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Test procedures, measurements and standards for TVs

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1 Measurement standards and test procedures

A standard definition for energy consumption and a test procedure to measure it are necessary to ensure market transparency and to apply effective policies. Electricity consumption of TVs is measured in accordance with IEC62087.

A standard definition for the specific energy consumption per unit is necessary to compare the energy performance of TVs. Furthermore, a test procedure is needed to measure this specific energy consumption in a comparable and reproducible way. Together, the definition and the test procedure form a test standard. Such a standard makes it possible to introduce MEPS (Minimum Energy Performance Standards) and labels.

2 Test standard IEC62087

2.1 International harmonisation of testing

For televisions, IEC62087 – 'Methods of measurement for the power consumption of audio, video and related equipment' was specifically developed as a globally applicable standard in order to provide a reliable and common reference for the technical properties of TVs. In general terms, this represents a good basis for harmonisation with respect to the performance testing of televisions (CLASP 2011A). Worldwide, most countries that are developing or implementing energy requirements adopt the most recent version of IEC62087.

2.2 Testing parameters

2.2.1 Key performance parameters

The key parameters for efficiency testing and measurement of TVs are related to the main tasks of receiving a broadcast signal and its conversion into a picture and its associated sound. Therefore, the average power consumption to undertake these tasks has to be set in relation with the size of the screen area of the display. Although the power consumption of TVs is basically depending on the brightness of the displayed pictures, the impact of this effect varies between different display technologies and even within the same technology. In order to address this aspect, the consumed energy for a standardised video sequence has to be measured (CLASP 2011A). By this means, other influencing parameters, like the kind of data stream being processed by the tuner or other additional devices integrated into the television, can be excluded.

The first edition of IEC62087, which was published back in 2002, covered only Cathode Ray Tube (CRT) TVs, which were prevailing at that time. The second edition was published in October 2008 and represented a complete revision of the standard and specifically included the energy related aspects of new and emerging display technologies, which nowadays dominate the TV market.

The IEC62087 test method for energy consumption and performance of TVs specifies the measurement methods for the energy consumption of TV sets, video recording equipment, Set Top Boxes (STBs), audio equipment and multi-function equipment for consumer use. For the purposes of the standard, TV sets include CRT, LCD, PDP, projection TVs as well as other potential technologies. In this context, IEC62087 defines a range of relevant operation modes for televisions, which are presented in Table 1.

Table 1: General testing conditions under IEC62087 and examples of labels based on the standard

Testing Parameters	IEC62087:2008 (Second Edition)
Off mode	The appliance is connected to a power source, produces neither sound nor picture and cannot be switched into any other mode with the remote control unit, an external or internal signal.
Standby passive	The appliance is connected to a power source, produces neither sound nor picture but can be switched into another mode with the remote control unit or an internal signal.
Standby active high	Identical to passive standby mode, but TV is additionally exchanging or receiving data with/from an external source (typically automatically down-loading an electronic programming guide for a short period each day).
On	The appliance is connected to a power source and produces sound and picture.
Exemplary Energy Labels with reference to the stand-ard	EU Energy label (Currently under review)

Source: Based on CLASP (2011A)

2.2.2 Test conditions and uncertainty of measurement

IEC62087 defines test conditions and the accepted uncertainty of measurement for the energy consumption of TVs. For on-mode power measurements, a standardized test video sequence is specified. Power measurements using a dynamic video signal ensure that the tuner is also activated and processes an incoming data stream close to real world conditions. The dynamic broadcast-content video signal to measure on mode varies over time and has a gamma corrected average picture level (APL) mean of 34 % (CLASP 2011A). The APL of the dynamic broadcast-content video signal was chosen to be representative for the actual APL measured for several international broadcast stations.

