# Internationally Aligned Test Methods and Performance Requirements for TVs

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**SEAD Standards and Labelling Working Group**

**Television Product Collaboration**

**APEC Expert Group on Energy Efficiency and Conservation (EGEE&C)**

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# Table of Contents

# Acronyms and Abbreviations

**ABC** automatic brightness control

**AEC** annual energy consumption

**APL** average picture level cd candela

**CEC** California Energy Commission

**cm** centimetre

**cm$^2$** square centimetre

**CRT** cathode ray tube

**DOE** United States Department of Energy

**DVD** digital video (versatile) disc

**EEI** energy efficiency index

**EU** European Union

**HD** high definition.

**HDTV** may be transmitted in various formats from 720p (~0.92 MP) per frame to 1080p (~2.07 megapixels).

**HDMI** high definition multimedia interface

**Hz** Hertz

**IEC** International Electrotechnical Commission

**IPS** in-plane switching – a type of LCD panel

**in$^2$** square inch

**kWh** kilowatt hour

**LCD** liquid crystal display

**LED** light-emitting diode lm lumens

**lm/W** lumens per Watt

**MP** Megapixels

**OLED** organic light-emitting diode

**R&D** research and development

**RF** Radio Frequency

**SEAD** super-efficient equipment and appliance deployment

**TN** twisted nematic – a type of LCD panel

**TV** television

**UHD** ultra high definition, includes 4K UHD and 8K UHD

**US EPA** United States Environmental Protection Agency

**VA** vertical alignment – a type of LCD panel

**W** Watt

**3D** 3DTV conveys three-dimensional (depth) perception to the viewer.

**4K** horizontal resolution on the order of 4,000 pixels. Sometimes used synonymously with UHD.

**8K** horizontal resolution on the order of 8,000 pixels. Sometimes used synonymously with UHD.

# Policy Maker Summary

This report presents results of an analysis undertaken in 2014 to evaluate the global differences between i) test methodologies used to measure the energy performance of televisions and ii) energy performance policy requirements for televisions. The study has a particular focus on SEAD participating countries[1] and other relevant economies. Opportunities are identified to work toward greater international harmonisation on testing and policy approaches. These include suggested refinements to test methods for greater affordability and repeatability, and a proposed policy foundation of internationally-aligned efficiency reference thresholds on which regulations and labels could be built.

## Findings from comparing test methods for televisions

A total of 6 test methods for televisions were examined in detail. The comparison between the test methods found that the largest differences between test methodologies exist between the largest markets most active in policy development, EU, USA and China. In addition, Australia was the first region to regulate TVs in 2009, and to use the maximum luminance ratio approach in their policy (see Report 4 for details).

There are two main standards for televisions that are relevant to international harmonisation efforts:

- IEC 62087, which addresses on mode testing of TVs and has a major rewrite in the process of being finalised in 2014 - The findings of this project are relevant to the subsequent revision.
- GB 24850-2013, which is the testing method used in China.

### Key findings from comparing test methods

The following key findings were drawn from the comparative analysis:

- **Test methods need constant evolution:** TV test methods need to be constantly evolving due to the rapid rate of TV technology development, to ensure the testing results are representative of actual in-home energy consumption – for example, to account for increasingly sophisticated picture optimisation algorithms and automatic brightness control functionality. For this reason, refinements have been suggested to the video signal used during TV testing (the 'dynamic broadcast-content video signal'), which is currently well harmonised across the globe.
- **Sample preparation is key:** TV sample preparation (luminance configuration) is the biggest disruptive influence on comparability of energy test results, and normalisation approaches are unlikely to be sufficiently robust to enable the results of tests carried out in many international regions (using IEC 62087) to be compared with tests carried out in China (GB 24850-2013).
- **Policy requirements add testing divergence:** Policy approaches can introduce additional variance in the application of testing approaches in some countries. Key areas for harmonisation in policy relating to testing approaches include i) standardisation on the illuminance levels used for ABC testing, ii) incentives for ABC, and iii) harmonised approaches to peak luminance levels in policy. For further details on policy and testing recommendations related to ABC, please see "Appendix D - ABC testing and policy recommendations" and Report 3.

