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What users can save with energy efficient TVs

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Index

1 Introduction

A significant part of the typical energy consumption of today's televisions could be saved with the most efficient appliances currently available, and even higher savings will be possible with next generation technologies.

Televisions (TVs) are one of the most widespread consumer electronics in the world. Due to the popularity of televisions, saturation of this type of appliances is generally very high in industrialized and already high in newly industrializing countries. Within these countries most households own at least one TV, while at the same time a high growth rate can be observed also in developing countries. In many industrialized countries, televisions are among the highest energy-using consumer electronics in the average home.

With focus on the user perspective, this bigEE document presents exemplarily the energy and cost saving potentials, which can be achieved by the most efficient appliances currently available (Best Available Technology, BAT) and from designs that are technically feasible with what we know today, but which are not yet commercialised (BNAT: Best Not (yet) Available Technology) for common types of televisions (See chapter 2). Prior to that, some basic facts about televisions and their technology are presented.

1.1 What are televisions?

A television (TV) or 'television set' means a product designed primarily for the display and reception of audio-visual signals. It consists of a display as well as one or more tuner(s)/receiver(s) and optional additional functions for data storage and/or display such as digital versatile disc (DVD), hard disk drive (HDD) or videocassette recorder (VCR), either in a single unit combined with the display, or in separate units (European Commission 2009A). According to IEC62087, a TV is 'an appliance for the display and possible reception of television broadcast and similar services for terrestrial, cable, satellite and broadband network transmission of analogue and/or digital signals'. The most distinguishing feature for a television is the integrated tuner to receive and decode a broadcast signal (CLASP 2011A). In contrast, computer monitors are per definition displays that do not have an integrated TV tuner.

1.2 Main types of televisions, technical background

Light Emitting Diode backlit LCD (LED-LCD) TVs are substantially more efficient than conventional cathode ray tube (CRT), Plasma Display Panel (PDP) TVs or Cold Cathode Fluorescent Lamp backlit LCD (CCFL-LCD) TVs.

Since mid of the 2000s, the global TV market has undergone a major transition from traditional Cathode Ray Tube (CRT) TVs to other types, particularly flat panel display (FPD) TVs such as Liquid Crystal Displays (LCD) and Plasma Display Panels (PDP). In recent years, within the flat panel display (FPD) market another large-scale transition is undergoing towards to Light Emitting Diode backlit LCD (LED-LCD) TVs. Although remainders of CRT TVs and other types of FPDs are expected to remain popular in certain second-tier markets for the next few years, major TV brands are likely to provide more affordable energy saving LED-LCD TVs in order to replace out-dated types of TVs also in these markets (LBNL 2013A).

Televisions contain a tuner to receive and decode broadcast signals, which can be analogue, digital or both. In many world-regions the technology transition of TV technology away from traditional analogue broadcasts towards digital only broadcasts is already completed. Furthermore, there are several technical aspects such as screen resolution with standard or (ultra) high definition (HD TV with 720 or Full HD TV with 1080 lines, UHD with 4k or 8k) or screen aspect ratio (e.g. 16:9 = widescreen) characterizing the properties of a specific TV. Thereby, TVs can usually also receive external video and audio signals from other distinct and external devices via audio/video interfaces (e.g. HDMI, High-Definition Multimedia Interface). TVs with digital receivers usually have at least a basic electronic program guide (EPG) or even include ‘smart’ functions in order to receive advanced broadcast information, e.g. via Hybrid broadcast broadband TV (HbbTV) or directly via Web browser and Internet (CLASP 2011A). Additionally, TVs can be equipped with integrated video devices such as VCRs (disappearing due to the decrease of TVs with analogue tuners), DVD or Blu-ray disc players as well as digital hard disk recorders (PVR).

1.1.1 Liquid crystal display (LCD)

LCD TVs are characterized by a flat panel design with improved picture quality and brightness compared to traditional CRT TVs. In the beginning, screen sizes have tended to be smaller than other technologies (e.g. PDP), but nowadays much larger sizes with more than 120 cm are broadly available. Sizes of 280 cm (110 inches) or more have already been demonstrated (International Consumer Electronics Show 2015). Liquid Crystal Displays use a backlit panel, which is covered by a layer of liquid crystals. Changing the properties of the liquid crystal layer, which is situated between the backlight and the viewer, generates moving pictures. The technical properties of the liquid crystals determine what colour and amount of light is transmitted from the screen (CLASP 2011A).

More in detail, the liquid crystal layer is subdivided in individual cells (pixels), which number determines the resolution of the image. In general, LED-LCD TVs consume 20 to 30 % less energy than equal size CCFL-LCD TVs (LBNL 2013A). New materials could even increase the efficiency gains. E.g., quantum dots are light-emitting semiconductor nano-crystals that can be tuned — by changing their size, nanometre by nanometre — to emit all colours across the visible spectrum. By tuning these dots to red and green, and using a blue backlight to energize them in optical components, the colour gamut for LCD televisions can be boosted by roughly 50 %, and the energy-efficiency by around 20 % (MIT 2014).

