The impact of changing TV technologies and market trends on the energy consumption on TVs and the need for a better TV energy test method

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Abstract
For some time it has been apparent that TVs, due to technology change and the trend toward increased screen size, have developed increased energy use footprint within households. Existing measurement standards have been shown to be inadequate in the measurement of TV energy use. This has resulted in an international effort lead by the IEC to develop a new method that cover all technologies and screen sizes and represents real life use of TVs.

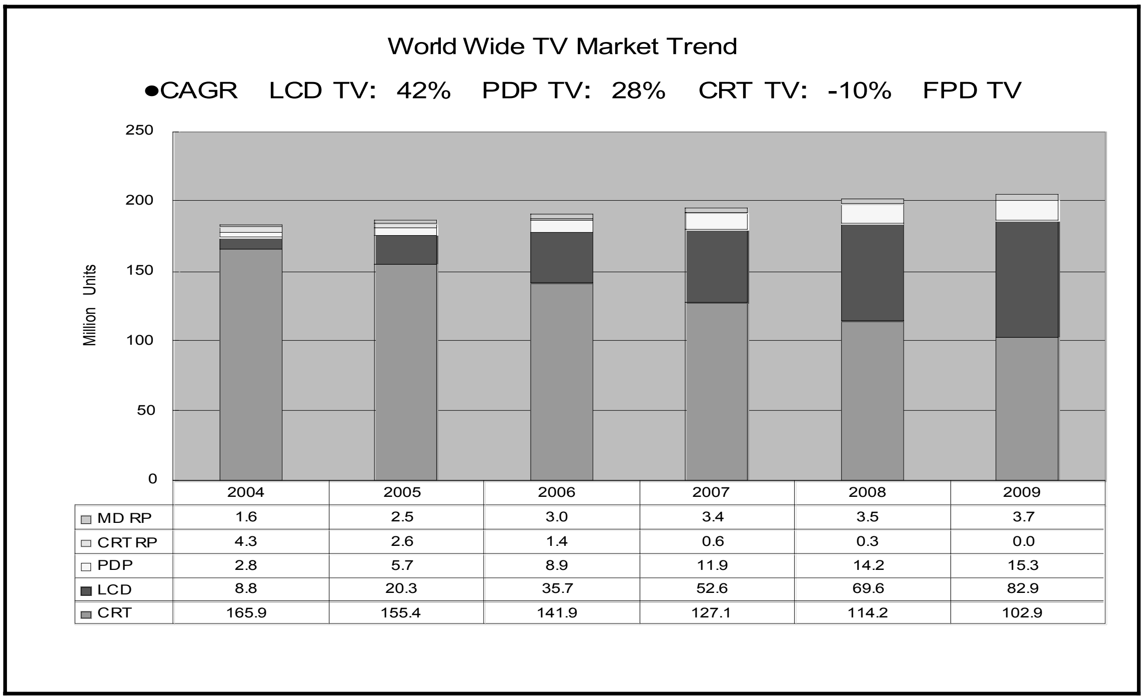
This paper discusses the issues and progress associated with this international effort. Included is a comparison of the energy use of TVs compared to other common household appliances. The existing standards for the measurement of TV energy use are considered as is the newly proposed standard. One of the aims of the new TV Energy measurement Standard was to develop a method that was equally applicable to all TV technology types. The extent to which this has been achieved with the new method is assessed.

One of the conclusions that can be drawn is that current understanding of plasma TV energy use is not accurate and although plasma TVs by virtue of their size do consume considerably more energy than traditional TVs this may not be as high as previously thought. Another conclusion that is drawn is that the new proposed method, by more accurately characterising the TV that is actually watched, will encourage the adoption of energy saving technologies such as modulated backlights for LCD TVs.

Introduction
Until recently Television Technology was based on well established Cathode Ray Tube Technology (CRT) which, due to a number, of constraints limited the screen sizes to around 80 cm for 4x3 aspect ratio TVs and 86 cm for 16x9 TVs. Both these measurements are the diagonal screen distance. Over the last few years demand for bigger screen sizes, fuelled through such roll outs as Digital TV services and the take up of DVD players, has led to the development of new display technologies such as Plasma and LCD. This paper explores these developments and their likely impact for the energy use of TVs. In addition this paper looks at current standards for TV energy measurement and whether the methods offer a fair and accurate assessment for the measurement of TV power. The IEC initiative to develop a new measurement standard based on Average Picture Levels (APLs) is discussed in detail.