[1] Super-efficient Equipment and Appliance Deployment (SEAD) participating countries including but not limited to Australia, China, India, Japan, Korea, the Philippines, the United States, and Vietnam, plus, although not part of APEC, the European Union.

## Harmonisation progress to date

The comparison between the test methods found that there is good alignment on measuring equipment requirements, the broadcast content test video signal, and confidence level requirements for measurement of uncertainty. There are a number of small variations that are often compatible and even necessary, e.g. different testing temperature ranges or input voltage variations. These are minor concerns but may have a small impact when comparing test results between regions. High priority issues for harmonisation are summarised in the table below:

| Aspect of test method | Magnitude of impact |
|---|---|
| Illuminance levels and calculations for on mode testing with ABC | H |
| TV sample preparation for on mode testing (luminance setting) | H |
| Dynamic broadcast-content video signal (need for revision) | H |
| Equipment - Light source colour temperature and directionality | M |
| Test video signals for new formats (UHD and 3D) | M |
| Luminance testing and measurement for on mode testing | L |
| Identifying ABC sensor location | L |
| Impact of TV stands in low illuminance on-mode-with-ABC testing | L |
| Sample preparation - inputs (RF vs HDMI) | L |
| Definitions and calculations relating to uncertainties | L |

## Exploration of underlying reasons for divergence in test approaches

In some cases, aspects of test approaches are not harmonised simply because they had yet to be addressed within an international standards process. In other cases, different approaches are used due where technical studies in these countries support their respective approaches. Laboratory set up between countries is relatively consistent and therefore regional variations in test approaches are not likely to be due to testing laboratory facilities. Where variation occurs in a lab-by-lab basis, it is usually down to a training issue that has resulted in misinterpretation of a test standard.

Some variations in test standards may be due to cultural differences – for example due to the timing of a digital switch over or consumer attitudes toward default product settings. In practical terms, the opportunity to change or adjust existing test methods is constrained by a number of factors including:

- Timing of regional revision cycles for test methods in relation to activities of other regions.
- Variations in regional priorities for test method application.
- The lack of a formal mechanism to improve alignment between regions.
- The creation of uncertainty while new test methods are under development.
- The cost to industry and end-users from testing products according to a new method.
- Industry concern that changes in procedures may impact the availability and cost of products.
- The loss of insights gained from accumulated data according to a particular test methodology.
- Local technology availability, for example a greater prevalence of the use of Radio Frequency (RF) inputs in China (see Report 1).

## Toward greater test method harmonisation

The standardisation of the illuminance light source and testing methodology for testing of ABC conformance criteria has been catalysed by DOE work to optimise the repeatability of test results, particularly by tightly defining the lamp specification. However, optimised ABC control characteristics for a wider range of room illuminance may be required in the future. Therefore the team considered potential future refinements to testing methodologies in order to reduce the laboratory time required to check ABC control conformance over many test points. Initial experimental findings suggest that one potential refinement in the test standards area could be the potential shift to a light source such as a projector, which (accompanied by appropriate test material) would allow for simplified and more robust setting of illuminance and reduce the severity of many of the other testing issues identified, for example the criticality of lamp inclination. Such an approach could readily replicate current DOE ABC illuminance testing criteria in terms of illuminance, colour temperature and level but in addition allow a wide repeatable range of illuminance from 1 lux upwards to efficiently characterise the full ABC control curve.

Above all, greater harmonisation of test approaches between Chinese and IEC approaches (principally in terms of screen luminance levels) is essential in order to allow future comparisons between China and other regions. There is currently not a conversion method sufficiently robust to translate the results of individual tests between the two test approaches for comparison.

It is recommended that SEAD generate further discussion on the proposals put forward in this report and gain consensus on the way forward through active dissemination of this report to those within international, regional and national standardisation organisations concerned with televisions. SEAD could engage with relevant television test standard staff and committees, particularly in China, to make them aware of the report findings.