1.1.2 Plasma Display Panel (PDP)

A bright and richly coloured picture characterizes plasma Display Panels (PDP) or Plasma flat panel displays. In a simplifying way, plasma screens consist of a large number of very small fluorescent lights embedded into a flat screen. Thereby, each individual fluorescent light is a pixel. The number of the pixels on the screen determines the resolution of the image. Changing the colour and intensity of light generated by each pixel generates moving pictures. The typical size of PDP is larger than 42” or 108 cm respectively (CLASP 2011A).

1.1.3 Cathode ray tube (CRT)

The cathode ray tube (CRT) technology was originally developed in the 1920’s and introduced commercially for the first time in the 1930’s. A CRT comprises an electron gun, which generates a stream of electrons, which are projected through a vacuum onto a screen that contains a fluorescent material. A set of deflection coils around the electron stream create a magnetic field that deflects the electrons to create different patterns and therefore images on the screen.

Moving pictures are generated using lines that are rapidly and sequentially deflected across and down the screen. The rate at which the lines fill a complete screen is called the refresh rate. The volume of electrons from the electron gun mainly affects the picture brightness. Together with the deflection coils, this process uses a major part of the energy required by a CRT TV. The typical screen sizes of CRT were between 20 and 100 cm. The cathode ray tube is still a relevant television technology installed in the stock of many countries, although this will change within the next few years. Consequently, the end of the worldwide CRT TV production is foreseeable between 2015 and 2020 at the latest.

1.1.4 Projection type TVs

Projection-type TVs have been popular for very large screen sizes and especially for home cinema applications. The two main types of technology are 'rear projection' and 'front projection' (for very large screen areas). A high power ultra-high pressure (UHP) mercury or xenon arc lamp generates a strong, constant point light source, which is projected through or reflected from an image control screen, which is typically a liquid crystal display. The imaging device controls the transmittance or reflection of the light to the projection screen. However, due to limitations in their viewing angle and the emerging advanced (very) large-screen LED LCD TVs, the popularity of large screen rear projection televisions is rapidly declining (CLASP 2011A).

1.1.5 Scope

Energy efficient TVs incorporate numerous saving technologies and features. However, as LCD TVs are expected to dominate worldwide sales in the next years, the presented design options to further reduce the environmental impacts of TVs usually refer to this type of television sets. Although it is expected that the energy efficiency of LCD TVs will improve over time even in the BAU (Business As Usual) scenario (due to energy efficiency measures already in force and constant progress in technology), it is important to analyse the further efficiency improvement potential in LCD TVs. As consequence of a predicted increase in average screen size and increasing TV ownership rates world wide (intensified by the trend towards two or even more TVs per household), the absolute LCD TV on-mode electricity consumption is expected to increase without further efficiency improvements.

A more detailed description of the technical background of TVs and which technical options are available to reduce energy consumption as well as the climate change impact, is provided in the bigEE text ***'Technical background and design options to raise energy efficiency and reduce the environmental impact of TVs'.***

2 Energy and cost saving potential of LCD TVs

2.1.1 Overview and description of the appliance

Light Emitting Diode backlit LCD (LED-LCD) TVs dominate the market and offer large energy savings.

In contrast to PDP and OLED (organic light-emitting diode), LCD is a non-emissive display technology that uses a CCFL or LED backlight as a light source. LCDs comprise millions of pixels consisting of liquid crystals (LCs) with the ability to alter their crystalline structure or orientation when voltage is applied, resulting in different transparency levels. The light from the light source passes first through a polarization filter, gets modulated by the LCs and creates a red, green or blue pixel (RGB colour model) after passing through colour filters (IZM 2007).

Besides the light source, there are various optical components in the backlight unit. An optical film stack is typically made up of diffuser(s), prism(s) and a reflective polarizer. A diffusion film uniformly distributes the light over the whole area of the LCD panel. A prism film optimizes the angle of light and redirects light towards the LCD panel and the viewer. A reflective polarizer adjusts the light's polarization and minimizes the amount of light absorbed by the panel's polarizers. Overall, the final luminance available to the viewer is less than 10 % of the initial luminance available from the backlight source after passing two crossed polarizers, a colour filter and Thin Film Transistor (TFT) arrays in the LCD panel (Shieh et al. 2009). Hence, the overall efficiency of LCD TVs can be optimized especially by reducing the amount of light absorbed by the different functional layers of the panel.