THE WORLD TV MARKET TREND
Television broadcasting is changing rapidly throughout the world as the transition from analog broadcasting to digital broadcasting accelerates. The digital broadcasting brings about significant improvements in picture quality particularly when High Definition broadcasting is adopted. The trend to bigger screen sizes was evident even before digital broadcasting but the problem of picture quality on the bigger screens inhibited the take up to a certain extent.

The improved picture quality of Digital TV, Digital HD TV, DVD and more recently Blue Ray and HD DVD has seen these impediments reduced. As a result Fig 1 shows how the adoption of LCD and Plasma, the two main technologies offering the improvement in screen size, has grown world wide from



	2004	2005	2006	2007	2008	2009
MD RP	1.6	2.5	3.0	3.4	3.5	3.7
CRT RP	4.3	2.6	1.4	0.6	0.3	0.0
PDP	2.8	5.7	8.9	11.9	14.2	15.3
LCD	8.8	20.3	35.7	52.6	69.6	82.9
CRT	165.9	155.4	141.9	127.1	114.2	102.9

Fig 1 – Growth of Plasma and LCD Technologies [1]

2003 to the predicted levels of 2009. This figure demonstrates that in 2009 the 50/50 point between CRT and FDP (LDC and Plasma) will be reached world wide within just six years of FDPs appearing in the market. In other parts of the world such as Australia this point has already been reached in 2006 and as of February 2007 is as high as 60 %[2].

As to the screen sizes Fig 2 shows the trend for the major technologies. CRTs will, on average, get smaller as they are displaced by FDPs in the larger screen categories. Price will ensure that CRTs continue to have a presence in developing economies where the TVs that can be afforded will be the smaller screen sizes. LCDs and Plasmas, however, on average will increase in size substantially. Plasmas will find good position in the 42 inch and larger while LCDs will displace CRTs in the smaller and medium screen sizes. This graph shows that CRTs will reduce on average by 2 inches LCDs will increase by 10 inches and Plasmas by about 2 inches. Rear Projection technologies are also present but as Fig 1 shows they have a relatively low penetration in the market and are not projected to improve upon this significantly in the future and as such do not impact greatly in terms of the World Wide Market. Other technologies may also have an impact but as yet have not emerged as major factors. These include OLEDs, Laser and SED display types.

TV MARKET AND POWER CONSUMPTION

The question becomes what impact will this shift in the market have on energy consumption? Fig 3 and Table 1 models likely consumption outcomes. The model is based on the market data presented and the author's most recent typical measurements of the power consumption of TVs by technology type and screen size and an average of 5 hrs use per day (Reports from the USA show TVs are on for more than 8 hrs per day[3]).

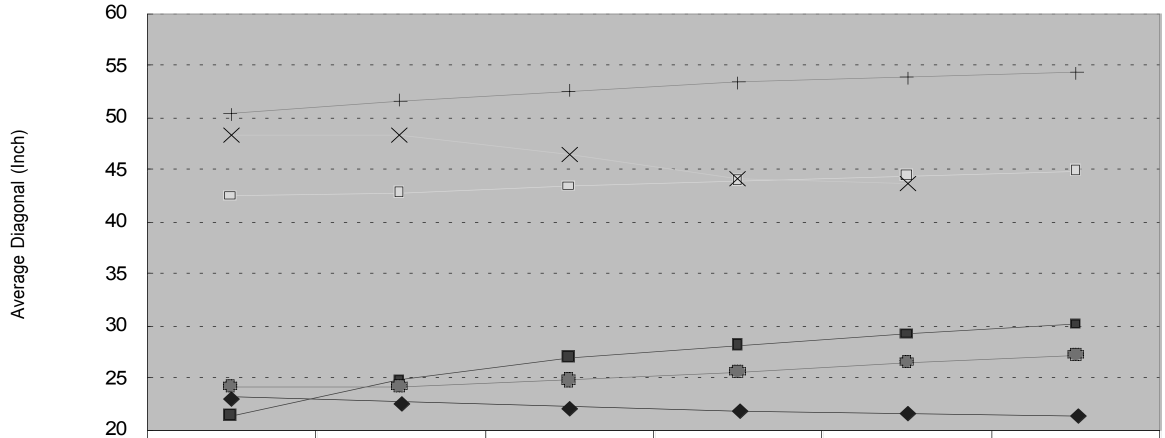
The results, it has to be said, are worrying. CRT based TV's energy consumption will decrease whereas LCD and Plasma show a considerable increase. In 2004 energy consumption can be seen to be 23274.23 Giga Watt hrs but with the current market trends will increase to 41190.25 Giga Watt hrs by 2009.