IEC62087 also allows an energy measurement using a series of static images (black, white and various test patterns) to maintain a backwards compatibility to the first edition of IEC62087 and with Japanese JEITA (Japan Electronics and Information Technology Industries Association) test methods. All energy relevant parameters, such as video format and aspect ratio, are specified. For example, the sound must be 'audible' for power measurements purposes (CLASP 2011A). Additionally, the standard requires user dependent functions to be set as originally adjusted by the manufacturer as factory settings ('as delivered'). All user settings required for the initial activation of a TV set have to be set to the 'standard mode' or factory setting, which is defined as 'recommended by the manufacturer for normal home use'. IEC62087 defines the measurement of display luminance with reference to IEC60107-1: 'Methods of measurement on receivers for television broadcast transmissions - Part 1, General considerations - measurements at radio and video frequencies'.

Generally, IEC62087 was fully revised between 2004 and 2008 in order to prepare its second edition. In contrast to the first edition, which only covered CRT TVs, the revised edition also covers new display technologies. However, another main driver for the revision was the growing general interest in the energy consumption of televisions and the possibility for governments to regulate these products under energy efficiency considerations. Another attempt was to create a global basis for harmonisation of testing for energy consumption of TVs. For this purpose, a reliable and applicable method for the determination of TV energy consumption was required (CLASP 2011A). Thereby, due to the different new display technologies, energy consumption turned out to be very sensitive to the Average Picture Level (APL) of the displayed video stream. Based on this finding, significant effort was made to analyse the APL range of broadcast content worldwide in order to define a 'typical' dynamic broadcast-content test video signal. For the purposes of the second edition of IEC62087, the uncertainty of measurement of the energy readings was defined as 2 % for power levels above 0.5 W (CLASP 2011A).

2.2.3 IEC62087: 2011

In April 2011 the third edition of IEC62087 'Methods of measurement for the power consumption of audio, video and related equipment' was published. According to Edition 2, the scope of the new IEC62087:2011 includes methods of measurement for the power consumption of television sets, video recording equipment, set top boxes, audio equipment and multifunction equipment for consumer use. Television sets may include CRT, LCD, PDP, projection systems as well as other potentially similar technologies. The third edition of IEC62087 replaces the second edition, published in 2008, and constitutes a technical revision. However, the main changes with respect to the previous edition are focussed primarily on set top boxes. In particular, Clause 8 ('Measuring conditions for set top boxes') has been expanded and Annex D (informative) 'General information on STBs technology and additional aspects of STB testing' as well as Annex E (informative) 'Comparison of power modes for IEC 62087:2008 and IEC62087:2011, CEA – 2013A and CEA – 2022' have been added. Furthermore, methods for measuring power consumption of set top boxes mainly in the modes of 'on-mode' and 'standby-active, high mode' have been revised (IEC 2011).

2.2.4 IEC62087: 2015

Part 1: General (Audio, video, and related equipment - Determination of power consumption)

IEC 62087-1:2015(E) specifies the general requirements for the determination of power consumption of audio, video, and related equipment. Requirements for specific types of equipment are specified in additional parts of this series of standards and may supersede the requirements specified in this standard. Moreover, this part of IEC 62087 defines the different modes of operation which are relevant for determining power consumption. This first edition of IEC 62087-1 together with IEC 62087-2 to IEC 62087-6 replaces IEC 62087:2011 in its entirety. This edition constitutes a technical revision and includes the following significant technical changes with respect to Clauses 1 to 5 of IEC 62087:2011: It includes new information about operation modes and equipment that includes removable main batteries is now considered. Light measuring equipment is now also specified (IEC 2015).

Part 2: Signals & media (Audio, video & related equipment - Determination of power consumption)
IEC 62087-2:2015(E) specifies signals and media used in determination of the power consumption of audio, video, and related equipment, such as television sets and computer monitors. It also specifies signals for determining the peak luminance ratio that is sometimes associated with television power consumption measurement programs. In addition, this part specifies equipment, interfaces, and accuracy related to signal generation. This first edition of IEC 62087-2 together with IEC 62087-1 and IEC 62087-3 to IEC 62087-6 replaces IEC 62087:2011 in its entirety. This edition constitutes a technical revision and includes the following significant technical changes with respect to Clause 11 of IEC 62087:2011: The signals included on the test discs are now numbered generically, rather than being based on the subclause numbers within the text of the television test method. Video test patterns used to determine the peak luminance ratio are now included on the discs. Audio test signals are specified and box as well as outline video signals have been added. This publication is available in disc format only. The 5-disc package contains the publication on a CD and video files on two DVDs as well as two Blu-ray™ Discs (IEC 2015).

