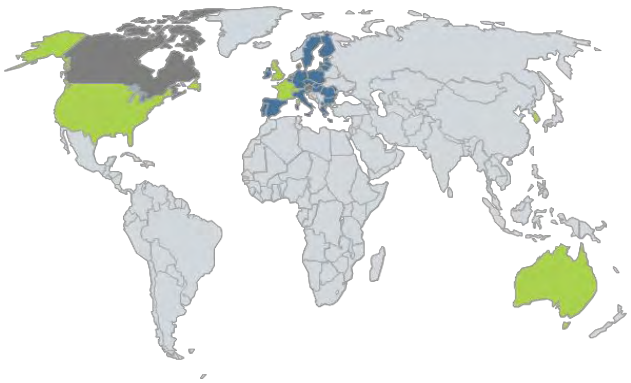
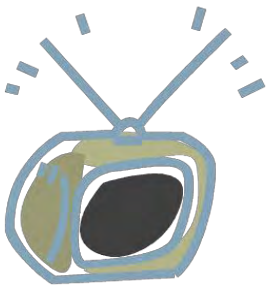
Benchmarking Document

Technology: Televisions





Participating Countries:
Australia, Austria, France, Republic of Korea, Switzerland, UK, USA

Other Regions covered:
EU15

Other Funding countries:
Canada, Denmark, Netherlands

Introduction

This document explains the overall conclusions from mapping of television performance standards in six countries, comparing trends and performance in the countries mapped. The summary definition for this product is:

'A commercially available and mains electricity powered product consisting of a display and one or more tuner(s)/receiver(s) combined in a single housing. It is designed to receive, decode and display audiovisual signals and reproduce sound from analogue sources and/or digital sources that are decoded directly broadcast via satellite, cable or antenna signals. In the case of digital sources, decoding may be via any external adaptor or receiver.'

For which segregation and analysis will done through data requested on:

- Screen size, 28cm and above covered (previous upper limit waived to ensure a more complete picture of the market)
- Aspect ratio (used to calculate screen area and so consumption per unit screen area)
- Screen technology

Excluded are:

- Combination products (i.e. with integrated DVD player, VCR player / recorder, hard drive).
- Screen sizes under 28cm
- Television monitors and computer displays

The detailed product definitions can be found at the Annex website:
http://mappingandbenchmarking.iea-4e.org/

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Benchmarking Energy Efficiency of New Televisions

Summary for Policy Makers

This is the second benchmarking report issued on televisions. The first draft was discussed briefly at the Korea project meeting in November 2009, and in more detail in Vienna in early March 2010. This second draft follows the supply of significant additional data in March/April 2010 from UK, Austria, EU15 and also adjustments to the original data for France.

This report summarises the analysis and conclusions on the nature and performance of new televisions from Australia, Austria, France, Republic of Korea, Switzerland, United Kingdom and USA, plus data for the EU15[1] as a whole.

Datasets – types and limitations

Most of the data are for 2007, 2008 and 2009 and most countries provided sales weighted data. The principal limitation on the data is that they are mostly manufacturers' declared data without any declared test methodology, which means that the energy performance analysis can only be considered illustrative. Available evidence and expert views indicate that manufacturers are currently over-declaring on mode power due to changes in test methodology over the past two years. This means that efficiency levels are probably up to 20% higher and power demand up to 20% lower than this data might imply.

Datasets from USA, Republic of Korea and Australia were derived from Government product registration schemes; data sets from the other countries were GfK[2] or other market overview sources. Only USA data were not sales weighted. As well as the GfK data, the UK also included results from testing of around 200 products over several years, but that data was only used in analysis of standby as the GfK data did not include standby information. For all other aspects the full market sales weighted data from GfK was considered more representative.

The average screen size across all types and participating countries was 82cm (diagonal) in 2009. Trends in screen size are not clear due to variability in data sets and screen technologies over time, but isolating LCD and plasma data for 2007 to 2009 implies growth of less than 3% for LCD and 2% for plasma over that period implying that growth in screen size has slowed significantly in recent years. The Republic of Korea appears to have the largest average screen size at 94cm (2008).

[1] EU15 for which GfK collected this data set are: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, and United Kingdom. It is acknowledged that the EU15 data includes Austria, UK and France, but the other countries also included in this EU15 set make it a sufficiently different data set to merit inclusion and comparison in its own right.
[2] GfK is a global commercial provider of retail product sales data from 'point of sale' (i.e. checkout data from retailers), combined with other market and performance data provided by manufacturers.

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CRT screens represent less than 5% of sales in UK, USA, Switzerland, Austria and Australia in 2008/09, but remain at just under 25% in the Republic of Korea *(robust[3])*. LCD was the dominant technology in 2009 accounting for half (Republic of Korea) to just over 90% (Austria) of new sales across the different countries.

The overall average Energy Efficiency Index (EEI) for all technologies for 2009 was 0.95 *(illustrative)*. In 2007, CRT offered the best EEI of the three dominant screen technologies with EEI around 0.8 (though from a smaller data set than LCD and plasma), compared to 0.99 for LCD and 1.28 for plasma. But efficiency appears to be improving and LCD screens of 2009 averaged EEI of 0.87, and plasma had improved to EEI 1.19 *(illustrative)*. Note: LED backlighting technology for LCD is claimed to significantly increase efficiency and was not significant on the market for the data analysed in this report. Plasma market share appears to be growing, particularly at the larger sizes, and this technology appears to have EEI over 35% higher (worse) than LCD for 2009.

On mode consumption (W) provides policymakers with the most appropriate indicator of likely national consumption and in 2009 showed an average across three countries with data of 145W *(illustrative)* for new sales, varying from 141W (UK) to 152W (Austria, 2009) (*illustrative*). Average on mode consumptions for new televisions by technology are: CRT 74W (2007); LCD 134W (2009); plasma 287W (2009) (*illustrative*).

Standby consumption has fallen from an indicative average of 4.4W in 2000[4] to 0.6W in 2009[5]. Austria, Switzerland, UK and Republic of Korea appear to have been on track to achieve less than 1 W standby in 2010 (*indicative*), with others possibly reaching the same level but this cannot be proven by available data. Some national policies (Republic of Korea, USA) have directly addressed standby consumption for televisions over many years. However, much higher consuming (non-default) standby modes are becoming available, for example to enable rapid start (examples found include over 17W consumption for this mode).

Data did not allow conclusions to be drawn on the effectiveness of voluntary energy efficiency label schemes in UK, USA and Australia. As data availability and quality improves in these and other countries introducing voluntary and mandatory policies, this analysis should become possible.

[3] Datasets in this analysis have been assessed as robust, indicative or illustrative. For definitions of these terms please refer to page 11.
[4] Only data for Switzerland and UK available for that year.
[5] Only data for Austria available for 2009.

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The key issues identified for policy makers are:

- **Growth in screen size *(robust)***: Swiss longer term data implies a growth in screen size diagonal of over 40% from 2000 to 2008 which equates to double the screen area, and 60% higher on mode power. Growth of diagonal has slowed to around 4% from 2007 to 2009 (indicative) for new sales which would add some 7% to energy consumption for the same usage and efficiency[6].

- **Market share of large plasma screens:** The average new plasma screen consumes twice the power of the average new LCD screen *(illustrative).* Plasma screens have established varying market shares in different countries (between 8% and 30%). Insufficient data were available to conclude trends reliably, but interestingly in Austria plasma market share fell from 10% to 8% from 2008-2009. Since plasma screens had average on mode power rating over twice that of LCD in 2009, and efficiency of plasma screens appears at least 35% poorer than LCD screens for new sales, a trend towards more plasma screens would seem likely to significantly increase consumption *(illustrative)*. Efficiency of plasma screens is showing signs of improvement from 2008 to 2009 *(illustrative)*.

- **New and emerging technologies** are improving energy efficiency and could offset the impact of increasing screen size, most notably LED back-lit LCD screens and OLED screens, but also modulating backlit LCD, and SED screens. These should also enable the setting of ambitious MEPS. Other new features are also appearing: Additional tuners built-in, e.g. for high definition terrestrial reception, might add between 1 W and 5 W in on mode; Web/Internet enabled televisions (Internet protocol television, IP TV) should add no more than 1 W per LAN socket in on mode power; 3-D television is emerging but those based on plasma screens should not significantly increase consumption over standard plasma screens, whilst other 3-D technologies may have more impact.

Potential areas that policy makers might consider investigating include:

- Availability of **better quality performance data** according to the internationally recognised test methodology IEC 62087 edition 2, matched with sales to facilitate market monitoring and emissions forecasting. This should include tracking on mode power (W) and the associated test methodology used, as well as an efficiency metric such as Energy Efficiency Index (EEI, as proposed to be used in Europe for energy labelling of televisions from 2011).

- To monitor the availability and prevalence of **high consumption alternatives to standby mode**, such as ‘rapid start’, and ensure that they do not fall outside the scope of current policies.

[6] Energy consumption is proportional to the screen *area*, not screen diagonal (squared relationship to diagonal).

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- To monitor consumption of **emerging functionalities** such as Internet enabled televisions, televisions with multiple tuners etc and ensure that these do not inflate national emissions nor fall outside the scope of current policies.
- As the control of total product consumption is likely not to be possible, policy makers could consider policy based on **consumption caps** or efficiency thresholds becoming significantly more demanding at higher screen sizes, to constrain overall consumption.
- To ensure an appropriate level of consistency in policies that impact television efficiency compared to policies that impact computer displays and television monitors (i.e. screens sold without television tuners).