This analysis is of course only an estimate and many factors could cause different outcomes. It also only shows the energy consumption for TV sold in each year and not the impact due to changes in the world wide stock of TVs. It does represent, however, a reasonable estimation of the impact that the TVs sold in each year have on the increased energy consumption that can attributed to TVs. Action on encouraging the development of more energy efficient TVs will of course reduce the energy use outcome, but trends such as an increasing number of TVs per household (Australian estimates now at 2.4 TVs per household[3] and USA 2.8 TVs per household[4]) could be replicated elsewhere meaning that the number of TVs sold would increase as would the energy consumption associated with them.

AUSTRALIAN TV ENERGY CONSUMPTION AND OTHER HOUSEHOLD APPLIANCES

For Australia Fig 4 shows the relative energy usage of a number of domestic appliances. On average, new televisions are consuming more energy than many other household appliances already subject to the mandatory Energy Rating Label such as Refrigerators and Washing Machines. This has not been the case for traditional CRT televisions, but with the trend toward larger screen sizes and technologies such as plasma, new televisions could represent approximately 4 % of household energy consumption.

This discussion has shown that, given the rapidly changing world wide market for TVs and the likely impact on energy use, it is crucial that the method used to measure TV energy consumption represents real life use of the TVs and provides as accurate measurements as possible.



	2004	2005	2006	2007	2008	2009
CRT	23.2	22.6	22.2	21.9	21.6	21.4
LCD	21.4	24.8	27.0	28.2	29.2	30.1
PDP	42.4	42.8	43.4	43.9	44.4	44.8
CRT RP	48.3	48.2	46.5	44.0	43.6	
MD RP	50.3	51.6	52.6	53.3	53.9	54.3
Total	24.2	24.2	24.7	25.5	26.5	27.2

Fig 2 – Growth of screen size for TVs world wide [1]

Table 1. World Wide Energy Consumption of TVs 2004-2009

Year	2004	2005	2006	2007	2008	2009
CRT TVs Sold (Giga Watt hrs/Year)	21193.73	19852.35	18127.73	16237.03	14589.05	13145.48
LCD TVs Sold (Giga Watt hrs/Year)	803	2222.85	4560.675	7679.6	13972.2	19668.03
PDP TVs Sold (Giga Watt hrs/Year)	1277.5	2600.625	4385.475	5863.725	7774.5	8376.75
Total TVs Sold (Giga Watt hrs/Year)	23274.23	24675.83	27073.88	29780.35	36335.75	41190.25

