

Trends in television energy use: where it is and where its going

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ABSTRACT

Most developed countries in the world now have television ownership levels approaching or exceeding 2 per household and this appears to be increasing. Even developing countries like China have an ownership of 1.33 televisions per household in urban areas. It is estimated that 1 billion televisions were installed world wide by 1996 and with annual production running at more than 200 million units a year, the world stock is already likely to more than 2 billion.

CRT televisions form the bulk of the existing stock of televisions, but it is estimated that new technologies such as LCD and plasma will become the majority of new sales by 2010. Increasing screen sizes and high on-mode energy consumption of new technology televisions and their peripherals is likely to result in a marked increase in the energy consumption televisions.

Analysis has shown that there is a factor of 2 or 3 (or more) between the lowest and highest energy models of the same technology and size (based on analysis of hundreds of models). This suggests a strong case for providing information to consumers on these differences (e.g. some form of energy labeling) and/or mandating efficiency standards (MEPS). While standby is generally improving, the increase in on-mode energy consumption will mostly likely swamp any benefits.

Existing test methods do not adequately account for changes in power consumption of different television technologies in response to picture brightness and contrast, but new test methods that address these issues are progressing. China is the only country which currently has MEPS for on-mode for televisions but others are ready to do so. Japan covers on-mode in their Top Runner program.

Energy Drivers for Televisions

Energy consumption of televisions is driven by a range of factors such as the screen technology, screen size, the number installed and used (ownership) and viewing patterns. All but viewing patterns are investigated in this paper.

What are the Main Television Technologies?

Until the late 1990's, the CRT television was the only realistic option commercially available to consumers. In the past few years, several new technologies have appeared and the market and these are set to have a significant impact on the television market and the installed stock. The main television technologies are:

- CRT - the cathode ray tube is the predominant television technology installed and will remain so for probably the next 15 years. A wide range of sizes are available (20cm to 100cm). Newer models have excellent picture quality and are very cost effective.

- Plasma – flat panel display with a bright picture, price reductions in recent years have resulted in increased demand. Typical size is 42” (108cm) or larger. Also called PDP.
- LCD – liquid crystal display – flat panel design, improved picture and brightness has increased its popularity. Sizes have tended to be smaller but larger sizes (up to 120cm) are now available.
- Projection – popular for larger screens especially for very high quality home cinema. The popularity of large screen rear projection televisions is declining due to limitations in viewing angle, while for CRT types there is a decline due to poor picture quality.

Cathode Ray Tube (CRT): A cathode ray tube comprises an electron gun which generates a stream of electrons which are projected through a vacuum onto a screen which 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. Pictures are generated using lines that are rapidly deflected across and down the screen (odd lines then even lines are generated sequentially – called interlacing). The rate at which the lines fill a complete screen is called the refresh rate. The picture brightness is mainly affected by the volume of electrons from the electron gun. A significant part of the energy required by a CRT TV is dependant on picture brightness and the energy used in the deflection coils.

Plasma: Simplistically, plasma screens have a large number of very small fluorescent lights embedded into a flat screen. Each individual fluorescent light is a pixel. The number of pixels on the screen determines the resolution of the image. Pictures are generated by changing the color and intensity of light generated by each pixel (in fact three colors are separately generated within each pixel).

LCD: Liquid Crystal Displays use a backlit panel which is covered by a layer of liquid crystal. Pictures are generated by changes in the properties of the liquid crystal layer which lie between the back light and the viewer. The properties of the liquid crystals determines what color and amount of light is transmitted from the screen. The liquid crystal layer is broken down into individual cells (pixels) which determine the resolution of the image.

Projection: Two main types are rear projection (becoming less popular) and front projection. A high power UHP mercury or xenon arc lamp generates a strong, constant point light source which is projected through, or reflected from, an image control screen, (typically a liquid crystal display). Transmittance or reflection of the light to the projection screen is controlled by the imaging device.

Table 1: Summary of Television Technologies – Energy Consumption

Parameter	CRT	LCD	Plasma	Projection
Image resolution	Lines	Pixels	Pixels	Pixels
Screen size effect – energy	Yes	Yes	Yes	No
Picture brightness effect – energy	Partial	No ³	Yes	No
High definition effect – energy	Yes ¹	No	No ²	No

Note 1: CRT television energy can change substantially between standard and HD modes, depending on signal. However HD CRT is not expected to have any significant future market share.

Note 2: There can be significant energy differences between standard definition and high definition models of the same size, but the energy consumption will not be affected by the signal (standard or HD) within a particular unit.

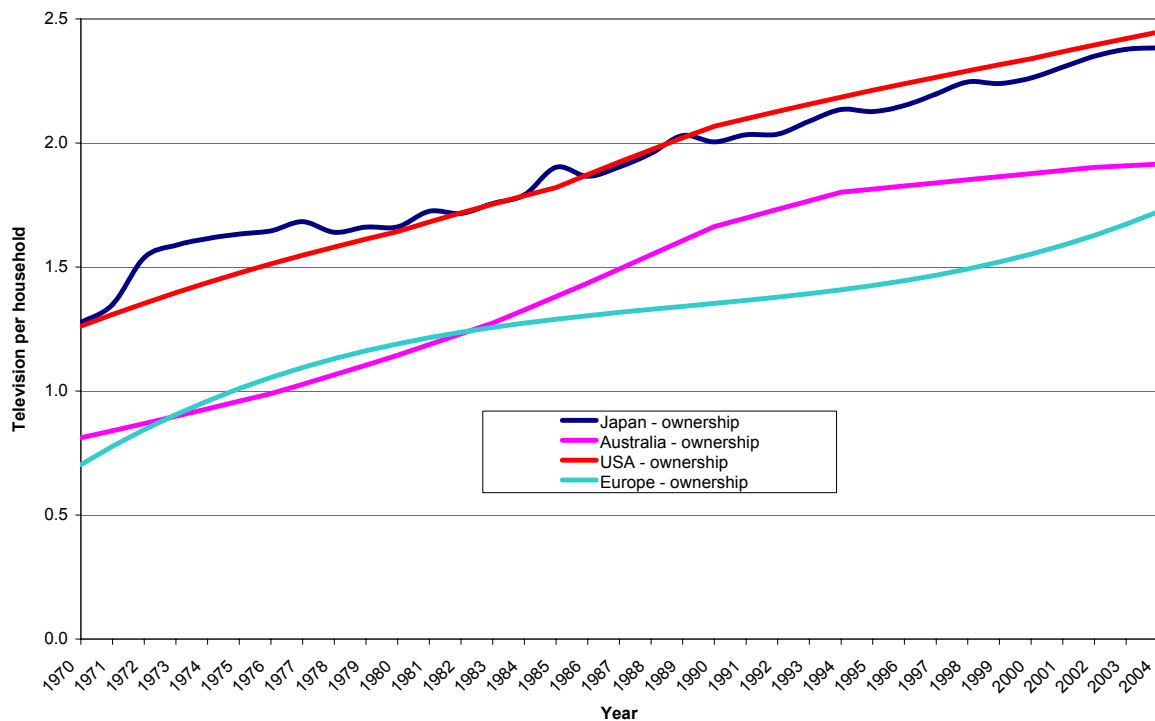
Note 3: Modulated backlight LCD screens may vary their power in accordance with picture brightness.