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Table 1. Summary table of demographic issues on televisions for new sales

Aspect	Global trends, local variations
Screen size *(robust)*	Overall average screen size (diagonal, 2009 data unless otherwise noted) of new sales varied from 78cm (EU15), to 82cm (UK), to 85cm (Austria) and 94cm (Republic of Korea, 2008), with an average of 82cm (USA data excluded). Average sizes: CRT 54cm (2008); LCD 78cm (2009); Plasma 112cm (2008 and 2009). **Recent trend:** Variations in data available for each year and variations in the proportion of the market accounted for by each technology results in no clear trend for screen size. A straight average of all available data from 2007 to 2009 indicates small variation in average screen size (with a small rise then smaller fall), with different sets present in each year. Analysing each technology separately, and isolating only the data sets that are consistent over 2007 to 2009 indicates a rise of less than 3% for LCD screen size and rise of around 2% for plasma screens over that period.
Screen technology *(robust)*	Typically over four fifths of sales are LCD screen, and this varies from 47% (Republic of Korea) to 92% (Austria). Plasma accounts for between 6% (UK) and 30% (Republic of Korea, Australia) with an average of around 16%. Just under one quarter of sales remained CRT in Republic of Korea (2008); CRT sales are 5% in UK, 3% for EU15 and negligible for Australia, Austria and Switzerland. Other technologies were not consistently recorded. **Apparent trend**: CRT has been widely displaced by LCD, with plasma now growing from a smaller base, particularly for larger screens.
Televisions per household *(not graded for robustness)*	Government assumptions for this varied between 1.35 (Switzerland) and 2.86 (USA). **Trend**: All countries with historical data show a significant increase (1.82 to 1.93 (10 years) Australia; 1.37 to 1.48 (11 years) Republic of Korea; 1.84 to 2.24 (10 years).
On hours per day *(not graded for robustness)*	Government assumptions for this varied between 3.7 hours (Switzerland) to 7.3 hours (Australia). **Recent trend:** Anecdotal evidence suggests that the estimates made of viewing hours are not robust, and so no clear trends can be deduced.

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Table 2. Summary table of energy performance issues on new televisions.

Aspect	Global Trends, local variations
On mode consumption (W) *(illustrative)*	Average country on mode consumption varied from 141W (UK and EU15, 2009) to 152W (Austria, 2008) with an average 145W in 2009. USA data showed 132W product-weighted average but this is ENERGY STAR data and so skewed towards better products. Lowest on mode power are 16W (UK, 2009, 36cm LCD screen); highest on mode power are 750W (UK, 2009, 160cm plasma screen). Average on mode power figures are: CRT 74W (2007); LCD 134W (2009); plasma 287W (2009). **Recent trends**: Recent trends are mixed and incomplete data makes trends harder to discern. Most recently, isolating the three countries with data for both 2008 and 2009 reveals a **fall** of 7% in average power overall, and 8% fall for LCD, and 13% fall for plasma screens. Previous to that, isolating the data sets consistent from 2007 and 2008 (eliminating USA as inconsistent, and Australia as incomplete) shows a 9% **rise** overall, with a 4% rise for LCD and a 7% rise for plasma. The most recent fall is consistent with expectations based upon increased regulatory and consumer focus on energy consumption.
Efficiency (W/dm^2) ***(lower figure means more efficient)*** *(illustrative)*	Average country sales weighted energy consumption per unit screen area varies from 4.79 W/dm^2 (UK, 2009) to 5.9 W/dm^2 (EU15, 2008), with an average of 5.3 in 2008 (with 4 data points). Note: LED backlighting technology is claimed to significantly increase efficiency of LCD screens and was not significant on the market for the data analysed in this report.

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(Table 2 continued)

Aspect	Global Trends, local variations
Energy Efficiency Index (EEI) **(Lower EEI means better efficiency)** *(illustrative)*	Sales weighted average EEI (USA data excluded) was 0.95 for 2009. Overall average EEI for 2008 ranged from 0.99 for Switzerland to 1.05 for EU15 (USA was 0.69 for the ENERGY STAR data set). France showed EEI of 1.19 for 2007. Best individual product found was EEI of 0.26 for a 56cm LCD in USA, with the best plasma EEI of 0.63 for a 106cm screen in USA. Worst individual product was EEI 2.46 (for 94cm plasma in UK). Note that only USA and UK data allowed identification of individual products; see *Additional Notes on Data Analysis*, point 6, below for further explanation. Average for 2008 (USA data excluded) was EEI 0.95 for LCD and 1.4 for plasma, with 2009 showing EEI 0.87 for LCD and 1.19 for plasma (so plasma is over 35% worse than LCD on this metric). **Recent Trend:** Isolating the datasets that are consistent for 2008 and 2009 **(**UK, Austria and EU15) shows an improving average EEI across all screen technologies from 1.03 to 0.95, an 8% improvement. Previous to that, 2007 to 2008 shows negligible change of EEI (with USA data excluded as it is inconsistent between these years).
Standby (W) *(indicative)*	The most data were available for 2007, for which the average was 1.5W, on a clear downward trend from 4.4W in 2000. The most recent data for Austria, Republic of Korea and UK shows achievement of standby of less than 1W. The Australian average was 1.4 W in 2008. **Trend**: Overall trend appears to be towards levels below 1W in 2010, although evidence does not prove this for France, Australia and USA (although the ENERGYSTAR models' average is below 1W). Examples of standby consumption of 31W (USA, 2007), 25W (UK, 2002) and 17W (Australia, 2007) had disappeared by 2009. But examples are emerging of higher (non-default) 'rapid start' standby modes that consume over 17W for certain products.

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Principal limitations on analysis and datasets

The first analysis process in October-December 2009, used data from six countries (Australia, France, Republic of Korea, Switzerland, the UK and the USA). But no two countries' datasets were sufficiently similar in source or nature to make comparison worthwhile. Substantial additional data sets from GfK were made available in March/April 2010 for UK, Austria and for the EU15[7] set of countries, plus additions / clarifications for Switzerland and a correction to some source data for France. It is acknowledged that the EU15 data includes Austria, UK and France, but the other countries also included in this EU15 set make it a sufficiently different to merit inclusion and comparison in its own right. This second analysis of April/May 2010 presents findings from a more consistent, comprehensive and up to date data set than the first analysis.

The principal limitation overall is that for the data sets from Austria, France, UK, EU15 and Switzerland there is no test methodology declared, and it is manufacturers' declared data (see below). This means that results can only be considered 'illustrative' (rather than 'indicative' or 'robust' – see definitions on page 11).

The new data sets can be characterised into four distinct types:

1. Four of the eight data sets were derived from GfK market sales data representing full or close to full market sales for the country, with manufacturers declared performance data for Austria, France, UK and also for the EU15. Swiss data was derived from a manufacturers' trade association using sales weighted performance data. Available evidence suggests that all five of these data sets should be fully representative of the markets in those countries and should be comparable with one another (exceptions noted below). Associated issues include:

    - No data for individual products, so no best and worst products can be identified (except for the UK data set where the granularity allowed particular screen sizes and consumptions to be discerned)

    - Product performance for France and Switzerland had to be inferred from market research statistics on numbers of products falling into certain ranges of screen size and consumption levels. This leads to possible inaccuracy of efficiency analysis. Efficiency statistics calculated from the source data by the data supplier were used for the UK and EU15 analysis, so this should be of good accuracy to the source data.

    - Swiss data combines LCD and plasma screens into a single category ('flat screens'). It has been assumed that LCD account for the vast majority of these up to 2005 and so this data has been plotted with LCD data for other countries. Beyond this date, the plasma screens would become a significant minority (likely of the order of 5% to 10%) and so likely to distort the results

[7] EU15 for which GfK collected this data set are: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, and United Kingdom.

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for LCD. Swiss data for flat screens of 2006 and beyond has not been plotted on LCD energy performance graphs, nor included in calculations of averages.

- The most recent data available for France was 2007. This is particularly significant due to the rapid pace of change of television technology and markets in the past few years.
- The declared on mode consumption is based on a test methodology which is not reported, and is manufacturer declared data. Anecdotal evidence implies that manufacturers have traditionally declared the maximum consumption for electrical safety, often measured at full volume and brightness but bearing no consistent relationship with current laboratory energy efficiency test results (to IEC 62087 Ed 2). Data is likely therefore to over estimate consumption and underestimate efficiency.

2. Australian data was from a Government product database listing virtually all products sold, but lacked complete energy performance data. The energy data included is, however, from laboratory testing carried out on behalf of the Government. Only around 4% of products had energy performance data, 171 products representing 23% of sales in 2007 and <1% in 2008. It is not known how representative the performance data from the Australian set is of the actual market, but with such low coverage for 2008 the data is not representative and has not been plotted on the graphs, nor included in the calculations of averages. Comparisons with other countries should be treated with caution.
3. The USA data was from the ENERGY STAR database for 2008 and 2009 and so represents only the more energy efficient products on the market in those years (likely to be the top 25% to 50% of the market, more in 2009 than in 2008), and contains no sales data. The data from 2007 is from a more comprehensive snapshot of the market gathered as part of research to set the ENERGY STAR criteria for the scheme in 2008, but also contains no sales data. USA efficiency data for 2008 and 2009 cannot be fairly compared with the first or second groups above (other than cautiously on trends for 2008 to 2009), but comparisons with 2007 USA data could at least be illustrative.
    - Worst products and averages are not representative of the whole market, and should not be compared with other data sets.
    - Only product weighted analysis is possible.
4. The data for the Republic of Korea was from a Government database primarily set up to monitor standby consumption and fully representative of the market, including sales data, but no on mode power data was available and so no energy performance analysis was possible other than for standby which is fully comparable with other data sets.