Consequently, various LCD TV efficiency improvements are possible including more efficient backlight sources, efficient combinations of optical films, increased panel transmittance, efficient power supply units and more effective power management schemes. The efficiency improvement options for LCD TVs are discussed further in depth in the bigEE text ***'Technical background and design options to raise energy efficiency and reduce the environmental impact of TVs'.***

2.1.2 Used mainly in the following world regions

In principle, the same TV technology is used worldwide and there are only limited regional differences in the preferences for TV screen technologies and sizes. Generally, markets in industrialized countries tend to be already dominated mainly by LCD/LED TVs and a small and declining share of plasma displays. In contrast, markets in many developing countries still include remainders of CRTs.

Historically, the use of different refresh rates in the world regions dictated the use of different underlying picture formats and frame rates (frames per second, fps) for video content. There were also regional requirements regarding the broadcast signal and frequency, which meant that TVs had to be factory configured according to the specified destination region. However, with recent TV technology these former issues can be solved by minor hardware or software modifications (CLASP 2011A). Due to the use of universal power supplies, a different supply voltage and power frequency is also no problem anymore.

Consequently, for a given size and display technology, TVs sold in different regions of the world are very similar today. In addition, TV manufacturing is highly globalized and concentrated. The six major TV brands produce more than 60 % of TVs sold worldwide (LBNL 2013A).

2.1.3 Comparing inefficient models and BAT with future BNAT potential

Table 1: Energy and cost saving potential by efficient TVs in Europe

Screen size		Energy consumption (kWh/year)	Energy class	Energy saving potential versus inefficient model (%)	Lifetime energy cost savings versus inefficient model (€)
Small < 32" / 82 cm	Inefficient model	54.8	B		
	BAT level	26.6	A+	51	56
	BNAT	14.1		74	81
Medium 32"–46" (82 – 117 cm)	Inefficient model	139.4	B		
	BAT level	51.8	A++	63	175
	BNAT	22.4		84	234
Large > 46" / 117 cm	Inefficient model	227.8	B		
	BAT level	84.0	A++	63	288
	BNAT	57.4		75	341

Energy Consumption (kWh/year): Daily 4 hours in On mode, 20 hours in Standby mode, based on 2010 EU Energy Labelling
Lifetime energy cost savings (EUR): for 10 years at 20 EUR-Cent/kWh (topten.eu 2015)

Source: topten.eu 11/2015 for energy consumption of typical inefficient model and example of BAT model, appliance lifetime and energy cost; Own calculations of BNAT level, energy saving potential and for lifetime energy cost savings

Table 2: Energy and cost saving potential by efficient TVs in USA

Screen size		Energy consumption (kWh/year)	Energy class	Energy saving potential versus standard model (%)	Lifetime energy cost savings versus standard model (€)
Small < 32" / 82 cm	Standard model	59.6	ENERGY STAR		
	BAT level	40.0	ENERGY STAR	33	39
	BNAT	17.7		70	84
Medium 32" – 46" (82 – 117 cm)	Standard model	115.8	ENERGY STAR		
	BAT level	61.0	ENERGY STAR	47	110
	BNAT	27.7		76	176
Large > 46" / 117 cm	Standard model	176.3	ENERGY STAR		
	BAT level	117.0	ENERGY STAR	34	119
	BNAT	84.2		52	184

Energy Consumption (kWh/year): Daily 5 hours in On mode, 19 hours in Standby mode, based on ENERGY STAR
Lifetime energy cost savings (EUR): for 10 years at 20 EUR-Cent/kWh

Source: Analysis based on examples from toptenusa.org 2013 / ENERGY STAR 2015 for energy consumption of example ENERGY STAR standard model and ENERGY STAR BAT model, appliance lifetime; topten.eu 11/2015 for energy cost; Own calculations of BNAT level, energy saving potential and for lifetime energy cost savings

Table 3: Energy and cost saving potential by efficient TVs in China

Screen size		Energy consumption (kWh/year)	Energy class (National energy efficiency grade)	Energy saving potential versus inefficient model (%)	Lifetime energy cost savings versus inefficient model (€)
Small < 32" / 82 cm	Inefficient model	119.2	Grade 3		
	BAT level	38.2	Grade 1	68	162
	BNAT	18.2		85	202
Medium 32" – 46" (82 – 117 cm)	Inefficient model	194.8	Grade 3		
	BAT level	119.2	Grade 1	39	151
	BNAT	25.4		87	339
Large > 46" / 117 cm	Inefficient model	193.7	Grade 3		
	BAT level	97.6	Grade 1	50	192
	BNAT	36.5		81	315

Energy Consumption (kWh/year): 1080 hours/y in On mode and 842 hours/y in Standby mode, based on CNIS market analysis report
Lifetime energy cost savings (EUR): for 10 years at 20 EUR-Cent/kWh

Source: top10.cn 11/2015 for energy consumption of typical inefficient model and example of BAT model, appliance lifetime; topten.eu 11/2015 for energy cost; Own calculations of BNAT level, energy saving potential and for lifetime energy cost savings

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The bigee.net platform informs users about energy efficiency options and savings potentials, net benefits and how policy can support achieving those savings. Targeted information is paired with recommendations and examples of good practice.

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