Another technology which is set to enter the market in the near future is the so called Field Effect Display which has been developed by Toshiba and Canon (also called SED or Surface-conduction Electron-emitter Display). This is also a flat panel design which is well suited to large display sizes. It operates on the same principle as the standard cathode ray tube but instead of a central electron gun, each pixel effectively has its own dedicated solid state electron emitter to generate the required picture – so called “nano-tubes”. The most important aspect, apart from excellent picture quality and brightness, is the claimed lower energy consumption of this technology. This product is yet to be commercially released.

Trends in Television Penetration and Ownership

When television first became available, it was very much a product of the wealthy and middle class. However, televisions are now a common appliance in developed economies, with most countries now reporting penetration¹ of around 99%. The other trend that appears set to continue is the increased stock of televisions beyond an ownership² level of one unit per household. Time series data for Japan, Australia, USA and Europe shown in Figure 1 illustrates these trends over the past 30 years. While the shape of ownership curves for these very different countries differ, they illustrate the trend towards large numbers of these products in the home.

Figure 1: Trends in Television Ownership – Selected Countries



Source: EES (1999), ABS4602 (2005), ESRI 2005, NRDC 2005, EICTA 2004, author estimates.

Note: Japan and Australia had rapid conversion from black and white to color up to around 1980. Europe is EU25.

¹ Penetration is the number of household with one or more of the appliance.

² Ownership is the average number of appliance per household (stock).

In China, ownership is 0.75 televisions/household in rural areas but 1.33 televisions/household in urban areas (which covers the bulk of the population) (Lin 2006).

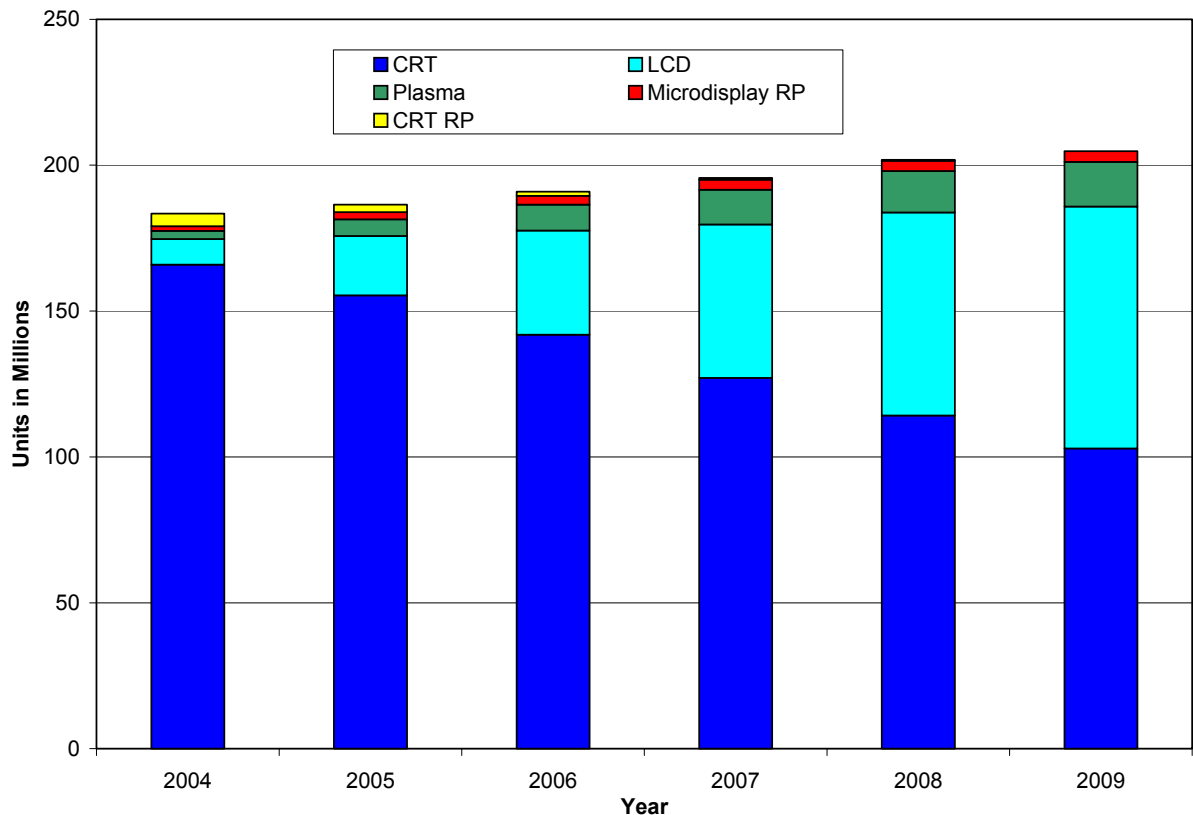
It is estimated that by 1996 some 1 billion televisions were installed world wide (Inventors 2006). With annual production running at more than 200 million units a year, the world stock is likely to have already reached 2 billion units and is set to increase.