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Note: In addition to GfK data, the UK also supplied laboratory tests results from some 250 products over a period of five years, and also outputs of sophisticated Government product stock models derived from many and varied data and expert views. Since the test results data sets were not representative of the whole UK market, their averages were not consistent with the UK model data. The test data was used in the analysis of standby (as standby was not included in the UK GfK data); the UK model data has not been used in the analysis.

Important Cautions for Interpreting Mapping and Benchmarking Information – Grading of conclusions for robustness

The aim of the Mapping and Benchmarking Annex is, within a defined set of resources, to provide policy makers with high level information to facilitate strategic decision making and/or to enable them to target further resources to investigate specific areas of interest. Grading of the outputs is provided so that policy makers can understand the relative reliability of outcomes and recommendations.

The data gathered by the Annex for analysis is necessarily from different and varied sources. In some cases sources and data quality vary significantly within a single set of information supplied for one country for a single product group. Clearly this problem is magnified when data is collected for a number of countries. Variabilities within data for one country and/or between data for different countries include:

- Scope of market covered (best to worst, product types/sub-types)
- Proportion of all sales accounted for by products listed
- Whether data is provided as market average statistics, in product sub groups (by size, technology etc.) or as lists of individual product data
- Whether data is supplier declared values, or third party tested data
- Sales weighted or no/partial sales data
- Completeness of energy and associated product performance and type data
- Whether energy data is supplied as absolute values or as energy label classifications
- Test methodology (consistency, accuracy, validity)
- Consistency between successive years (i.e. if trends are valid)

Sometimes data sets require manipulation or adjustment before they become comparable with other data from the same country, and/or with data from other countries although this has been minimised and also explained where it was judged necessary. Further, the specific approaches taken have been detailed in the overall Mapping and Benchmarking Framework, with steps specific to particular products explained in the Product Definition and in the individual Country Mapping Sheets and, where necessary, within the Benchmarking document.

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The variabilities and known flaws across the data sets have been taken into account during analysis and drawing of any conclusions. Unfortunately it is not possible within the project budget to provide sensitivity analysis to quantify how robust the data sets are. Thus, in order to provide a reader with some indication of how confident they should be in the results, the analysis and graphics within the benchmarking documents have been labeled '**robust'**, '**indicative'** or **illustrative'** according to the judgement of the analysis team. *This assessment is necessarily a professional judgement because the variabilities are complex and different in every case.*

Given it has not been possible to derive a set of water-tight definitions that can be applied to each individual case, the rationale influencing the judgement is provided in the framework below to provide some transparency:

1 Framework for Grading Mapping and Benchmarking Outputs

Assessments have been made for a country's complete data set and, if necessary, for sub-sets, e.g. television screen size data has a different assessment to television energy efficiency data as sources and reliability of data are different. It is also possible that separate assessments may be necessary for individual years of data within a sub-set, for example when different sources have been used for some years. In such cases the label reflects the majority of the data, with annotations to explain anomalies. The labeling framework is also separately applied to the conclusions or graphs comparing two or more countries' data sets.

2 For an individual country (mapping):

Robust – where typically:

- The data are largely representative of the full market and
- The data include at least a significant element of individual product data and
- The data are from known and reliable sources and
- Test methodologies are known and reliable and
- Any data manipulations are based on solid evidence and should not unduly distort results

Conclusions from such data sets are as reliable as reasonably possible within boundaries outlined above.

Indicative, where typically:

- Data sets may not be fully representative of the markets (but do account for a majority, ideally a known and understood majority) and/or
- Any data manipulation used includes some assumptions or unavoidable approximations that could unintentionally reduce accuracy

Accuracy is, however, judged such that meaningful but qualified conclusions could be

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drawn.

Illustrative – where typically:

- One or more significant parts of a data set is known to represent less than a majority of the full market or
- Test methodologies used to derive data are not known or
- Test methodologies used to derive data are known but could lead to significant differences in outcome or
- Data manipulations for the analysis contain an element of speculation or significant assumption or
- Conflicting and equally valid evidence is available

Rather than being rejected completely, perhaps because the flaws in the data are at least consistent, such data could provide some insight into the market situation and so is worth reporting, but results must be treated with caution.

3 For comparison between countries (benchmarking):

Robust – where:

- The data sources being compared are each largely 'robust' and
- No data manipulations for benchmarking were necessary; or if manipulations were used they were based upon solid evidence and should not distort results.

Conclusions from comparisons within and between such data sets are as reliable as reasonably possible within boundaries outlined above.

Indicative – where:

- Data sets being compared are themselves only 'indicative' and/or
- Any data manipulation used for benchmarking includes some assumptions or unavoidable approximations that could unintentionally reduce accuracy and/or
- For any other reason(s) subsets of the data may not be strictly comparable which leads to some distortion

However, accuracy is such that meaningful but qualified conclusions could be drawn.

Illustrative – where:

- One or more significant parts of the data sets are themselves 'illustrative' and/or
- Data manipulations for the benchmarking process contain an element of speculation or significant assumption

Rather than being rejected completely, perhaps because the flaws in the data are at least consistent, such data could provide insight into the market situation and so is worth reporting, but results must be treated with caution.

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Grading of country data for televisions

Using the framework described above, the data on television performance has been graded as follows:

Country / region	Screen size	Screen Type	Energy Efficiency
Australia	Robust	Robust	Illustrative
Austria	Indicative	Robust	Illustrative
France	Indicative	Robust	Illustrative
Republic of Korea	Robust	Robust	N/a
Switzerland	Indicative	Robust	Illustrative
UK	Robust	Robust	Illustrative
USA	Illustrative	Illustrative	Illustrative
EU15	Robust	Robust	Illustrative

Data from Austria, Switzerland and France can only be considered indicative on screen size since assumptions had to be made on the average screen size within 'buckets' of data. All data is illustrative on energy efficiency because test methodologies are not specified, combined with incomplete market coverage for Australia, and no sales weighting for USA data. USA screen type data is only illustrative as it is not sales weighted, and represents an incomplete picture of the market (ENERGY STAR data that is only for the more efficient products on the market).

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Additional notes on data analysis

1. No data manipulation has been carried out to adjust for variation in test methodologies (which are not known for all GfK data). This is because no reliable rule of thumb could be ascertained to convert from, for example, manufacturers' declared data (see above) to the IEC 62087 edition 2 test methodology results.

2. Similarly, no adjustment has been made for variation in power supply voltage or frequency as this was not considered necessary (power consumed by, and efficiency of some types of electric motors are affected by frequency, this is not the case for consumer electronics).

3. Energy efficiency (W/dm^2) was calculated from the submitted screen dimensions and on mode power consumption. In some cases an average efficiency had to be calculated from a market average on mode consumption divided by a market average screen area (leading to inevitable uncertainties on accuracy). Energy Efficiency Index was subsequently used instead of simple efficiency – see 5 below.

4. 'Product-weighted' data is derived from a simple listing of products available on the market or products tested in the lab – i.e. with no sales weighting. 'Sales weighted' data reflects the proportion of products actually sold. *Note that the sales weighting of data for Australia for energy performance is based upon a highly incomplete market sales data set.*

5. The analytical approach proposed in the Product Definition[8] document was changed in two respects during analysis:
   a) Although W/dm^2 is widely used as an efficiency metric, it does not fairly compensate for inevitable differences of efficiency between small and large screen sizes. An alternative metric was therefore adopted: The Energy Efficiency Index (EEI)[9] that has been developed for the imminent European energy label[10]. Whilst this is not used globally, it is easily calculated from the data available and provides a useful metric for benchmarking.
   b) In some cases differences and changes in mix of screen technology between countries were masking trends in consumption, efficiency and screen size. The data for each country was therefore disaggregated into the screen technologies (LCD and plasma, with limited analysis of CRT; insufficient data were available to analyse any other screen technologies).

6. Identifying best and worst products (as quoted in table 2): Only the UK and USA data sets enabled identification of individual products, and as USA data was ENERGY STAR it could not be used to identify any 'worst products'. Hence this cannot be considered a global perspective on best and worst products. In addition, the data sets indicated initial best and worst products for which the EEI's were not credible, based on an independent expert view of what the very best plasma screen

[8] See http://mappingandbenchmarking.iea-4e.org/matrix?type=product&id=2
[9] EEI = (on mode consumption in Watts)/(20 + 4.3224 x screen area). Where screen area is in dm^2 (1 dm^2 = 100 cm^2).
[10] EU energy labelling for televisions is under development, expected to take effect in late 2010 or early 2011. Draft documents have been made available as part of the consultation process.

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technology of 2010 is capable of. Hence three plasma products with apparent EEI better than 0.3 were ignored. For LCD screens EEI 0.26 (the best product identified in the data set) was considered feasible. For the 'worst products', isolated outliers over EEI 3 were considered erroneous and ignored (the data set did not enable the usual 'bottom 5th percentile' approach to determining worst product performance).