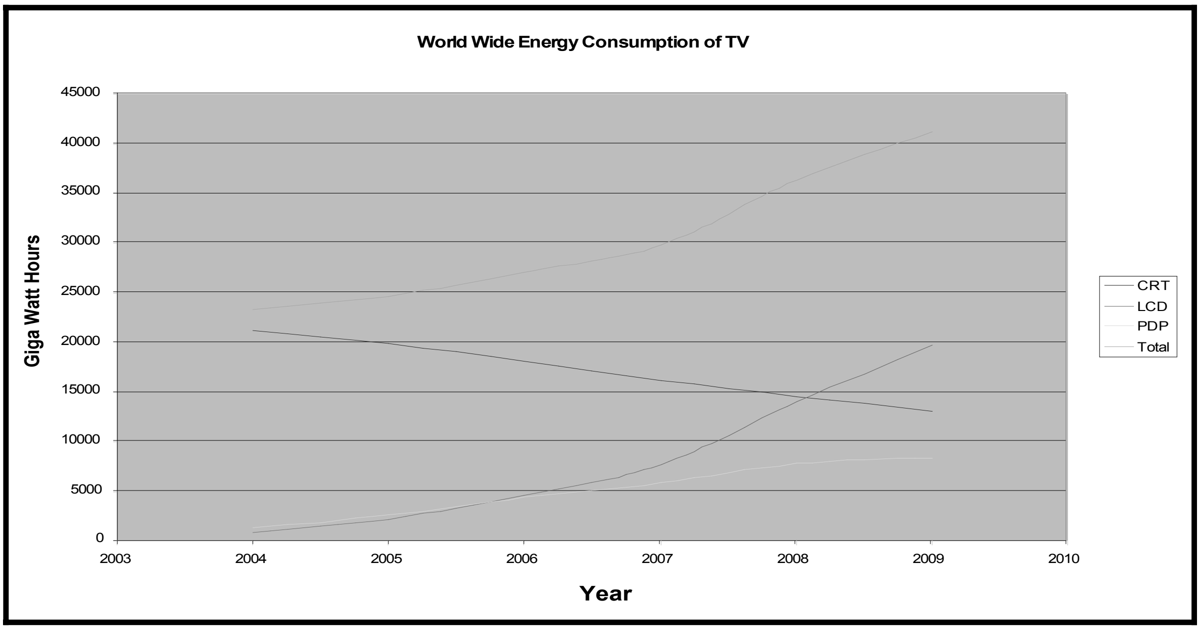


Fig 3 – Estimated Global Power Consumption 2004 - 2009

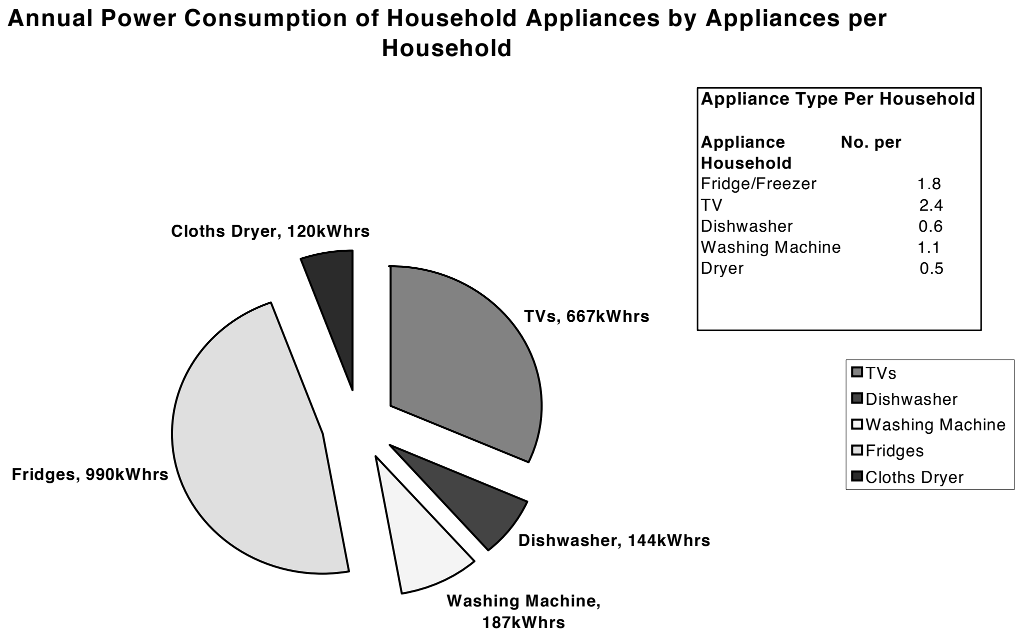


Fig 4 – Annual cost of operating common household appliances (Australian Data)[3]. Note: All of these products have mandatory labelling except televisions. Not all houses have a dryer or dishwasher. Many houses have more than one refrigerator. Most houses have more than 1 television.