World Television Production

Current world production of televisions is currently around 190 million units per annum. The current and projected total world production by screen type is shown in Figure 2.

Nearly half of the current production is from China. This share is set to increase into the future. The most important aspect of Figure 2 is that the total production of CRT televisions is set to decline dramatically, to around 60% of production volumes within 5 years. Projections give the lions share of new production to LCD technology, rather than plasma, which many perceive as a dominant future technology at the moment. According to these forecasts LCD is set to become the dominant technology type after 2010, although the advent of other new technologies such as SED may affect these projections.

Figure 2: Current and Project Production of Television by Screen Type



Source: Displaysearch 2006. RP is Rear Projection.

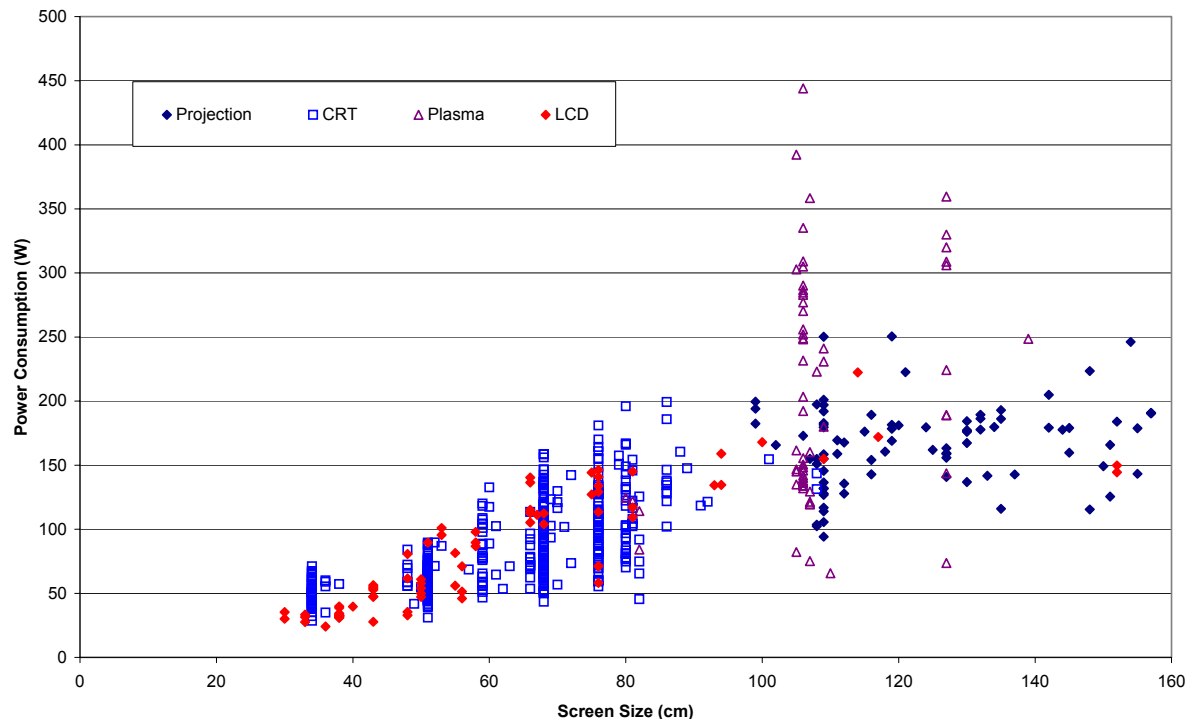
While some energy policy commentators may see this as a relief (compared to a plasma dominated future), it needs to be noted that there are many LCD screens which have high power consumption and a poor Energy Efficiency Index (EEI). This may be also affected by the advent

of modulated backlight systems which increase luminosity and enable LCDs to compete with plasma on picture brightness. In addition, LCD screens have looked like a low energy option compared to plasma in the past, partly because of their relatively small size (typically 60cm for LCD versus 108cm for plasma). Forecasts suggest a steady share in the LCD 80cm (32") size bracket but a marked increase in total share for the 96cm (38") and 108cm (42") sizes. This will push stock average sizes up as well as energy consumption. It is important to note that CRT technology will still be the mainstream product in most developing countries for the next 10 years.

Energy Attributes of Televisions

There are many assertions made about the energy consumption of television sets. In particular, some commentators have been almost hysterical about the power consumption of plasma televisions. Superficially, this appears to be warranted. In order to examine this issue objectively, data from some 770 new television sets of a variety of technologies has been collected in Australia over the period 2001 to 2005 (EnergyConsult 2005). This is summarized in Figure 3. It is important to note that for this data set the screen image was not always controlled. While this will have only a minor impact on the power consumption of LCD and projection displays, it may bias the CRT and Plasma readings somewhat (see later discussion on test method). But the data is still indicative of total power consumption levels by model.

Figure 3: Power Consumption of New Television in Australia



Source: EnergyConsult 2004.