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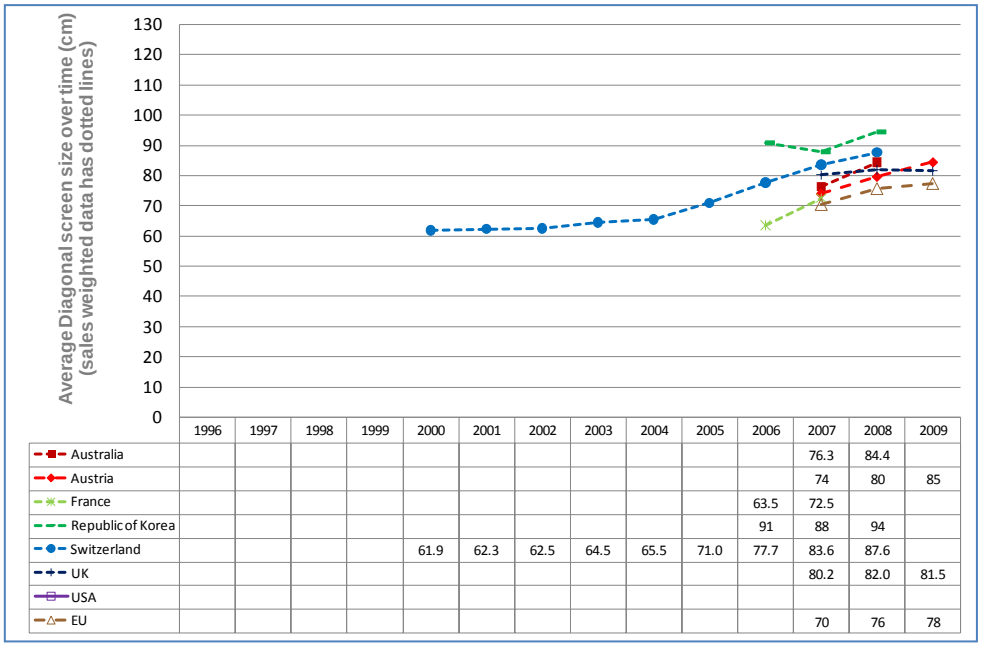
Demographics - how the nature of products and their usage is changing

Key issues arising from the demographics are summarised in **Table 1.**

Screen size (indicative)

See Figure 1. The size of the screen is a very important aspect from an energy point of view since consumption in on mode is proportional to the screen area. Swiss longer term data implies a growth in screen size diagonal of over 40% from 2000 to 2008 which equates to double the screen area, and 60% higher on mode power. Overall average screen size (diagonal, 2009 data unless otherwise noted) of new sales varied from 78cm (EU15), to 82cm (UK), to 85cm (Austria) and 94cm (Republic of Korea, 2008), with an average of 82cm (USA data excluded). Average sizes by technology are: CRT 54cm (2008); LCD 78cm (2009); Plasma 112cm (2008 and 2009).

Variations in data available for each year and variations in the proportion of the market accounted for by each technology results in confused trends for screen size. A straight average of all available data from 2007 to 2009 indicates a small rise followed by a smaller fall, with different sets present in each year. Analysing each technology separately, and isolating only the data sets that are consistent over 2007 to 2009 indicates a rise of less than 3% for LCD screen size and rise of around 2% for plasma screens over that period, which is equivalent to an increase in annual energy consumption (if other factors remain equal) of around 4% to 6% for all products sold. Growth in screen size therefore appears to have slowed significantly in the past two or three years.



	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Australia												76.3	84.4	
Austria												74	80	85
France											63.5	72.5		
Republic of Korea											91	88	94	
Switzerland					61.9	62.3	62.5	64.5	65.5	71.0	77.7	83.6	87.6	
UK												80.2	82.0	81.5
USA														
EU												70	76	78

Figure 1. Graph of average diagonal screen size (cm) over time, for all screen technologies (indicative). Data for USA removed as it is not sales weighted.

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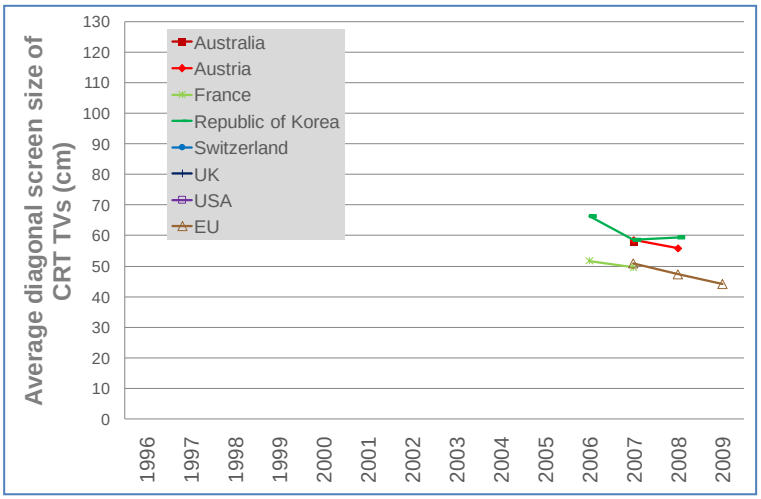
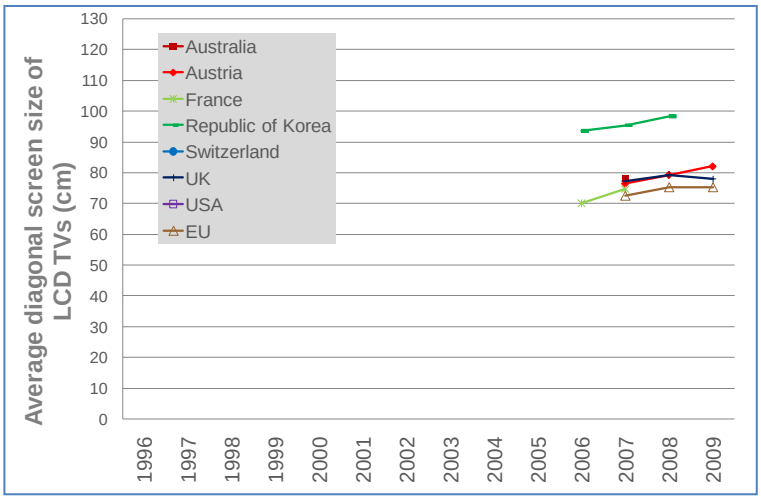
Note that Australian data for screen size is fully populated (unlike the on mode power data) and so can be included for these screen size graphs.

Figure 2 CRT screen size (indicative).



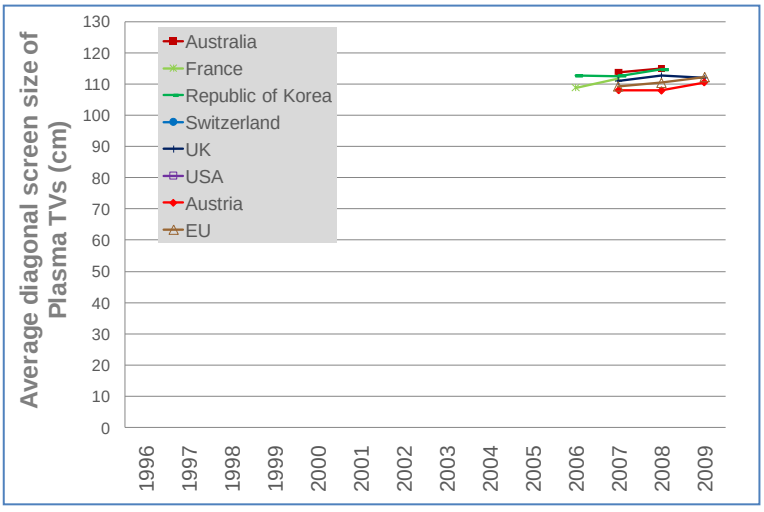
CRT screens represent less than 5% of sales in UK, USA, Switzerland, Austria and Australia in 2008/09, but remain at just under 25% in the Republic of Korea and France. A trend was apparent for CRT screens becoming smaller, dropping between 5% and 10% between 2006 and 2008. This is consistent with them being latterly used as secondary televisions (in the kitchen, bedroom). The 2007 average screen size was 57cm (the year for which most data is available).

Figure 3 LCD screen size (indicative).



Data indicates a trend for slightly increasing screen size, of only around 1% (when isolating data that is consistent between 2006 and 2008). USA data for 2008 and 2009 is not shown as it is not representative of the full market. LCD technology development has enabled larger and larger screens and so this trend is likely to continue, competing with plasma screens in larger sizes. The 2008 average screen size was 83cm, pushed up by Republic of Korea which has a market average screen size for LCD of 98cm; 2009 average (for which no Republic of Korea data was available) is 78cm.

Figure 4 *Plasma screen size* (indicative)



The average screen size was 112 cm for both 2009 and 2008. Plasma screen diagonals were around 44% larger than LCD screens in 2009, equivalent to 106% larger screen area. Growth in screen diagonal from 2007 to 2009 was 2.7% for EU15 data; 2.4% for Austrian

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data and 0.7% for UK data.

Screen technologies (robust)

Figure 5 shows market share data for participating countries and the EU15, for 2009 where available, and for 2008 for Switzerland, The Republic of Korea and Australia. No data were available on the proportion of the market that has LED backlit LCD screens, but it is widely reported that this more energy efficient screen technology is growing rapidly during 2009/2010.

The majority of screens are LCD, varying from 47% (Republic of Korea) to 92% (Austria) of sales in the markets with an average of 82%. Plasma screens vary from 6% (UK) to 30% (Republic of Korea) with an average of 16%. CRT screen technology has all but disappeared from the Australian, Austrian and Swiss markets, accounts for 5% of UK market and 3% of the EU15 market, but remains stronger at just under one quarter of the Republic of Korea market. Other technologies such as rear projection and OLED account for less than 2% of all markets. The limited data available spanning different years indicate significant growth in market share for LCD screens from 2006-2009. The current trend for plasma screen market share is inconclusive, with Austria showing a slight fall from 10% to 8% from 2008-2009 and no other data for these recent years.