The need for a new TV Energy Test Method

Over the last several years there has been much discussion at many forums as to the inadequacy of current test methods for the power consumption of Televisions. In 2005 Dr Larry Weber delivered a paper[5] in San Francisco that highlighted the inadequacy of current test patterns to correctly simulate the Average Picture Levels (APLs) that are inherent in the video signals being displayed on TV display devices.

The problem of not considering APLs when measuring the energy use of televisions is demonstrated in Fig 5. As can be seen APL has a significant effect on the energy consumption for all but non backlight modulated LCD TVs. It is further evident that APLs above 40 % have little effect on the energy consumption which, on most TV technology types, is already at 100 % of their maximum energy use. The exception being non backlight modulated LCD technology which alway consumes 100 % regardless of the APL level. From this point of view LCDs can be seen to be energy inefficient as the energy consumed by this type is always sufficient to produce peak white even though this rarely occurs (see Fig 6).

RESULTS OF THE APL SAMPLING SURVEY FROM AUSTRALIA, USA, JAPAN,NETHERLANDS AND THE UK

As part of the work to develop a new measurement method APLs were collected from USA,UK, Australia, Netherlands, and Japan in order to produce a video test that truly represented TV use. The objective of the survey was to gain a better understanding of the nature of the APLs inherent in the video that is then displayed on a Television under normal use conditions. The methodology adopted was to sample 40 Hours of Prime time viewing ensuring that a mix of genre was also sampled so as not to bias the results toward any particular content. It seems reasonable to postulate that this method would collect results that do indeed represent average viewing habits. The method was considered by the Working Group to provide data of sufficient accuracy so as to be able to produce the new video test clip in a time frame that was consistent with the urgency of the work as demonstrated in the above discussion on TV market and energy use growth.

The results can be seen in Fig 6. The first point that should be made is that the histograms from each country are all remarkably similar. Differences associated with fluctuations between the samples have little impact on energy use as they are averaged out through the operation of the power supply in the TV. The figure also shows that few pictures are in excess of 50 % and the average for the samples vary from 30 % (Aust) to 35 % (Japan). Japan is higher because there is a higher percentage of cartoon material that is watched and cartoons can be shown[6] to have a higher APL that many other types of content. Given the evidence that most TV pictures have APLs under 50 % and this is also the region in which TV energy use has its greater variation it is crucial, to get an accurate measurement of TV energy use, that APLs must be considered as a factor.

REVIEW OF JEITA AND PREVIOUS VERSION OF IEC 62087

For the purposes of this paper only the On Mode power measurement method of the JEITA and IEC 62087 will be considered. In doing this it is not implied that other aspects of the power consumption for TVs are not important. However, by limiting the discussion at this point only to the On Mode it will be easier to assess the effect each method has on the final measurement.