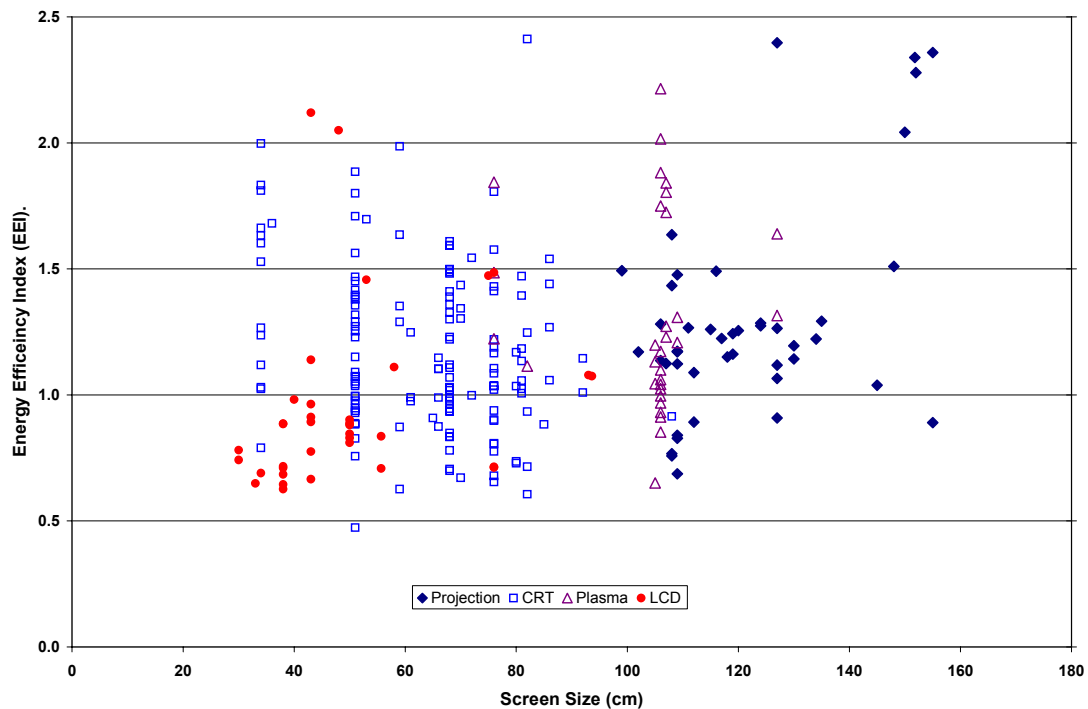
There are a number of very important observations that can be made about Figure 3. Firstly, there is an apparent impact of screen size on the power consumption of all television

types (except projection systems) – bigger screens use more power, which is fairly intuitive. The second important observation is that many plasma models seem to have very high power consumption in some cases (many over 300 Watts). This seems to support to some degree the concerns of some policy observers. Perhaps the most important observation is the fact that for nearly any screen size and technology depicted above, there is a difference in energy consumption by a factor of around 2 to 3 times from the lowest energy to the highest energy models. This factor is more like 4 times for plasma televisions.

If there is a factor of 2 or 3 between the lowest and highest energy models of the same technology and size, this would tend to suggest a strong case for providing information to consumers on these differences (e.g. some form of energy labeling) or mandating Minimum Energy Performance Standards (MEPS) to remove the least efficient models from the market.

In fact, Australia is moving towards regulation of television sets, which will cover both on-mode and standby-modes. The preliminary proposal was released in 2004 (EnergyConsult 2004). The proposal uses a so called “energy efficiency index” (EEI) to allow products to be compared across different screen sizes and technologies. This is the same index used in Europe as part of the European Eco-label and GEEA requirements. The index takes into account a number of different attributes such as high definition, aspect ratio and tuner type. Figure 4 illustrates that the EEI essentially removes the size bias from the technology comparison of televisions.

Figure 4: Proposed Energy Index for Televisions – Technology Comparison



Source: EnergyConsult 2004.

Trend data in Australia suggests that in 2000 the average television installed in households was 48cm (19”) and that this was increasing at about 0.5cm per year at the time. The average power consumption was about 66 Watts. Similar data was found in the USA in the

1990's (Rosen and Meier, 1999). This was prior to any significant market share for the new technology types such as large LCD and plasma (the sample included none of these types). Assuming an average viewing period of around 25 hours per week (which is increasing) (EnergyConsult 2004), the average television in Australia could be expected to consume around 80 kWh per year in on-mode and around a further 30 kWh per year in passive-standby mode. This is fairly modest and it could be argued that such a small energy consumption would hardly warrant strong policy action.

Recent data suggests that screen sizes will be growing dramatically over the next decade. In a pessimistic scenario, with an in-use power consumption of 200 Watts and 30 hours of use per week, the annual energy consumption is more than 300 kWh per year. Add on standby power (many poorer units are around 5 Watts or more for 7000 hours per year) and the total is approaching 350 kWh/year. This could be worse in a poorly networked product (see discussion below on peripherals). That is the energy consumption of a medium household refrigerator.

Given these likely trends, the energy future of these technology changes is not all that clear at this stage. However, larger screen sizes, together with the necessary peripherals and integration with home theatre are certainly likely to dramatically increase energy in the short term. Longer term trends may be tempered by new efficient screen technologies and negligible standby power levels if energy policies are effective.

So what is happening with standby?

Despite the apparent likely increases in power consumption during normal use, it appears that there have been some improvements in power consumption in passive standby mode (where the television is not displaying any picture or sound but can be activated by a remote control).

Happily, in Australia and Europe, most televisions have an off mode (where the unit cannot be activated by a remote control - although the presence of off switches in televisions is no longer universal in these markets) and the power consumption in most cases is at or close to 0.0 Watts. Data collected in late 2005 suggests that 60% of users leave their televisions in off mode or unplugged while 40% are left in passive standby mode (EES 2006). Data collected in USA shows that nearly all televisions in the USA do not have a "off mode", so passive standby is the only relevant mode for this region (NRDC 2005, Rosen & Meier 1999).

Australia has been concerned with monitoring trends in standby power consumption since 2000 and has collected substantial data, including information on passive standby for televisions. The 3 main data sets used to infer trends are a sample of 64 houses in 2000 (Harrington and Kleverlaan 2001), a sample of 120 houses in 2005 (EES 2006) and measurements on some 774 new products in stores over the period 2001 to 2005 (EnergyConsult 2005). Data suggests a downward trend from an average of around 15 Watts for models sold in the early 1990's to less than 4 Watts for new models sold in 2005. A similar trend is also present in Europe, where sales weighted average shipments have fallen from 6.2 Watts in 1996 to 1.9 Watts in 2004 (EICTA 2004). The voluntary agreement between the principle TV suppliers to the European market and the European Commission has driven standby power down significantly and no new TV chassis will have a passive standby of more than 1W by the end of 2007 (EICTA 2006).

While these trends are desirable, data for each of the 4 years of data collection in Australia shows that there is still a very wide distribution in the power consumption in this mode. Only 10% to 20% of models each year use less than 1.0 Watt in passive standby mode

(EnergyConsult 2005). There are already many models with a passive standby of less than 0.5 Watt and models have been measured at less than 0.1W, so the technology and designs to achieve very low passive standby power are readily available. This is clearly an area where manufacturers need to be pushed harder.