Part 3: Television sets (Audio, video & related equipment - Determination of power consumption)
IEC 62087-3:2015(E) specifies the determination of the power consumption and related characteristics of television sets. Television sets include, but are not limited to, those with CRT, LCD, PDP, OLED, or projection technologies. The operating modes and functions, as they specifically apply to television sets, are defined in detail in this part of IEC 62087. This first edition of IEC 62087-3 replaces Clauses 6 and 11 and Annex B of IEC 62087:2011. This standard together with IEC 62087-1 to IEC 62087-2 and IEC 62087-4 to IEC 62087-6 replaces IEC 62087:2011 in its entirety. This edition constitutes a technical revision and includes the following significant technical changes with respect to Clauses 6 and 11 and Annex B of IEC 62087:2011: For TVs with an automatic brightness control feature, power may now be measured at multiple specific illumination levels. A method has been defined for determining the ratio of peak luminance expected in the home versus the peak luminance expected in the retail environment. Sections related to general measuring conditions and procedures are now included in IEC 62087-1:2015. Sections related to signals and media are now covered by IEC 62087-2:2015. The titles have changed in order to comply with the current directives and to accommodate the multipart structure (IEC 2015).

Part 4-6: Audio, video & related equipment - Determination of power consumption
IEC 62087-4:2015(E) (Part 4) specifies methods of measurement for the power consumption of video recording equipment with removable media and specifies the different modes of operation which are relevant for measuring power consumption. Part 5, IEC 62087-5:2015(E) specifies methods of measurement for the power consumption of set top boxes (STBs) and Part 6 covers the determination of the power consumption of audio equipment for consumer use.

3 Test metrics of existing policies and programs

3.1 Basic approach

Up to the present time, there are only few countries or regions with an energy efficiency regulation for TVs. One explanation is that the energy consumption and therefore energy efficiency of televisions was broadly considered as less relevant compared to other types of appliances. However, new display technologies led to a rapid increase of the available screen sizes, of the on-mode energy consumption and therefore to a more diverse range of product energy efficiency on the market (CLASP 2011A). In combination with the rapidly increasing ownership rates for TVs worldwide as well as improved information on the actual usage patterns of TVs, the perception of the technical development resulted in an increased awareness for the saving opportunities of minimum efficiency standards and energy labelling.

In the beginning of energy efficiency programs, e.g. by implementing MEPS (Minimum Energy Performance Standards), energy targets, Top Runner programmes, as well as comparative or endorsement labels, one major obstacle concerning TVs was the first edition of IEC62087, which was limited to CRT and therefore not applicable to set appropriate requirements for all recent display technologies. Consequently, all country or regional specific regulations implemented before the publication of the second edition of IEC62087 are generally characterized by a very limited comparability. In contrast, the direct test results of all countries using IEC62087 Edition 2 will be essentially comparable. However, even using the same test standard, the further calculation of the test results for the purposes of country or region specific energy programmes may include proprietary extensions for energy metering (see also chapter 3 ‘Why different test metrics?’). For example, in some regions, the ‘annual energy consumption’ of TVs is displayed on the label or in the product data sheet for a more exemplifying and comprehensible presentation of measurement data. For this purpose, a ‘typical’ user profile has to be defined, which usually includes the ‘on mode’ energy consumption, the specified number of operating hours per day as well as the time of waiting in different standby modes. As long as not standardized, the assumptions for these additional metering parameters may vary a lot between different countries or regions.