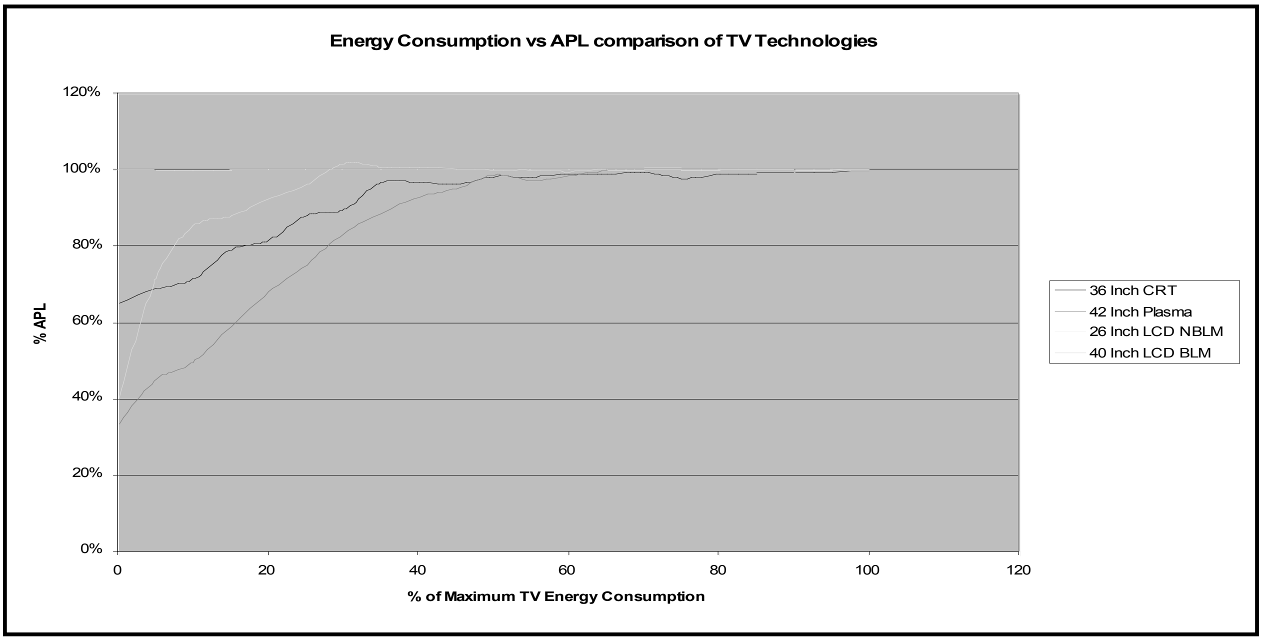


Fig 5 – Comparison of differing TV technology energy consumption characteristic[6]

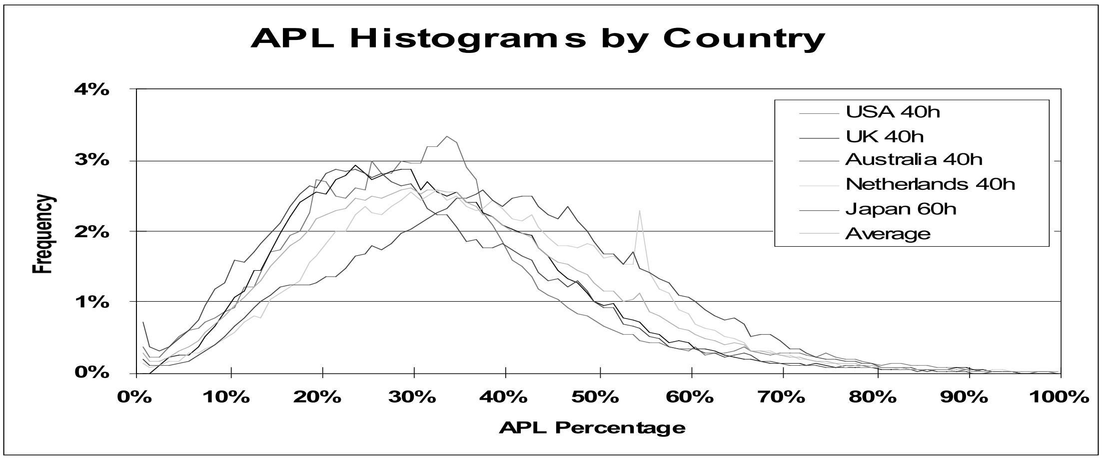


Figure 6 – APLs sampled from Around the World[7]

IEC 62087

IEC 62087 uses a three bar black and white pattern for the measurement of ON Mode Power. This pattern has an APL of 50 %. As has already been discussed, from the power consumption characteristics of most display types, TVs at this APL level will show a power consumption of 100 % of maximum. This pattern therefore, in effect, will give the same power measurement as a 100 % APL white raster in most cases. Given that the TVs are actually showing pictures with APLs below 50 % eighty percent of the time the suitability of this test pattern must be questioned. This is reflected with the IEC currently in the process of forming a working group to look at this issue.