# Findings from comparing performance requirements for televisions

Policies in a total of 13 regions were analysed, including over 70 performance thresholds from those regions. This revealed a startling array of different thresholds in use, despite televisions being very similar in technology the world over.

## Relative stringency of requirements

Regulatory requirements (MEPS) tend to be set at a power demand three or four times lower than the best models on the market, but the wide range of efficiency allows significant scope for them to be tightened whilst retaining a wide consumer choice. Ambition of energy labels is essential in the fast improving TV market, but often lacking. The highest efficiency classes in some areas coincide with the most stringent MEPS in others, and high proportions of products are quickly able to populate these classes. Some regions lose a number of efficiency classes from their label scheme due to local MEPS being specified higher up the labelling scale.

The baseload power allowance is the component in formula to calculate TV energy efficiency that accounts for the power demand necessary to drive the electrical circuitry regardless of the screen size. A higher baseload allowance generally enables more small TVs to meet the criteria. A careful choice of baseload allowance is necessary to ensure that appropriate proportions of smaller TVs are able to meet requirements. This is especially important where policies reduce the baseload power proportionally with the classes. The policy threshold lines that have the best market distribution involve i) reasonably flat curved thresholds (based on technically relevant and easy to use formula), ii) fixed baseload allowances that don’t reduce as thresholds become more stringent.

## Exploration of underlying reasons for divergence of policy

A considerable global variation in TV energy efficiency policy has been identified. There are many underlying reasons for differences in the level of ambition between EU, US, Australia, Singapore and others such as Korea, Vietnam, Malaysia. These include:

- **Resources:** Limited budgets available to assess the market and develop requirements.
- **Policy and market evidence:** Insights available to policy-makers at time of setting policies.
- **Regional politics:** Due to i) the prioritisation of energy efficiency concerns by government, ii) the broader policy framework – for example, what policies can be applied and the number of levels in an energy label, iii) any political influence of local manufacturers resistant to change.
- **Policy schedules / revision cycles:** Policies tend to become more ambitious over time, in line with the increasing efficiency of new TVs. If some regions do not update their requirements on a frequent basis they are likely to have less influence on the market. In addition, if policy schedules do not align with other global policy timings, inconsistent interim approaches may be adopted in order to meet deadlines.
- **Product mix and cost concerns:** There may be a reluctance to revise requirements toward greater stringency due to assumptions that this may impact product availability and cost.

## Towards greater policy harmonisation

This study proposes a series of benchmark performance levels that policy-makers can use as a foundation for setting their own local policies and label schemes – called reference thresholds (RTs). The reasonably flat curved thresholds were chosen (based upon a hyperbolic tangent / "tanh" approach used in the ENERGY STAR TVs draft Version 7 equation) to mimic the average performance curves for current and emerging technologies. The five classes of reference threshold provide an 'international ladder of performance', ranging from minimum requirements for a current average global market (class RT1) up to incentive performance levels for 2018 (class RT5). Labels and MEPS can be set at levels suitable for local economics and product availability, but if they are based around these reference thresholds, they will be globally coherent and easier and more cost-effective to enforce - benefitting both manufacturers and policy-makers.