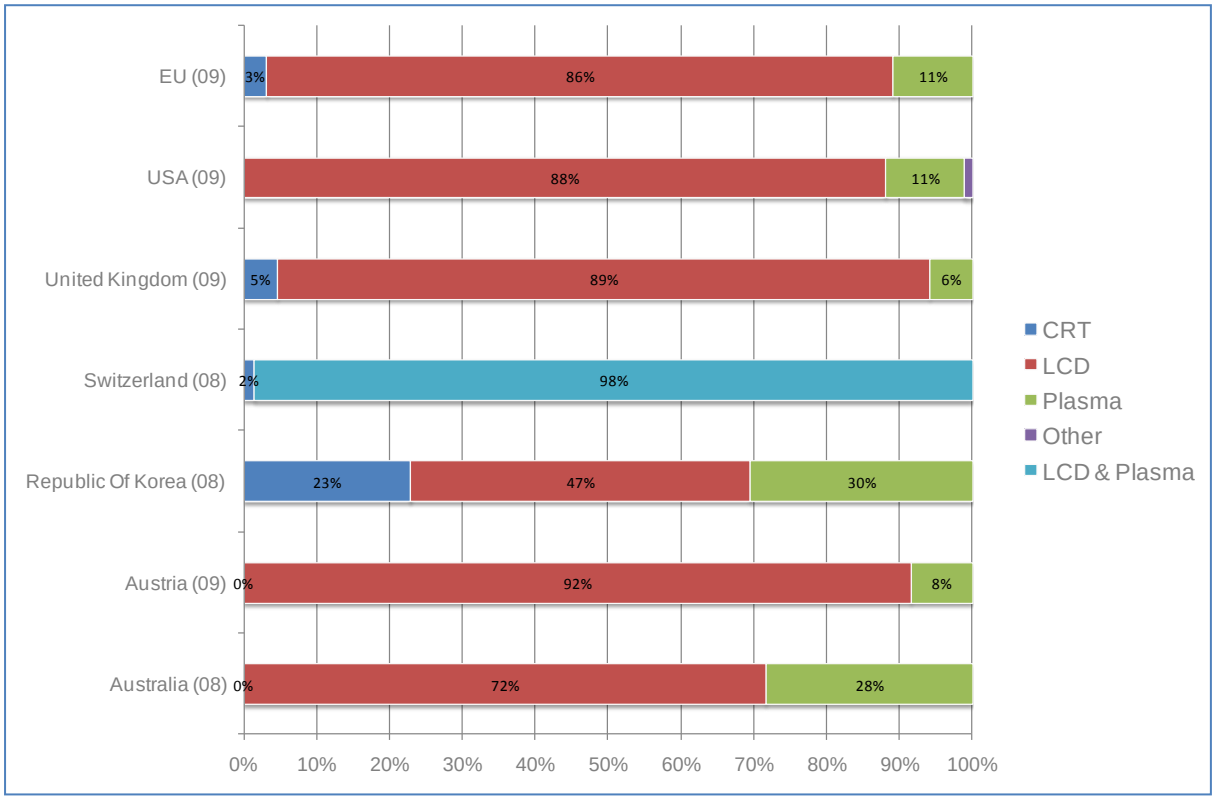

Figure 5. Market breakdown of screen technologies for new televisions. USA data is product weighted only, others sales weighted (robust).

Note: For Switzerland plasma and LCD data were combined. French data is not shown as it is from 2007 and so is no longer representative alongside more recent data.

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Televisions per household (not graded for robustness)

Government assumptions for the number of televisions present in each household vary from 1.28 (Austria) to 2.86 (USA), see Table 3. These are the figures reported as adopted by each Government / agency for its own analysis (various published reports identify (alternative) figures for several countries, but these are figures adopted / recognised by the country representatives for this project). Very little underpinning evidence (e.g. whether from household survey or estimate based on sales/lifetime) was available for these viewing hour data and so assessment of overall robustness was not possible.

Table 3. Number of televisions per household (not graded for robustness).

	UK	USA	Australia	Switzerland	Republic of Korea	Austria	France	Simple Average across countries
Televisions per household	2.24	2.86	1.93	1.35	1.48	1.28	no data	1.86
Year	2009	2009	2008	2007	2008	2007		

Viewing hours per day (not graded for robustness)

Government assumptions on viewing hours per day varied from 3.72 (Switzerland) to 7.3 (Australia), see Table 4. Note that the number of hours that an average EU television was assumed to be on for is 4 hours per day according to the EuP Preparatory Study for Televisions[11]. No underpinning evidence was available for these data and so assessment of robustness was not possible. A complicating factor is that data appears inconsistent in the approach taken (e.g. to separating primary vs. secondary televisions viewing figures).

Table 4. Viewing hours (on mode) per day for televisions in national stock (illustrative).

	UK	USA	Australia	Switzerland	Republic of Korea	France	Austria	Simple Average across countries
Assumed hours per day in on mode	4.8 primary; 2.2 secondary	no data	7.3	3.72	6.9	no data	no data	6.0

[11] EuP Preparatory Studies "televisions" (Lot 5), Final Report on Task 3, "Consumer behaviour and local infrastructure", (August 2007) Frauenhofer Institute, section 3.1.2.2 T3 page 8.

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Other new features

- Additional tuners built-in, e.g. for high definition terrestrial reception, might add between 1 W and 5 W in on mode
- Web/Internet enabled televisions (Internet protocol television, IP TV) should add no more than 1 W per LAN socket in on mode power
- 3-D television is emerging but those based on plasma screens should not significantly increase consumption over standard plasma screens, whilst other 3-D technologies may have more impact.

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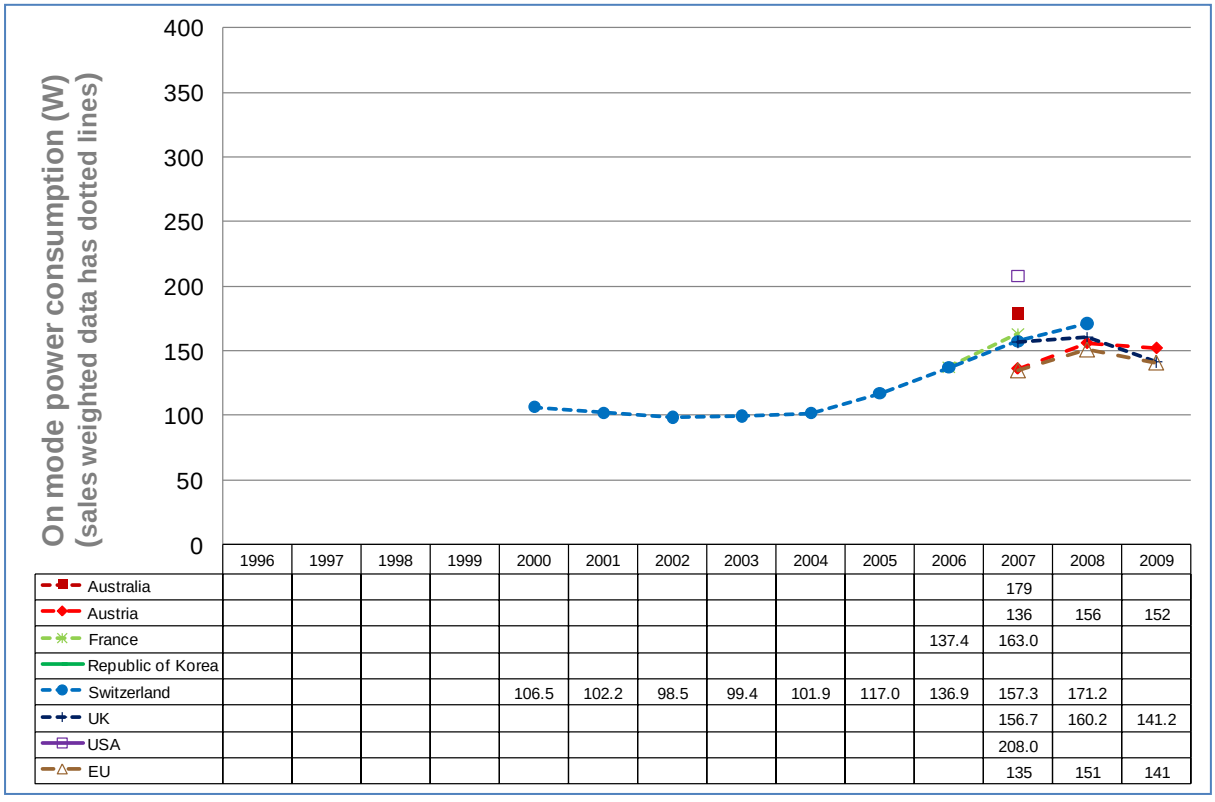
Energy performance

Key issues arising from energy performance are summarised in Table 2.

