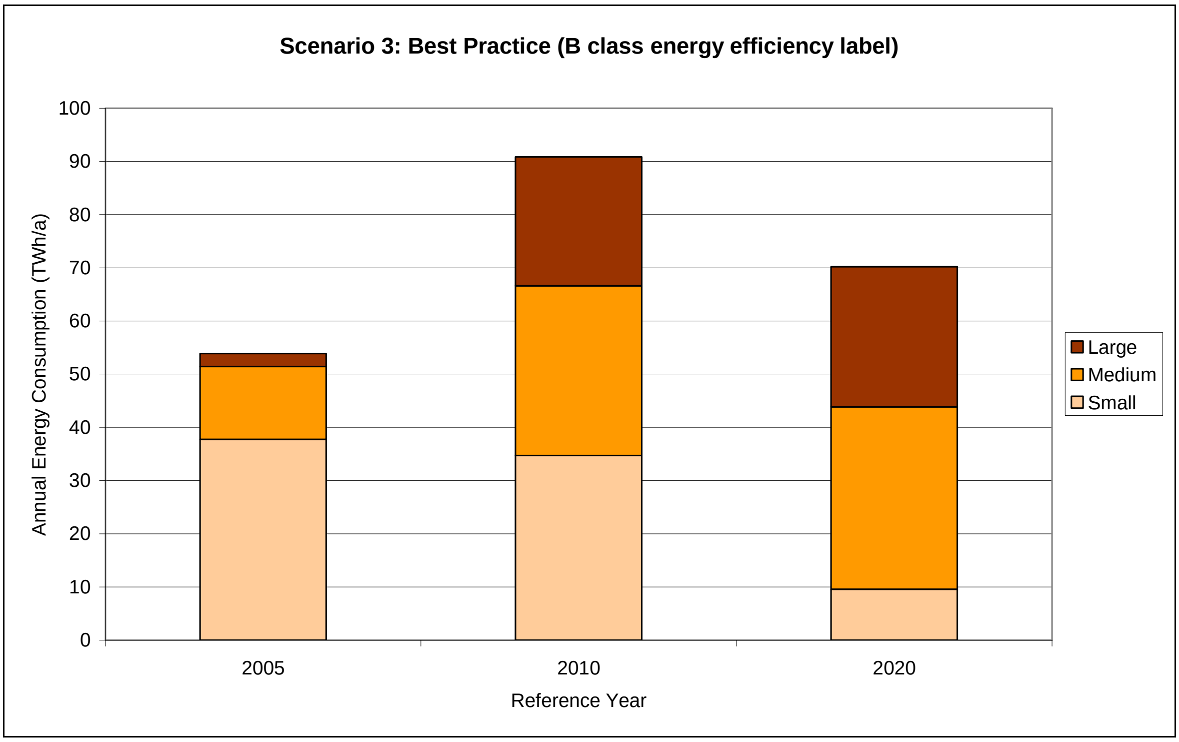

Figure 15: Scenario 4 "Best Practice"

Table 13: Main Data of Scenario 4

TV Screen Size (inch)	14/15"	21/23"	25/26"	28/29"	32"/33"	36/37"	42/43"	50/52"	61/65"	Total
2010 Stock Scenario										
Stock (in %)	10%	20%	25%	10%	12%	10%	10%	2%	1%	100%
Stock (in Units)	39.151.200	78.302.400	97.878.000	39.151.200	46.981.440	39.151.200	39.151.200	7.830.240	3.915.120	391.512.000
Power (W)	70	90	110	130	150	200	275	360	575	
Standby (W)	3	3	3	3	3	3	3	3	3	
4h on-mode (GWh/a)	4.001,25	10.288,94	15.719,21	7.430,90	10.288,94	11.432,15	15.719,21	4.115,57	3.286,74	82.282,90
20h standby (GWh/a)	857,41	1.714,82	2.143,53	857,41	1.028,89	857,41	857,41	171,48	85,74	8.574,11
Total Annual Power Consumption (GWh)										**90.857,02**
2010 Stock Scenario		**Small**			**Medium**			**Large**		**Total**
on-mode power		30.009,39			29.151,98			23.121,52		**82.282,90**
standby power		4.715,76			2.743,72			1.114,63		**8.574,11**
Annual power total (GWh/a)		34.725,16			31.895,70			24.236,16		**90.857,02**
2020 Stock Scenario										
Stock (in %)	2%	5%	15%	5%	25%	22%	20%	5%	1%	100%
Stock (in Units)	8.216.000	20.540.000	61.620.000	20.540.000	102.700.000	90.376.000	82.160.000	20.540.000	4.108.000	410.800.000
Power (W)	50	61	72	84	96	120	147	200	322	
Standby (W)	1	1	1	1	1	1	1	1	1	
4h on-mode (GWh/a)	599,77	1.829,29	6.477,49	2.519,03	14.394,43	15.833,88	17.633,18	5.997,68	1.931,25	67.216,00
20h standby (GWh/a)	59,98	149,94	449,83	149,94	749,71	659,74	599,77	149,94	29,99	2.998,84
Total Annual Power Consumption (GWh)										**70.214,84**
2020 Stock Scenario		**Small**			**Medium**			**Large**		**Total**
on-mode power		8.906,55			32.747,33			25.562,11		**67.216,00**
standby power		659,74			1.559,40			779,70		**2.998,84**
Annual power total (GWh/a)		9.566,30			34.306,73			26.341,81		**70.214,84**