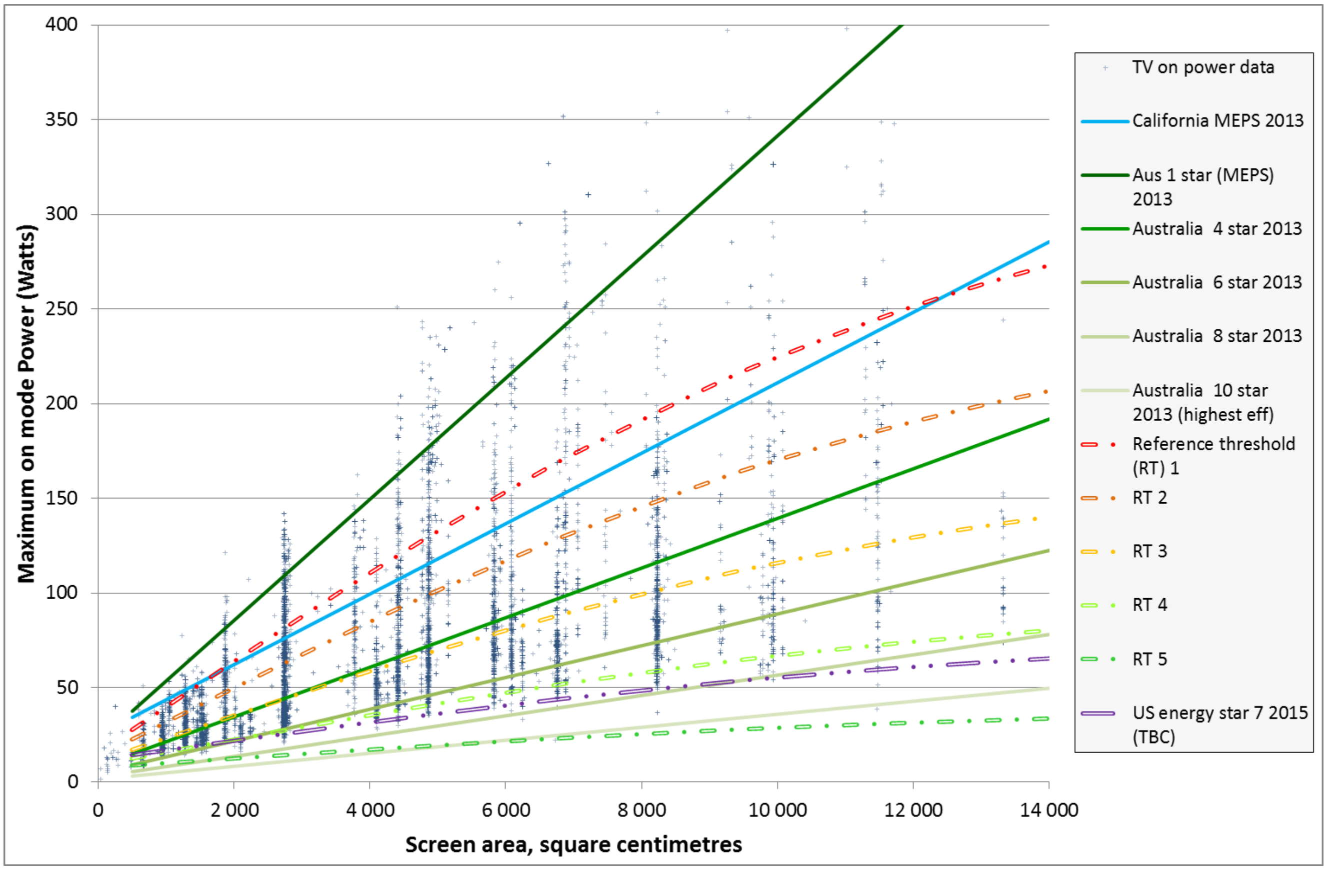


**Figure S1: Proposed globally relevant reference thresholds (RT) for policy-makers – RT1 (least stringent) to RT5 most stringent), as compared with selected policy thresholds from Australia and the USA (California).**

The thresholds are screen-size and technology neutral. Since there is no significant change in TV service or functionality as the screen technology changes, policies should not in principle discriminate by technology, otherwise they run the risk of restricting innovation or even in promoting the deployment of less efficient technologies. There are no allowances for the number of tuners or for additional functionality such as hard drives, as such ancillary functionality is not considered a core part of the TV service.