It is also obvious that providing consumers with information on standby power is likely to be ineffective – the difference between a product using 1 Watt and 2 Watts in passive standby mode will mean nothing to a consumer (this equates to less than US \$1 a year in operating cost and would rightly be ignored by all but the most zealous consumer). The transaction cost of taking this information into account is likely to be far too high relative to potential savings. The marginal cost of pushing passive standby to below 1 Watt will be negligible compared to the total cost of the product, so stronger policy measures in this area may be warranted.

The magnitude of standby in proportion to on mode consumption also needs to be kept in perspective. For a product with low hours of use, low on mode power (say small CRT) and higher standby, total annual energy would be around 100 kWh/year³ of which standby could be 50%. However for a product with high hours of use, high on mode power (say large plasma) and low standby, total annual energy would be more than 400 kWh/year⁴ of which standby could be less than 1%. A typical figure for standby is around 10% to 20% of total energy but this obviously varies considerably by product and the actual usage pattern assumed.

Other factors that will affect future television energy consumption

Changes in screen size and technology will undoubtedly transform future energy consumption of televisions in the home. However there are a number of other factors that will also have an impact. The magnitude of these varies, but each are worthy of consideration.

Conversion to digital broadcasts: this is perhaps the most significant issue with regard to future energy consumption associated with televisions. Most governments around the world have announced the conversion of free-to-air television services from analogue to digital broadcasts.

The main consequence of concern is the legacy of installed analogue televisions and how they will operate in a digital broadcast future. The short and simple answer is the digital converter – this is a digital receiver that can convert digital broadcasts into a suitable analogue signal which can continue to be viewed using existing equipment (often called a set top box). The energy consequence is a burgeoning growth in the demand for set top boxes as we move towards the shut down of analogue broadcasts. Given that there are likely to be some 2 billion installed televisions world wide (of which very few will have digital tuners), the world demand for digital set top box converters could conceivably something like 1.5 billion over the next 10 years. China itself estimates the need for some 500 million digital to analogue converters (ACEEE 2004). The worrying aspect is that many of these products use significant amounts of power and there is no protocol for them to automatically power down when a connected analogue device is not in use. There various MEPS proposals for simple and complex converters.

Digital tuners: many new televisions now include a digital tuner which will be required for reception of free to air broadcasts in many countries in the future. Digital tuners appear to have a greater energy requirement compared to analogue tuners due to the increased data processing requirements which are implicit in the need to decode, error correct and decompress the broadcast data stream. While this effect is measurable (of the order of 3 to 8 Watts more than

³ Values assumed are 60 Watts on, 6 Watts standby, 15 hours per week.

⁴ Values assumed are 200 Watts on, 0.5 Watts standby, 40 hours per week.

analogue processing, and this difference is declining), it is not a substantial energy overhead in comparison with the energy required to drive the display. Some televisions have no tuner⁵ and rely on AV inputs directly from an external source (set top box, DVD player etc.), which also has some energy impacts.

Widescreen formats: There is a move from the traditional 4:3 format towards the 16:9 (widescreen) format. In itself this has no overt impact on energy consumption. In most cases the energy consumption is proportional to total screen area, so this is the most critical factor. But most high definition broadcasts are in 16:9 format.

High definition: In a world of plasma, LCD or other pixel based flat panel displays, the effect of high definition (or not) is largely immaterial. For these screen types, the screen definition and power consumption attributes are defined at the time of manufacture via the number and size of individual pixels built into the display. However, high definition models will generally use more energy for the same screen size compared to standard definition models, especially for plasma and SED. The only energy impact a high definition versus a standard definition broadcast will have on such displays is how the tuner decodes and translates (interprets) an HD signal for an SD display or vice versa⁶ which has no energy impact.

Complexity of Interfaces: Virtually all televisions now have the capability of receiving external AV signals – many television have several inputs and several interface options. The most common interface is still the separate audio and composite video or component video. Some newer televisions have an HDMI interface (High-Definition Multimedia Interface). This is a digital video connectivity standard which is intended to replace the Digital Visual Interface (DVI). HDMI can transmit both uncompressed digital audio and video signals. However, this interface is protected by High-bandwidth Digital Content Protection patent. The potential of HDMI (or other interfaces which enable two way communication between devices) is that it provides a means of implementing energy management of all devices on the HDMI network. While little work has been undertaken on the energy management capabilities for HDMI, this is clearly an import area that could reduce energy consumption of all home entertainment devices on any such network to be the minimum possible. UK estimates have shown that in a simple HDMI controlled network of TV, surround sound amplifier and DVD/Hard disc recorder, up to 1 kWh could be saved in a typical viewing day (6 hours on, 18 hours standby) in the 40% of households that forget to put the ancillary equipment connected to the TV into standby or off when they finish viewing (MTP 2006).

Regulation of Television for Energy Efficiency

International Energy Policies in Place or Proposed for Televisions

While there are a number of energy programs in place which address aspects of energy consumption for televisions, China is the only country to presently have a mandatory program

⁵ While a screen without a tuner has traditionally been classified as a “monitor”, there are now many screens which are clearly intended for use as home entertainment displays (large wall mounted flat panel displays) and these will clearly never be used as computer monitors.

⁶ It is technically possible to show a high definition picture on a CRT television that is capable to setting a finer line resolution with a variable scan rate. While such devices are probably rare in reality, there are substantial energy consequences for this technology. Under a high definition broadcast, a CRT television could be expected to use 30% to 50% more energy compared to a standard definition broadcast on the same unit.

which limits the energy consumption of color televisions in both on mode and passive standby mode. The initial MEPS were introduced in 2005 and the levels will become more stringent in 2009. The details are set out in GB12071.7 (1989). MEPS in China is defined as a maximum permitted Energy Efficiency Index (EEI), which is comparable to the European index system and that proposed in Australia. The level for 2005 is an EEI not exceeding 1.5 and the level for 2009 is an EEI not exceeding 1.0.