This scenario 4 indicates the necessity of promoting energy efficiency in order to decrease total energy demand in the long term. The improvement of medium and large screen size TVs has a priority. Keeping in mind that the use pattern as well as the actual screen size penetration rate has a significant impact on the overall energy consumption the scenarios show that minimum requirements in combination with promotion of energy efficiency (labeling) are policy measures to reduce the overall environmental impact related to the use of TVs in Europe.

8.2. Impact Analysis Industry and Consumers

8.2.1. Impact on the consumer

According to the study results a technical potential for reducing power consumption of current HD-ready TVs exists by approximately 20%. This improvement should be possible for both LCD-TVs and PDP-TVs as the technical analysis of the base cases (task 5) and the assessment of BAT (task 6) indicated[23]. The result of this analysis has been the base for supporting the recommendations regarding minimum on-mode power consumption requirements (see task 8.1). Furthermore, the lifecycle cost calculations confirmed this existing improvement potential as economically feasible for the manufacturer with a cost advantage for the consumer. In task 7 we argued that simply because of the drastically decreasing product prices a limiting cost factor for the implementation of available improvement options is not given. Some improvement options are referring to proprietary technologies and have been therefore excluded form this analysis. In conclusion, no financial burdens can be identified for the consumer from the LLCC point of view.

8.2.2. Impact on PDP-TV manufacturers

The technical improvement options for achieving the proposed on-mode power minimum requirements are in the case of HD-ready PDP-TVs cost neutral due to the fact that the intrinsic plasma panel technology development already targets the improvement of luminous efficiency as the major task. The minimum requirements are demanding and at the present time not yet achieved by an average PDP-TV. The study however comes to the conclusion that the minimum requirements are technically feasible for PDP-TVs by the year 2010 although the latest comments by the two Korean PDP manufacturers indicated great concern that 3 lm/W efficiency might not be a realistic target. It was argued that the improvement of the luminous efficiency, which ideally results in less power consumption, might be compensated by the need to increase picture quality such as brightness and contrast ratio. One aspect which supports the feasibility of the minimum requirements is the fact that the revised IEC 62087 test standard, which gives the option to measure average power consumption with a dynamic video sequence, is reflecting the specific power

[23] The improvement potential varies largely according to the level of already implemented improvement options, the availability of proprietary technologies, as well as the technology generation applied to product. The current improvement potential of PDP-TVs has been assessed somewhat higher, keeping in mind that LCD-TVs are based on a more mature technology, which reduces the actual magnitude of continuous improvement. The power consumption values that have been identified only apply to HD-ready TVs. Full HD is considered a new technology level which does not start on the same power performance level.

consumption pattern of self-emitting displays such as PDP in a better way. This means that the new test standard makes the comparison of PDP-TVs with LCD-TVs more realistic. In reality the average power consumption measured with the new test standard is somewhat lower than with former three-bar black and white video signal.

8.2.3. Impact on LCD-TV manufacturers

In the case of LCD-TVs the improvement of picture quality such as wide color gamut, double frame technology (100Hz), high contrast ratio, etc. will have an negative effect on total power consumption and may counterbalance the assumed improvement potential (see task. 8.3.1 for details). The interrelation of picture quality and power consumption is similarly to the PDP industry also given in the LCD industry. But there are important differences to notice. Whereas the PDP-TV industry is very small due to the only five existing plasma panel manufacturers, the LCD-TV industry is much more diverse with a complex supply chain structure. Within this industry the LCD panel manufacturer and the backlight manufacturer have a dominant position. A lot of TV-set makers are fully depending on the availability and price of certain components or technologies. This situation leads to a less homogeneous interest of industry regarding the improvement of power consumption. On the other hand the necessity of improving power consumption provides a business option for highly specialized component manufacturers, as we have described on the example of highly efficient polarizer. In conclusion, LCD-TVs are more mature than PDP-TVs and show currently on average better energy efficiency. The improvement potential of LCD-TVs is somewhat lower in comparison to PDP-TVs due to their already higher efficiency level. The economical burden on the LCD industry for improving their products is difficult to assess.