Power in on mode (illustrative)

On mode power is an important metric for policymakers to track as it is directly proportional to total consumption (whereas for example tracking Energy Efficiency Index would mask the impact of growing screen sizes on overall consumption). The size of the screen has a direct impact on power in on mode, since power is proportional to the screen area. The Energy Efficiency Index (see next section) enables direct comparison of *efficiency* of televisions with different screen sizes. The data sets have reasonable agreement on the level of on mode power, but mixed implications on trends over time. The straight numerical averages from 2000 to 2009 imply a steady growth in on mode power from 107W in 2000, peaking at 162W in 2007, falling slightly to 145W in 2009 (although these years each include different data sets). Isolating three data sets with data consistent between 2007 and 2009 (Austria, UK and EU15) implies a 9% rise from 2007 to 2008 followed by a 7% fall from 2008 to 2009. Country sales weighted averages varied from 141W (EU15 and UK for 2009) to 171W (Switzerland, 2008). Average on mode consumptions for new televisions by technology are: CRT 74W (2007); LCD 134W (2009); plasma 287W (2009) (illustrative) and thus the average new plasma television can be expected to demand over twice the power of the average new LCD television.



	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Australia												179		
Austria												136	156	152
France											137.4	163.0		
Republic of Korea														
Switzerland					106.5	102.2	98.5	99.4	101.9	117.0	136.9	157.3	171.2	
UK												156.7	160.2	141.2
USA												208.0		
EU												135	151	141

Figure 6. Variation of overall average on mode power consumption (illustrative).

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Changes in on mode power will result in proportionate overall changes in national energy consumption for televisions (if all else remains equal). Other trends are apparent when looking at screen technologies separately as in the following sections.

Figure 7. *CRT on mode consumption* (illustrative).

Swiss data implies that CRT average on mode power has fallen from 107W in 2000 to 85W in 2005. The collective data show no consistent trend but changes seem small. The 2008 average, with data for four countries plus EU15, was 74W.

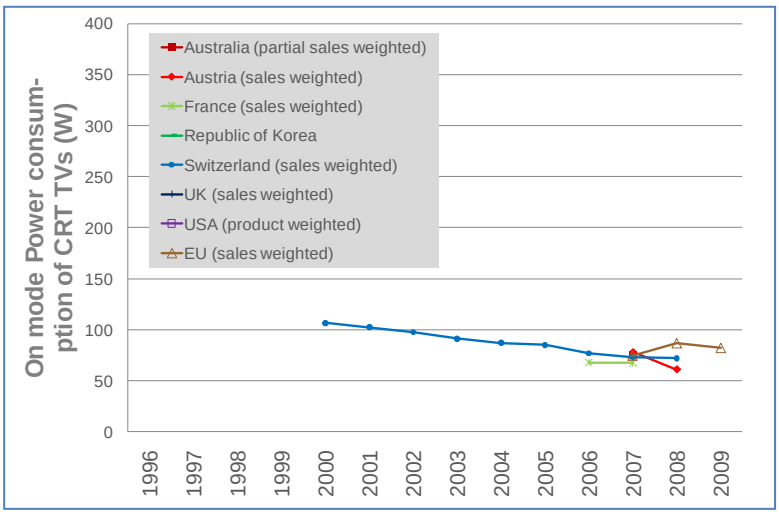

Figure 8.* LCD on mode consumption *(illustrative)

Average on mode consumption in 2008 was 146W, falling by 8% to 134W for 2009. UK data (high resolution GfK sales weighted data) implies an average of 143W in 2008 and 126W in 2009 – a fall of 12%.

The following data was excluded: USA data for 2008 and 2009 (ENEGYSTAR); Australia for 2008 (<1% of the market); Swiss data from 2006 and after (combines LCD and plasma products and so will be slightly skewed upwards in the latter years by the proportion of plasma on the market, likely to be less than 5%).

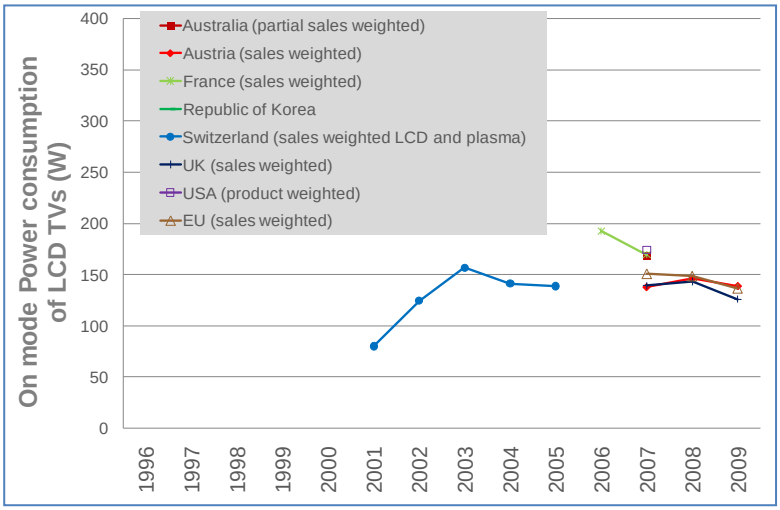

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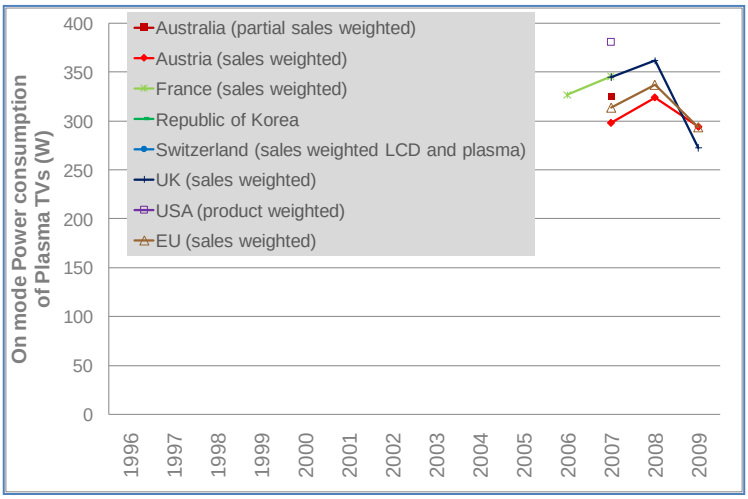
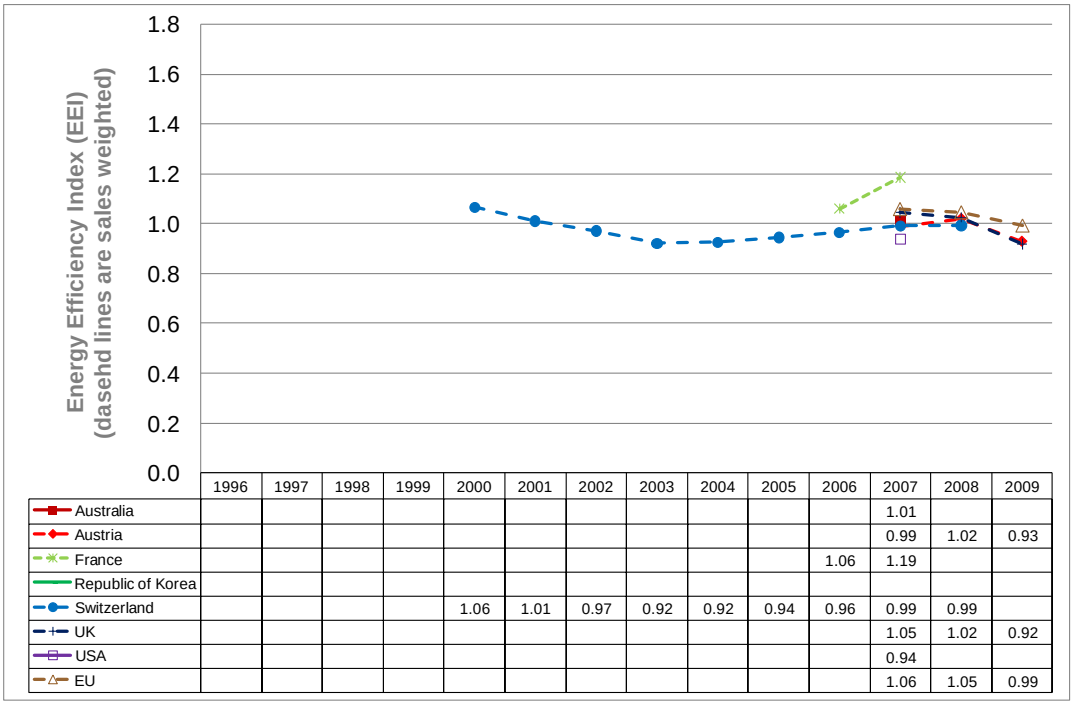
Figure 9. *Plasma on mode consumption* (illustrative)



2007 has the most data, with an average of 335W. Isolating the data sets with consistent data between 2007 and 2009 (Austria, UK, EU15) implies a rise of 7% to 341W in 2008 followed by a fall of 16% to an overall average of 287W in 2009.

Energy Efficiency Index (EEI)

This metric was developed as the basis for the European energy label for televisions and has been chosen in preference to the previously proposed W/dm^2 as it indicates overall efficiency regardless of screen size. It is calculated by comparing the product in question with a notional market average television of the same screen size[12]. Lower EEI means better energy efficiency[13], with the most efficient products indicating EEI around 0.3 and poorest over 2.



	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Australia												1.01		
Austria												0.99	1.02	0.93
France											1.06	1.19		
Republic of Korea														
Switzerland					1.06	1.01	0.97	0.92	0.92	0.94	0.96	0.99	0.99	
UK												1.05	1.02	0.92
USA												0.94		
EU												1.06	1.05	0.99

Figure 10. Average Energy Efficiency Index (EEI) for all television types (illustrative).