Japan has the Top Runner program which sets so called “voluntary” efficiency targets for a wide range of products, including televisions. The first round of Top Runner limits for televisions were announced in 1999 and the target date for assessment was fiscal year 2003 (ECCJ 2006). A new technical report assessing compliance and setting new targets was released in 2005 and this sets out new targets for televisions for fiscal year 2008. The new limits are very complex with 20 categories of CRT, 38 categories of LCD and 8 categories of plasma televisions (EESS 2005). The Japanese test procedure assumes 4.5 hours use per day with the balance of the time in passive standby mode. The on mode energy consumption is determined using a set of static test patterns. The Top Runner program also has associated with it a label which shows the performance of the product relative to the current Top Runner target (percent below or exceeding the target). An orange label shows that the product does not comply with the requirements and a green label indicates that the product exceeds the requirements.

In Korea the government has released its plan titled Standby Korea 2010: Korea’s 1-Watt Plan. Initially this comprises a local endorsement labeling scheme within Korea (also called Energy Boy) and is administered by KEMCO (Korean Energy Management Corporation). By 2010 many products move from a voluntary endorsement framework to mandatory requirements. Televisions are included in the proposed 1 Watt program for 2010 (KEMCO 2005). All television types have a voluntary target of 1 Watt for passive standby and off modes up to 2009 (eligible products may carry the Energy Boy label) and this 1 Watt target becomes mandatory in 2010.

Australia has also announced its intentions to introduce mandatory MEPS and possibly energy labeling for televisions (EnergyConsult, 2004). This will be based on a maximum permitted EEI. The program is being delayed while an international test method is finalized.

The remaining energy programs which cover televisions are voluntary in nature. These are summarized below.

Group for Energy Efficient Appliances, Europe: GEEA has an endorsement label for televisions. To qualify, the EEI must be less than 0.75.

Voluntary standby targets, Europe: In 1997 European Association of Consumer Electronics Manufacturers (EACEM) entered into a voluntary agreement with the European Commission to voluntarily reduce the sales weighted passive standby power of televisions. When EACEM was merged with EICTA, an updated agreement and targets were set for 2005 and a 1 Watt maximum for all new design products was set for 2007.

European Eco Label: Since 2002, TVs are eligible for the EU Eco label if they meet a range of criteria, which includes in-use and standby energy consumption criteria as well as use of natural resources, recycling and environmental damage or risks related to the use of hazardous substances. Targets include a maximum 1 Watt passive standby and an EEI of 0.65.

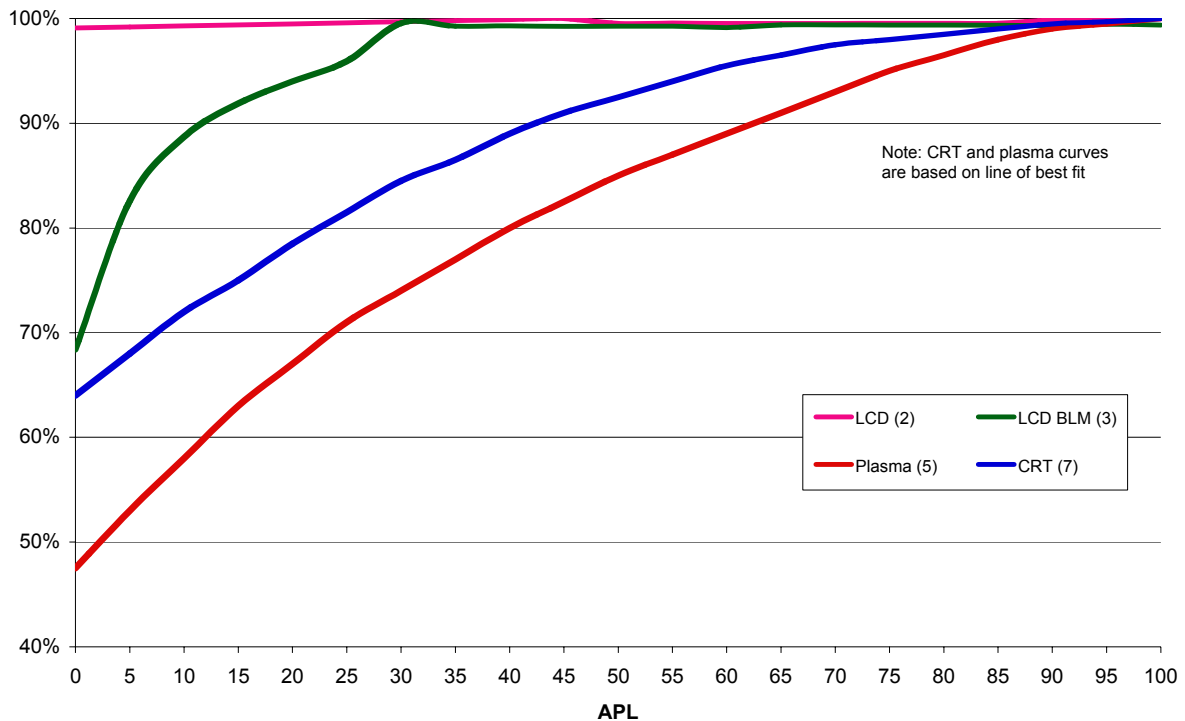
International Energy Star: Energy Star is an international endorsement labeling system. Energy Star criteria for televisions cover only standby requirements and these are well established and used widely in many partner countries (except Europe). Since 2005 televisions

must not exceed 1 Watt in passive standby mode to qualify. The US Environmental Protection Agency is interested in developing on-mode criteria for televisions and is participating in international developments in this area.

Developments in Test Procedures for Televisions

Before a product like a television can be regulated for energy labeling or efficiency standards (MEPS), a test procedure must exist that covers all of the main technology types. The International Electrotechnical Commission (IEC) test procedure IEC62087 defines a method for the measurement of on-mode energy consumption and low power modes such as passive standby and off-mode for televisions. However, this method was developed more than 20 years ago and is conceived around a standard analogue CRT device. In terms of active power energy consumption, it has little relevance for most flat panel technologies and products that have a digital input and/or digital picture processing. So a new approach is being developed to address the energy consumption of televisions across technology types.