8.2.4. Product design cycles and technology generations

The setting of a compliance date for future implementing measures such as minimum on-mode power consumption requirements should reflect concurrent technical development and product design cycles. According to industry such timeframes are very individual. They are depending on the manufacturer's technological and economical disposition. It was however indicated that major technology and product developments such as the introduction of a completely new technology generation are planned and realized over a period of two to four years. Concurrent engineering for minor improvements or intrinsic product redesigns are on the other hand cycling between nine and eighteen month.

8.3. Sensitivity Analysis of the main Parameters

8.3.1. Limiting factors related to picture quality improvement

The minimum on-mode power consumption requirements are taking the current market averages as an orientation point, which seems feasible against the identified improvement potential. At this point we have to ask which limiting factors might influence our current assumption of the improvement potential. Some limiting factors have been argued throughout the study; mainly the counterbalancing factor of the general technical development towards higher picture resolution (full HD), better picture quality, and higher functionality with a negative influence on power consumption. Despite the form factor (flat and large screen), which initiated the shift towards flat panel display TVs some five years ago, the picture resolution and quality is becoming the key sales criteria today which influences the focus of technical development. Both aspects – picture resolution and quality – are directly related to the power demand of the TV. The still relative immaturity of current flat panel technologies (LCD and PDP) makes picture quality improvements absolutely necessary. As a matter of fact this quality improvement requires a very high level of light (energy) that has to be generated and efficiently utilized. In consequence, we have to expect a rather increasing than decreasing of average power consumption over the next years. This means that the existing improvement potential could be actually overcompensated by improvements efforts regarding picture quality and resolution. This assessment applies particularly to new full HD technology in the case of PDP-TVs.

In conclusion, the defined minimum requirements are basically freezing the current level of power consumption in order to avoid further overcompensation meaning an increase in total power consumption of the average TV again. The minimum requirement scenario clearly shows that after the market saturation is reached by 2010 the level of power consumption (TV stock) would stay the same until 2020 although a complete exchange of products would occur during this time period. The reason for this development is the shift towards medium and large screen size segments as it is expected by market forecasts. If this expected shift towards larger screen sizes would not occur the total stock power consumption would decline. The following paragraph will therefore review the market conditions and assess limiting factors in that respect.

8.3.2. Penetration rate of large screen size TVs

A high market penetration of large size TVs is an important contributing factor to the overall energy consumption related to TVs. The extent of this market penetration will depend on the conditions for consumer spending. Over the past two years the macro-economical conditions within the EU improved to an extent that the current (2007) economical growth of 2.9% is the highest since 2000, while unemployment is at a 10-year low[24]. This positive economical situation will support consumer spending according to a recent EU survey, although consumer spending is still the weakest link in the European economy[25]. It seems likely that the current economic growth in the EU is fostering sales of medium and large flat panel TVs.

In our scenarios we have assumed that large TVs (40" to 65") will have a penetration rate of 13% by 2010 and 26% by 2020 respectively. Please notice in that respect that we assume the absolutely highest penetration rate in this segment to be the 40" to 43" TVs which in turn are the smallest TVs in this segment. From our point of view these figures are not underestimating the market share of large TVs throughout the next decade. It is rather likely that this penetration rate could be actually lower. On the one hand become TVs with a screen size of 40 inch and larger more and more economically achievable due to the drastic decline in sales price. However, the currently still suboptimal picture quality of HD-ready seems to limit sales in the large screen size segment as well.

The ongoing development towards full HD, spearheaded by the large screen sizes, supports this assumption. Full HD is not an intrinsic technology development but a big technological step that should be acknowledged a new level of technology particularly in the case of PDP. Full HD technology is expensive. Current sales prices for the first generation of full HD are three to eight times as much as comparable HD-ready products. In our assessment this cost factor has a potential to limit the extent to which large size TVs will penetrate the European market. Due to the proportionally high demand of energy related to large size TVs a lower penetration rate would positively influence the scenarios by reducing overall power consumption.

[24] This assessment was given by EC president José Manuel Barroso at the fifth European Business Summit held in March 2007 [CNBC European Business, May Issue 2007, page 13].
[25] Eurozone economic growth (EU Business 01-06-07): http://www.eubusiness.com/Factsfig/1180692014.05/

8.3.3. Changes in electricity costs

A required task is the assessment of how and to what extent do national differences in electricity costs as well as the general increase or decrease of these costs will influence the point of LLCC. The assessment of this aspect under the current conditions of dropping product prices simply leads to the conclusion that all measures and proposed improvement options will not be influenced in their applicability by whatever kind of assumed change of electricity costs. On the contrary, the high likeliness that the electricity costs will increase in the years to come (see current political discussion regarding climate change, availability of resource and related measures to explore environmental friendly but expensive energy sources) will actually improve the cost savings for the consumer in all parts of the EU.