For TVs, the most common basic approach to define efficiency metrics for energy efficiency programs is to use the measured average power according to defined test standard conditions in combination with the respective screen area. For the purpose of determining the overall energy consumption, low power modes can also be taken into account. In combination, these parameters allow a conversion of the on-mode energy consumption into a characteristic energy index value (CLASP 2011A). Alternatively, the on-mode-only energy consumption of TVs can be considered in combination with general and absolute consumption limits for the low power modes.

Furthermore, there are different approaches to combine the parameters 'energy consumption' and 'display area'. One common way is the 'energy per unit of display area', which is the inverse of efficiency (also defined as 'energy intensity'). The variation in the 'energy per unit of display area' can be large between different display technologies and even within the same display technology. If a straight ratio is used for the 'energy per unit of display area', for one and the same TV model, its large display versions may appear more efficient than the smaller display versions, due to potential energy consumption parameters not related to the screen area. Hence, efficiency metrics based on 'energy per unit of display area' usually include a correction of this potential size bias, mostly by the use of linear functions (CLASP 2011A). Based on this, a basic line of equal levels of efficiency can be defined, which usually shows the energy consumption across the range of available display areas. In order to define categories of efficiency or 'families of efficiency curves' within a metric (especially in order to set Minimum Energy Performance Standards (MEPS) or to define energy labelling categories), one approach is the 'geometric progression', which requires a fixed percentage reduction in terms of energy in order to achieve a respective efficiency level (CLASP 2011A). Other alternatives are 'linear progression' (a fixed absolute reduction in terms of energy is required to achieve a better/higher efficiency level) or also arbitrary definitions and requirements for better efficiency levels.

3.2 Countries and regions

3.2.1 China

China introduced MEPS (Minimum Energy Performance Standards) for televisions in 2005 with reference to GB12071.7 (1989) and revised MEPS levels in 2009. A maximum permitted Energy Efficiency Index (EEI) defines the MEPS in China, which is comparable to an early European index system. The MEPS for 2005 is an EEI not exceeding the value of 1.5 and the level for 2009 is an EEI not exceeding the value 1.0 (CLASP 2011A). The test method used in China for these MEPS is based on the first edition of IEC62087 and is not directly comparable to measurements made in other countries. In particular, the Chinese test method uses a luminance based energy performance metric (emitted luminance per Watt) whilst most other countries use an energy performance metric based on screen area (Watts per square centimeter) (IEA 2014). However, it is likely that China will consider the use of the most recent edition of IEC62087 when the existing program is reviewed.

3.2.2 Australia and New Zealand

Australia and New Zealand introduced MEPS and energy labelling for television in 2009 (CLASP 2011A). The test approach uses IEC62087 Edition 2.

3.2.3 Japan

The Japanese Top Runner program specifies requirements for TVs in terms of an energy target and a label. For the determination of the energy consumption, static images and test patterns according to the country specific JEITA standard are used (CLASP 2011A). Consequently, the results are not directly

comparable to measurements made in other countries. However, it is likely that Japan will consider the use of the most recent edition of IEC62087 when the existing program is reviewed.

3.2.4 USA

In the US, ENERGY STAR V7 requirements for TVs became effective on October 30, 2015:

The **On Mode Power Consumption Requirements for All TVs** is defined as:

$P_{ON\_MAX} = 78.5 \times \tanh (0.0005 \times (A - 140) + 0.038) + 14$

Where:

- P_{ON_MAX} is the maximum allowable On Mode Power consumption in W
- A is the viewable screen area of the product in sq. inches, calculated by multiplying the viewable image width by the viewable image height
- tanh is the hyperbolic tangent function

The **On Mode Power Allowance for High Resolution TVs (native vertical resolution ≥ 2160 lines)** is:

- $P_{HR\_} = 0.5 \times P_{ON\_MAX}$

Where:

- PHR is the high resolution On Mode Power Allowance in watts; and

Standby Mode Power Consumption Criteria:

Standby-Passive Mode:

TV is connected to mains power, produces neither sound nor picture, and can be switched into another mode with only the remote control unit or an internal signal. Requirement = ≤ 0.5 watts