Figure 5: Impact of Average Picture Level on Power Consumption by Screen Type



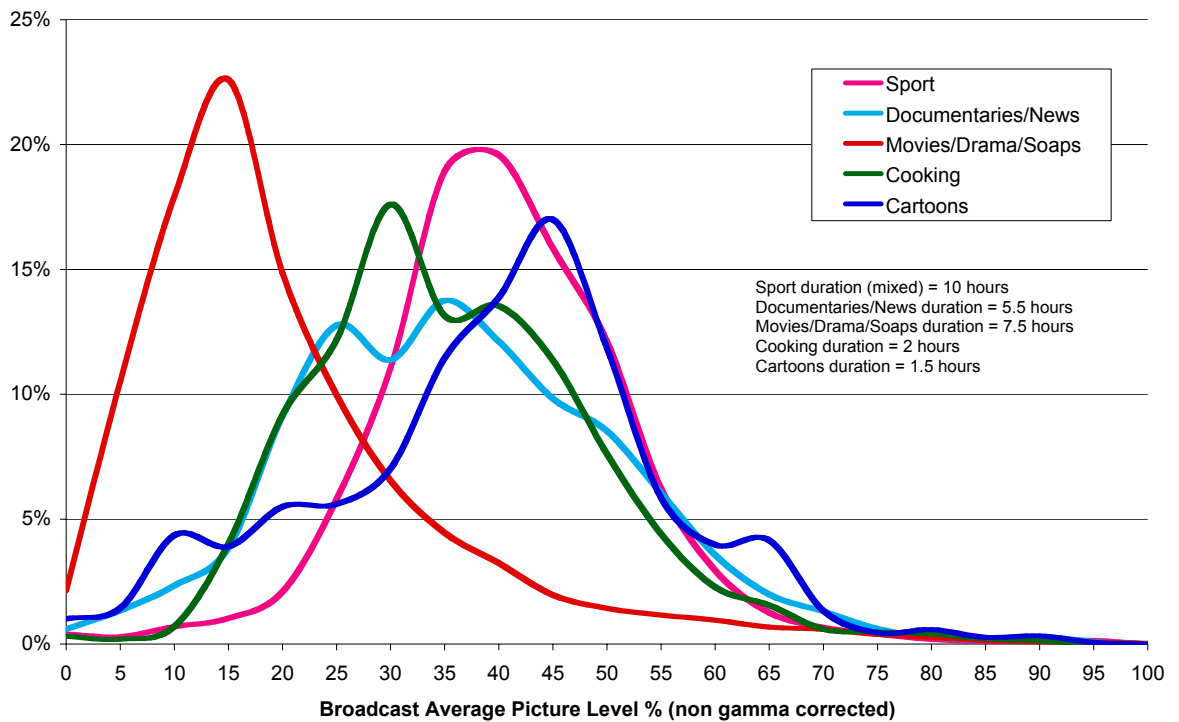
Source: In house measurements by authors of 17 televisions. Curves are indicative only and individual models may vary substantially from the curves shown. LCD BLM is LCD with backlight modulation.

As noted above, there are a number of things that will impact the energy consumption of a television during normal operation. Perhaps the most critical issue is the brightness of the

transmission or the so called broadcast average picture level (APL⁷). At a theoretical level, broadcast APL should have no impact on LCD and projection types and should only have a moderate impact of the energy consumption of CRTs. The APL is expected to have a significant impact on the power consumption of plasma screens up to a level where the automatic brightness limiting circuit starts to activate. Above this APL, the power consumption should be constant. A more in depth discussion on the issues related to and importance of picture brightness on energy consumption of plasma and LCD screens can be found in Weber (2005). A review of some test methods is provided in NRDC (2005).

Investigations on real televisions are naturally far more complex than the theory would suggest. Initial data show that energy consumption for CRTs, plasma and modulated LCD screens is both non linear as a function of APL and the brightness limiting circuit for plasma displays partially activates across a range of broadcast APLs. The varied response seems to be in part a function of contrast as well a APL, which makes measurement more complex. Average results for some 17 screens are summarized by technology in Figure 5.

Figure 6: Aggregate Broadcast APL from 50 sources - Australia



Source: In house measurements by authors of selected free to air and pay TV broadcasts, 2006.

Given the impact of APL on energy consumption for many screen types, work is under way to determine the range of typical broadcast APLs in different regions which could then be used to infer “in use” energy consumption. APLs are likely to vary by country and region and the non linear energy response of many screen types means the declaration of the on mode energy consumption of televisions could be complex (if being realistic is an objective). In Australia, the

⁷ In this context, we are referring to broadcast APL. These APLs are non gamma corrected and vary from actual filmed scene APL by a factor of a square root. For more detail see Weber (2005).

APL of free-to-air broadcasts varies from as low as zero to nearly 100 (although rarely over 70) with an average of around 33 (based on frame by frame measurements from 50 sources including drama, movies, sports, soaps, documentaries and news) – see Figure 6. It is clear that the energy response curve of a television to APL is a critical measurement in a test procedure – declaration of energy at a single APL is fraught with difficulty and is likely to favour one technology over another, depending on the APL selected.

In order to realistically determine the energy consumption of televisions it is necessary to use a moving image to ensure that the circuits responsible for the digital processing of the image and the subsequent rendition onto the screen are all active as normal. Ideally a moving image with a constant APL will enable a plot of APL versus power consumption to be determined – this will provide a generic performance curve which can be used to estimate energy consumption for any broadcast APL distribution in any country or region.

Australia, UK and the USA are undertaking joint investigations into a universal test procedure for television on mode using this approach as the basis. Proposals are well advanced and details are included in Jones (2006).

There is some work commencing in the IEC. Technical committees TC100 and TC110 have formed a joint working group to examine “TV Set Energy Consumption” (see IEC 110/66/INF at www.iec.ch).