JEITA

The other standard of interest is the JEITA standard. This uses four patterns. 0 % Black, 100 % White Raster, three bar Black and White and Colour bars both with an APL level of 50 %. The results of these measurements are then averaged according to the formula:

$$((Pw+Pb)/2 + Pc + Pt)/3$$

Where:

Pw is Power Measured with 100 % white
Pb is Power Measured with 0 % Black
Pc is Power Measured with Colour Bars
Pt is Power Measured with Three Bars

This method would be more accurate because it is at least considering power consumption at black level which would effectively reduce the measured power. However, referring back to Fig 6 in all the samples less than 1 % of frames were black or 0 %. In light of this the validity of using a 0 % pattern and giving it an effective weighting of 16.75 % in the calculation would have to be challenged.

The same could be argued for the 100 % white raster although given the figure that 10 % of APLs are greater than

55 % and that almost all the TVs sampled did consume 100 % of their maximum at that level it is indeed a closer representative figure.

The method becomes more distorted when we consider the Colour Bars and the Three Bars. These have an APL of 50 % which means most TVs are at or close to full power and their weighting is 66.6 % of the calculation.

In summary then the JEITA method gives effectively a weighting of 83.25 % to 100 % power consumption when in fact few pictures ever reach this level and 16.75 % weighting to the power consumed at 0 % APL when less than 1 % of pictures are at this level.

Summary of existing TV energy testing methods

The conclusion is that due to the nature of TV video signals and their APLs and the power consumption characteristics of TVs that neither the existing IEC62087 or the JEITA adequately measure TV power consumption in a way that reflects real word use. To be relevant the new test method must take into account the real world APLs. Power consumption of most TVs varies with the range of APLs that actually make up the pictures displayed so to measure power realistically the video used for the measurement must also have APLs that exist in the 0 %-50 % region.

OBJECTIVES OF A NEW TEST METHOD

Given the proliferation of display technologies, and the differing nature of their power consumption characteristics, the primary objective of any new test method must be to develop a test methodology that provides realistic power consumption measurements for all display types under real world use conditions. The test method should be a simple as possible to administer.

A key element of the new method was to create a video test that represented actual APLs and was in the form of natural moving images.

In addition to the power consumption associated with the pictures being displayed the test method must also consider the contribution to power consumption of the following factors:

- Audio
- Digital Tuners
- Standby Power
- Energy Saving Features and Settings

Lastly, the new test method must have some way to handle TVs with other devices built in such as DVD recorders etc.

This report demonstrates that a method that meets the above requirement is indeed possible and could be developed relatively quickly.

The average of these APL curves has been used to produce a 10 minute natural moving image test clip which, in conjunction with the revised TV testing method in IEC 62087, will produce far more accurate measurement of the power consumption of TV sets. This will also mean that for regulators and energy consumption planners that a much higher reliability will be able to be placed on energy consumption models based on measurements of TV power use using this new method. In latest developments comparison tests between the 10 minute test clip and the original 40 hrs of collected material is showing good correlation between the energy use measured for the 40 hrs and the 10 minute clip.

Questions could be raised as to how accurately this approach is but, in the view of the Authors and the IEC working group developing the new method, it provides a much more accurate measurement than was previously available as has already been discussed above.

Final Comments

The TV market is a rapidly growing market particularly in developed countries where the conversion to Plasma and LCD technology TVs along with the trend to larger screen sizes is well underway. This has catapulted TVs into a significant appliance in terms of energy consumption both because of the sheer numbers that are being used and the increased energy consumption that is associated with increased screen size. Current standards for the measurement of TV power are considered by many to be inadequate as they have not kept up with the technology used to make televisions.

Work toward a new TV measurement method that is suitable for all technologies based on APLs progressed though out 2006 and is now well into the IEC approval processes. This new method once approved will provide the essential tool needed to better define the impact and growth of the energy consumption of TVs.

Latest market data suggests that the model presented in this paper for the increased energy consumption of TV may well be conservative and the trend world wide toward LCD and PDP technologies may well be accelerating and the 50-50 point may well be reached well before 2009. One reason for this is that in countries like China consumers are preferring to switch to the newer technologies even though CRTs are considerably lower in price.

It is clear that a method of TV power measurement that is based on APLs will encourage manufacturers to make use of technologies that will give them a competitive edge in terms of power consumption. For example good energy saving and improved picture quality can be achieved with LCD technology with the use of modulated backlights where for darker pictures the backlight is dimmed producing better black levels and saving energy.

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