[12] EEI = (on mode consumption)/(20 + 4.3224 x screen area). Where screen area is in dm^2 (1 dm^2 = 100 cm^2).
[13] Note that this is not equivalent to lower energy consumption, as two televisions with the same efficiency will have different consumption if screen sizes are different.

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Historically, CRT technology appears to have achieved the best Energy Efficiency Index for 2007 of 0.78, followed by LCD at 0.99, with plasma least efficient with EEI 1.28. At this time CRT technology appeared at least 20% more efficient than the average LCD television. However, the relative efficiency of technologies has changed since 2007, given the rate of emergence of technology enhancements such as LED backlighting for LCD screens. Efficiency for LCD and plasma screens appears to be improving and LCD screens of 2009 averaged EEI of 0.87, and plasma had improved to EEI 1.19 (illustrative). Plasma still appears to have EEI over 35% higher (worse) than LCD in 2009.

Figure 11. *CRT Energy Efficiency Index* (illustrative)

Average EEI in 2007 was 0.8 (three countries Australia, Austria and France plus EU15, with France at 0.94). The jump to a worse EEI for EU15 in 2008 and 2009 is not explained, but could be a result of the smaller market share for CRT screens being influenced by relatively few products. Note that US and Australian data for 2007 are not graded for robustness as they are based on only seven televisions (most other data sets in this report are typically sales weighted, or based on more than 25 televisions).

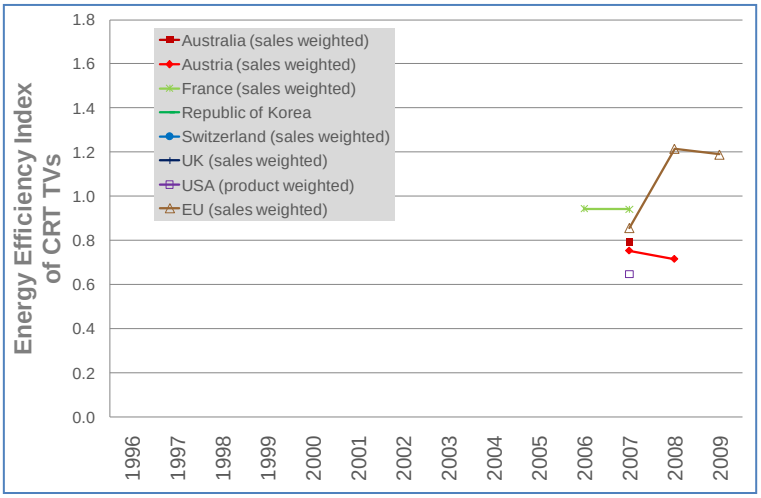

Figure 12. *LCD Energy Efficiency Index* (illustrative)

Average LCD EEI in 2009 was 0.87. Efficiency of LCD screens improved by 4% for 2007 to 2008, and by a further 8% to 2009.
Note: LED backlighting technology is claimed to significantly increase efficiency for LCD screens, and was not significant on the market before 2009.

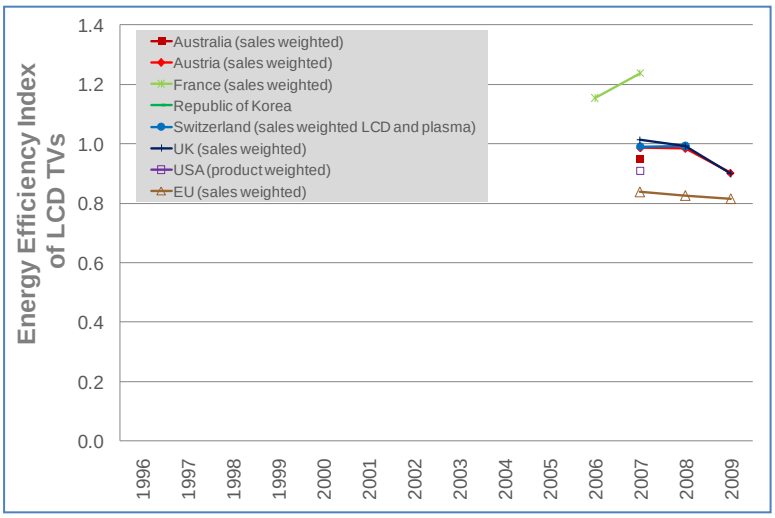

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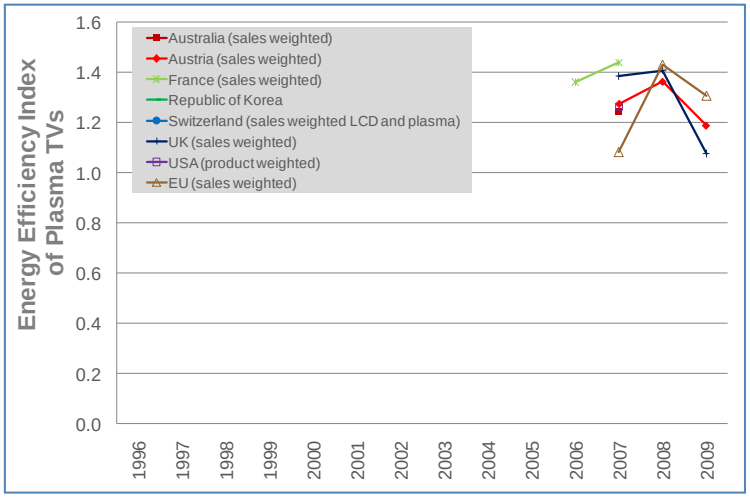
Figure 13. *Plasma Energy Efficiency Index* (illustrative)

Average EEI in 2009 was 1.19 and all three data sets of that period imply an improvement, averaging 15% from 2008 when the average was 1.4. EEI had, however, apparently become worse between 2007 and 2008.



Energy Efficiency (W/dm^2) *(Illustrative)*

This has not been analysed in detail by screen technology, having been replaced in benchmarking by the Energy Efficiency Index (EEI). However, the most data are available for 2007 for five countries plus EU15 with an average of 5.5 W/dm^2. French, Swiss, UK and EU15 data show a falling trend. The 2009 average, with only UK and EU15 data, is 5.0 W/dm^2.

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Standby *(Indicative)*

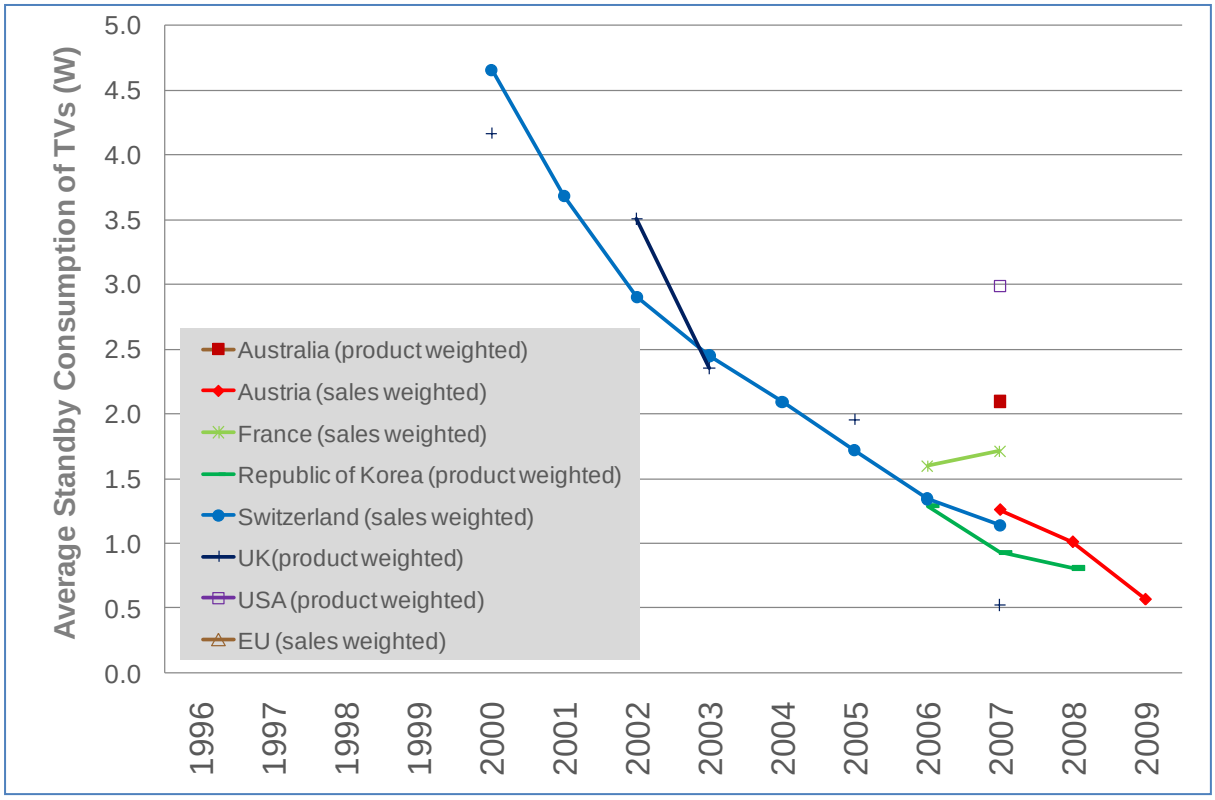

Figure 14. Standby consumption *(indicative)*

Standby consumption has fallen from an indicative average of 4.4W in 2000[14] to 0.6W in 2009[15]. The average standby consumption in 2007 was 1.5W. Austria, Switzerland, UK and Republic of Korea appear to have been on track to achieve less than 1 W standby in 2010 (robust), with others possibly reaching the same level but this is not proven by available data. Note that the data in Figure 14 for the UK are not sales weighted but from product test results provided by government sources since the available GfK data did not specify standby. USA data is also not sales weighted.