Standby-Active, Low Mode

TV is connected to mains power, produces neither sound nor picture, can be switched into another mode with only the remote control unit or an internal signal, and can additionally be switched into another mode with an external signal. Requirement = ≤ 3 watts

Luminance:

Luminance in the Brightest Selectable Preset Picture Setting	Luminance in the Default Picture Setting Requirement
< 350cd/m^2	≥ 65% the luminance in the Brightest Selectable Preset Picture Setting.
≥350cd/m^2	≥ 228 cd/m^2

TVs Using an External Power Supply (EPS):

EPSs must meet the level VI or higher performance requirements under the International Efficiency Marking Protocol and include the marking (ENERGY STAR 2015).

3.2.5 European Union

The existing European Ecodesign regulation sets minimum energy performance requirements for televisions from 20 August 2010 with different levels for Full HD resolution and all other resolutions. On 1 April 2012, requirements with one general level for all televisions were introduced. The requirements for power consumption are 1.0 Watt in off-mode, 1.0 to 2.0 W in standby mode (depending on reactivation function etc.) as of 7 January 2010 and 0.3 to 0.5 W in off-mode as well as 0.5 - 1.0 W in standby mode as of 20 August 2011 (ECEEE 2013B).

The European Energy labelling requirements for televisions entered into force as of 20 December 2010 with an A-G scale. According to the original regulation, it was intended to introduce the efficiency classes A+, A++ and A+++ in 2014, 2017 and 2020. The scale of efficiency classes is based on an "energy efficiency index" (EEI), which is the ratio between annual consumption of the appliance and a standard consumption of a typical similar model. Directly after coming into effect, the labelling scheme was allowed on a voluntary basis. One year after the entry into force it became mandatory for all televisions placed on the market (ECEEE 2013B).

Also due to the faster than expected progress of TV technology and market development, a revision of Ecodesign and Labelling requirements is under preparation.

3.2.6 India

India is developing a voluntary comparative ‘Star Rating’ label for televisions. This label will use IEC62087 Edition 2 as the basis for energy measurement, but additionally the usage of a range of static test patterns for determination of energy consumption rather than the dynamic video approach is intended (CLASP 2011A). However, it is likely that India will also review the use of static test patterns and may consider the complete usage of the most recent edition of IEC62087.

3.2.7 Other countries

In the context of test metrics for policies and programs, a number of additional countries have set specific requirements for certain low power modes for TVs, such as ‘off mode’ and ‘passive standby mode’. For the purpose of energy measurement, commonly the standard IEC62301 ‘Household electrical appliances - Measurement of standby power’ is used, which technical requirements are equivalent to IEC62087 with respect to uncertainty of measurement. However, the quality and effectiveness of these sub area requirements are not equivalent to comprehensive regulations based completely on IEC62087 (CLASP 2011A). Consequently, most countries with the intention to set energy performance requirements for TVs in the future, will use the most recent version of IEC62087 as basis for their regulation.

4 Why different test metrics?

Energy efficiency performance standards and labels are commonly based on energy consumption values obtained from test standards like e.g. IEC62087 for TVs. In principle, these test standards should already adopt test conditions, which reflect the existing in-field conditions to a reasonable extent, as well as procedures, which account for the effects of user behaviour on energy consumption (OECD 2006A). However, at the time of the development of new policies and respective energy efficiency programs for products, there is often a lack of appropriate state-of-the-art test standards, which reflect the actual technical development. And even in case of existing and recent test standards, the benchmark test conditions set by the respective standard can be too synthetic so that the obtained consumption data would be only a rough indicator of the actual 'real-world' energy consumption of a particular product unit.

Due to user- and situation specific factors like traditional habits or dominating technologies, the developers of new country or region specific energy efficiency programs may therefore decide to define proprietary test conditions or adapted metrics, which supplement or go far beyond the requirements of the 'official' standards created by international standardisation authorities. Consequently, there can be different reasons, which can make it very hard or even impossible to compare the energy consumption values obtained from different test metrics for energy efficiency programs.

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