Conclusions

Televisions have historically been ignored in terms of energy policy, mainly due to their relatively limited total energy consumption. The market in recent years is starting to dramatically transform, with an increase in screen sizes and the move to digital platforms and new screen technologies. Initial analysis suggests that the energy consumption of televisions is likely to increase substantially in the near future and that there is a large difference in the energy efficiency across different technology types and, more importantly, within each of the new technology types. With a ratio in energy efficiency index (EEI) ranging from 2 to 4 from the best to the worst products, there would seem to be ample justification now to proceed with more aggressive programs to reduce energy consumption. The most promising options are Minimum Energy Performance Standards (MEPS) and energy labeling.

Given that energy consumption of televisions has always been dominated by on-mode, it is critical that any program to address energy consumption of televisions include this mode. However, standby is still significant and also needs to be addressed. Given the magnitude of standby, it would appear that consumer information on this aspect may not be effective in reducing this further so programs such as voluntary and mandatory targets are probably warranted, despite the general improvements in passive standby power consumption over the past 10 years. Many commercial products are available now that have a passive standby power consumption of less than a fraction of a watt, so technical solutions are already feasible.

The advent of a range of flat panel technologies and digital image processing has meant that traditional test procedures for television need to be revamped. Given the energy sensitivity of some technologies to picture brightness and content, a more generic test procedure is required which can characterize the television across its normal range of operation, including the effect of any automatic brightness limiting circuitry. Good progress is being made on these aspects through international cooperation and it is hoped that details will be finalized during 2006.

The total world stock of televisions is likely to be 2 billion already, the time to act is now.

References

- ABS 2005, *Environmental Issues: People's Views and Practices*, Australian Bureau of Statistics, Catalogue number ABS4602.0, 29 November 2005. Available from www.abs.gov.au
- ACEEE 2004, Informal on standby power, ACEEE Summer Study, Asilomar, August 2004.
- APDB 2006, <http://www.d-pa.org/schedule/index.html> The Association for Promotion of Digital Broadcasting, Japan.
- Barker 2006, <http://my.integritynet.com.au/barkertv/> Victor Barker's website provides an excellent and detailed account of the early development of television technology, with a particular emphasis of the UK.
- DisplaySearch 2006, presentations and shipment data available from www.displaysearch.com
- Cyber College 2005, <http://www.cybercollege.com/tpv009.htm> provides a good explanation of the different broadcast systems and standards for televisions.
- ECCJ 2006, Top Runner program information, http://www.eccj.or.jp/top_runner/index.html Energy Conservation Centre of Japan website.
- EES 2006, *2005 Intrusive Residential Standby Survey Report*, prepared by Energy Efficient Strategies for Equipment Energy Efficiency Committee, Australia. Report 2006/02. See www.energyrating.gov.au
- EES 2005, *Final Report by TV sets and Video Cassette Recorders Evaluation Standard Subcommittee*, by the Energy Efficiency Standards Subcommittee of Advisory Committee for Natural Resources and Energy, Japan. Technical report details the Top Runner requirements for TVs, VCRs and DVD recorders in 2008 – available from http://www.eccj.or.jp/top_runner/index.html
- EICTA 2004, *Trends in Standby Power and Television Ownership*, internal report by TV Self Commitment Steering Group, European Information, Communications and Consumer Electronics Technology Industry Associations, Brussels.
- EICTA 2006, European Information, Communications and Consumer Electronics Technology Industry Associations, report library and website information. See <http://www.eicta.org/>
- EnergyConsult 2004, *MEPS Profile - Televisions*, prepared by EnergyConsult for National Appliance and Equipment Energy Efficiency Committee, Report 2004/11. See www.energyrating.gov.au
- EnergyConsult 2005, *Appliance Standby Power Consumption - Store Survey 2004/2005*, prepared by EnergyConsult for National Appliance and Equipment Energy Efficiency Committee, Report 2005/14. See www.energyrating.gov.au

ESRI 2005, *Consumer Confidence Survey*, Economic and Social Research Institute, Cabinet Office, Government of Japan.

GB12021.7 1989, *Limited values of energy efficiency and evaluating values of energy conservation for color television broadcasting receivers*, China State Bureau of Quality and Technical Supervision, see China Standardization Information Centre <http://www.china-cas.com/english/index.htm> and <http://www.cssn.net.cn> for more information (in Chinese).

Harrington and Kleverlaan 2001, *Quantification of residential standby power consumption in Australia-2001*, prepared for National Appliance and Equipment Energy Efficiency Committee. See www.energyrating.gov.au

IEC62087, *Methods of measurement for the power consumption of audio, video and related equipment*, International Electrotechnical Commission, Geneva, First Edition, March 2002. www.iec.ch

Inventors 2006, website www.inventors.com The History of TV.

Jones 2006, *Harmonising International Performance Standards and Test Methodologies for TVs and Set Top Boxes*, by Keith Jones, Paul Ryan & Bob Harrison, paper prepared for conference Energy Efficiency in Domestic Appliances and Lighting (EEDAL), London, June 2006.

KEMCO 2005, *Standby Korea 2010: Korea's 1-Watt Plan*, Korea Energy Management Corporation and Ministry of Commerce, Industry and Energy, Korea. See www.mocie.go.kr and www.kemco.or.kr

Lin 2006, personnel communication, Jiang Lin, Lawrence Berkeley National Laboratory, March 2006.

MTP 2006, Market Transformation Programme Briefing Note: Potential Saving of Power Management through HDMI, UK, available from www.mtprog.com

NRDC 2005, *Televisions: Active Mode Energy Use*, New Horizons for Energy Efficiency, Noah Horowitz (editor) with Eco Consulting (Ostendorp, Foster, and Calwell), March 2005. See <http://www.ecosconsulting.com>

Rosen and Meier 1999, *Energy Use of Televisions and Videocassette Recorders in the U.S.*, Karen B. Rosen and Alan K. Meier, Environmental Energy Technologies Division, Lawrence Berkeley National Laboratory, March 1999. See <http://eetd.lbl.gov/ea/reports>

Weber 2005, *Measuring Annual Energy Consumption of LCD-TVs and PDP-TVs*, paper prepared by Dr Larry F. Weber, 5 May 2005.