Anecdotal evidence indicates one issue to watch on standby: some recent products have a 'rapid start' mode as well as conventional standby. 'Rapid start' mode keeps the screen blank, but ready to display an image within a second or so of a user pressing the remote power button. Whilst the conventional standby mode requires less than 1 W, rapid start can require over 17 W. The wording of the European television regulation appears to address this[16] from January 2010, but this may be worth verifying (and if so, enforcing) for European and other national regulations.

[14] Only data for Switzerland and UK available for that year.
[15] Only data for Austria available for 2009.
[16] EC Regulation 642/2009 requires that the power consumption in "any condition providing only a reactivation function...shall not exceed 1.00 Watt."

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4. Policies and their impacts

Standby policies

Standby was the first energy efficiency parameter for televisions to be the subject of labelling, which appeared in 1988 in the USA under the ENERGY STAR programme. This was a voluntary scheme, as were following schemes in 1999 for Republic of Korea and 2008 in Australia. The Korean standby label became mandatory in 2008. Both Republic of Korea and Australia now have a mandatory label covering standby, and a European regulation came into force in January 2010 limiting standby to less than 1W for televisions.

Austria, Switzerland, UK and Republic of Korea appear to have been on track to achieve less than 1W standby in 2010 (robust), with others possible but not proven by available data.

On mode consumption and efficiency policies

The UK had a voluntary endorsement scheme for on mode consumption in 2006, followed by ENERGY STAR in the USA, and Australia in 2008. Australia introduced mandatory limits for on mode consumption in October 2009, and on mode consumption will be subject to a regulatory maximum in Europe from August 2010.

Mandatory maximum on mode consumption limits are under discussion for the USA state of California. The Republic of Korea will introduce mandatory energy efficiency labels (labelled 1 to 5) and MEPS (maximum on mode consumption limits) for televisions in 2012.

No clear difference between countries attributable to policies is discernible due to a spread of efficiencies across technologies and countries, although an overall trend towards higher efficiency is apparent (indicative).

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Table 5. Summary of policies in place for televisions for participating countries.

Country	Labels	MEPS	Other
Australia	Voluntary since Jul 2008; mandatory since Oct 2009.	MEPS from 1 Oct 2009 (update due Oct 2012).	None
France	None	None nationally. See EU below.	None
Republic of Korea	Voluntary label for **standby only** since 1999. Mandatory label for **standby** since 2008.	None	None
Switzerland	None	None	None
UK	Voluntary endorsement label[17] since Jan 2006 for standby and maximum on mode consumption.	None nationally. See EU below.	None
USA	ENERGY STAR endorsement label: For ***standby*** since Jan 1988; for **on mode** since Oct 2008, and updated May 2010. Criteria from May 2012 will include a maximum on mode power limit.	None nationally by 2010, but due in June 2013. MEPS for California begin Jan 2011, to be tightened in Jan 2013.	Some state / utility incentive programmes
EU	None. Mandatory energy label has been proposed, Directive is due to come into force in 2010.	2009 ecodesign regulation introduces MEPS in August 2010.	None

5. Key issues for policy-makers

National energy consumption

Whilst an evident increase in efficiency for all screen types will tend to mitigate energy consumption rises, the cumulative effect of screen size increases, more televisions per household, longer viewing hours and a shift of market share towards more plasma screens could all push total energy consumption upwards.

The following apparent trends could be influential in ***increasing*** **national energy consumption**:

- **Growth in screen size *(robust)***: Swiss longer term data implies a growth in screen size diagonal of over 40% from 2000 to 2008 which equates to double the screen area, and 60% higher on mode power. Growth has slowed more recently for all countries studied: Average screen size has increased by around 4% from 2007 to 2009 (indicative) for new sales, with an overall average screen size of 84cm in 2009.

[17] Energy Saving Recommended Scheme from the Energy Saving Trust.

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A 4% growth in screen diagonal would add some 7% to energy consumption for the same usage and efficiency[18]. The Republic of Korea and USA appear to have the largest average screen sizes at 94cm and 93cm respectively.

- **Longer viewing hours *(not graded for robustness)***: Assumptions by Governments on how many hours a typical television is in on mode vary significantly between countries, from 3.7 to 7.3 hours per day, although this cannot be graded for robustness due to no evidence on how figures are derived. More robust information on this might assist prioritisation of televisions compared to other products, but is unlikely to change the order of magnitude assumed for their consumption.
- **Slight trend towards more plasma screens *(robust)*:** The market proportion of plasma screens amongst new sales has been increasing from 2007 to 2009. In 2007 to 2009 in France, Austria and the UK, plasma has accounted for just under one tenth of sales; whereas in Australia and the Republic of Korea plasma has accounted for around one quarter of sales in 2007 and has risen to close to 30% in 2008. Since plasma screens had average on mode power rating over twice that of LCD and have EEI over 35% higher in 2009, a trend towards more plasma screens would seem likely to significantly increase consumption. Anecdotal evidence from a manufacturer trade association indicates that plasma technology will become more efficient as it is a relatively new technology compared to LCD, but it seems unlikely to match LCD in the near future. LCD efficiency is also improving.

Overall, it is **on mode consumption** that will most reliably indicate national energy consumption trends, and so it would be useful for policy-makers to track this (efficiency or EEI could be misleading in this regard as improving efficiency could accompany rising overall consumption if screen sizes also increase significantly). Any change in on mode consumption will lead to a proportional change in annual consumption, if other factors (stock, usage hours etc) remain equal. Evidence appears to indicate that on mode consumption has fallen between 2008 and 2009 by 7% for LCD and by 13% for plasma, reversing a rising trend for the preceding two years.

Note: Standby now accounts for less than 1% of the annual consumption of a typical new television, and if the historical trends apparent in these data continued then standby should be less than 1 W in 2010 in most countries. However, the emerging ‘rapid start’ mode could threaten to undermine this situation if a significant proportion of users switch to that as their default standby mode, in which product examples have been identified consuming over 17 W (illustrative).

[18] Energy consumption is proportional to the screen *area*, not screen diagonal (squared relationship to diagonal).

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Technology and efficiency issues

The most dominant factor in the energy efficiency of a television is the screen technology used. The electronics for control and tuner account for only around 20 W and this changes little with screen size. Screen size directly influences on mode consumption.

The data indicates that CRT was the most efficient technology on average in 2007, followed by LCD, with plasma the least efficient (*illustrative*). Thus in 2007 the reasonable average efficiency of CRT, combined with the smaller CRT screen sizes would have lead to a significantly lower on mode power compared to average LCD and plasma screens of the time. But screen technologies and their efficiency have advanced rapidly over recent years, with several new developments now entering the market. Recent efficiency improvements to LCD screens include a polarising filter to improve backlight efficiency by some 10%; modulating CFL backlighting (can save 30% compared to standard LCD); and LED backlighting which is more efficient still and avoids the use of mercury in the backlight. The better LCD screens on the market now appear significantly more efficient than CRT technology. The screen technologies of organic light emitting diode (OLED) and surface conduction electron emitter display (SED) have a reputation of being a possible Best Not Available Technology (BNAT), appearing to offer up to 50% energy-saving potential as well as other benefits. Hence policies may be more effective if focused on overall efficiency and/or on mode consumption, rather than addressing any specific technologies.

The emerging features on televisions include full High Definition (HD) becoming mainstream, inclusion of additional digital tuners and Internet enabled televisions (which include LAN socket, to offer YouTube, weather and recipes). But as these are low-power electronic elements, they should not add more than a few watts to mode consumption and so a policy maker who seeks to implement challenging MEPS is unlikely to inadvertently limit user functionality, especially given concurrent improvements in screen efficiency.

Issues on evidence for policy-making

This project has shown up the wide variability in quality and nature of data held by governments for televisions. Given that televisions perhaps account for between a third and a half of consumer electronics goods consumption in the home[19], better evidence for policy-making may be appropriate. The following areas could be considered for collating better evidence:

1. For policy planning, energy performance data could be fairly easily addressed now that a globally adopted and robust test methodology (IEC 62087 Edition 2) is in place, which also gives results reasonably representative of home use. Manufacturers are gearing up to deliver products that meet the minimum standards being established in several parts of the world and so good quality performance data is becoming available from most major suppliers. This will find its way into market research data (matched to sales data), as long as the demand for it is made clear to market research companies.

[19] Televisions and account for 40% of domestic consumer electronics consumption according to UK statistics from the Energy Saving Trust.

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2. Both on mode consumption and energy efficiency (perhaps usefully in the form of an Energy Efficiency Index that compensates for screen size) would be valuable to track for policymakers.

3. Whilst standby consumption appears to be almost universally less than 1 W now, any possible trends for widespread use of much higher consuming (non-default) standby modes such as ‘rapid start’ should be monitored closely.

4. The priority assigned to television consumption by governments would be highly dependent upon the assumed on hours. A better understanding of this could help improve understanding of domestic electrical consumption.

5. In order to track and understand trends which vary between different technologies, it would be advisable to collect data separately on LCD and plasma televisions, and at later stages on rear projection, OLED and other technologies as they become significant in the market.

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