The data basis for the reference thresholds is mainly from Australia and USA, and whilst representing a wide range of efficiencies, it may not provide an accurate representation of all markets. Therefore, when applying the reference thresholds to different regions, the variability of product mix and power demand by region needs to be taken into account. It is possible to adjust all the factors in the proposed formula. In particular, if a new MEPS regime is being considered in a country where there has been no previous TV policy activity, a less stringent line might be more appropriate. In order to account for market differences, at a basic level, policy makers could compare national average television consumption or efficiency data with the thresholds. Ideally a more detailed analysis would be undertaken to gather data on the current and pre-market models of regional brands and superimpose the reference thresholds over these data sets. Reference threshold parameters could then be adjusted, if necessary, for a fit that ensures an appropriate minimum coverage of these brands for the policy type.

The ideal approach to TV policy would be a foundation global MEPS at the RT1 level. It is possible that some locally adjusted less stringent standards may be justified in the short term if legacy product is necessary for economic reasons or where there are significant differences in market composition and regional manufacturers. However, with regard to newly manufactured products, the goal of MEPS for all TVs should be to set these at global stringency, and with appropriate policy signalling (including APEC government support of manufacture of efficient TV technologies), models produced locally to developing markets should all be able to meet the global MEPS.

As a support to harmonisation efforts, guidelines are recommended that could assist policy makers in initiatives to achieve cost effective efficiency improvements in televisions – for example providing:

- Information on increasing screen sizes, and the impact these have on increasing energy consumption of televisions.
- Insights on the ranges of energy efficiency in the television market by technology and screen size.
- Detail of potential risks of failure to implement energy efficiency policies – such as the risk of un-regulated markets becoming flooded with the least efficient products that cannot be sold elsewhere.
- Information on policy cost and potential savings to support a shift toward specification of a highest energy efficiency level that is feasible but not expected to occur in the absence of further policy action.
- Steps to apply the Reference Threshold approach in their region, supported by the provision of electronic tools and training.

The television area is exceptional in that global harmonisation of test methodologies, and even performance levels, could be made a reality within a few years. It is the authors' hope that this study provides a foundation to bring about this global shift.

# 1. Introduction

## Project overview

This project was commissioned by CLASP, the Australian Department of Resources, Energy and Tourism (now the Department of Industry and Science) and the U.S. Department of Energy, on behalf of the Asia-Pacific Economic Cooperation (APEC) Collaborative Assessment of Standards and Testing Methods (CAST) initiative and the Super-efficient Equipment and Appliance Deployment (SEAD) Initiative of the Clean Energy Ministerial.

The work was undertaken by Intertek PLC, Tait Consulting, Digital CEnergy Australia and Top Ten Europe. The aim was to analyse current standards and test methods for televisions in order to develop proposals for internationally harmonised energy efficiency test methods, metrics and efficiency classes for use in future efficiency policy measures. There is a particular focus on SEAD participating APEC countries and other relevant economies (including but not limited to Australia, China, India, Japan, Korea, the Philippines, the United States, and Vietnam, plus, although not part of APEC, the European Union). APEC governments have endorsed this work, as they are keen to work toward a globally harmonised standard that will support eventual aligned efficiency tiers/MEPS/labels.

## Scope

The focus of this work is televisions. As an additional consideration, non-commercial displays, which include computer monitors, are increasingly similar to televisions in screen technology terms. However, there are a number of distinct differences in characteristics and usage between TVs and computer displays:

- Displays are viewed from closer range, which means that typical luminance levels are lower. This requires a different setting of the power levels and potentially different approaches to ABC.
- Displays in offices tend to be used with higher ambient lighting levels, reducing potential savings due to ABC.
- The screen size of displays is generally smaller than TVs because displays tend to be viewed at a close range.
- The images typically viewed on computer displays are sometimes more static in nature and do not require the same level of image processing as TVs, which are optimized for rapidly moving images. Nevertheless, there is increasing convergence between TVs and monitors in terms of usage and image quality.

Efficiency metrics have historically differed, with more complex criteria for displays that accounted for screen resolution, or that were designed to account for the demanding professional requirements on some computer displays. Whilst most policies still retain a separation between the two product types in both policy requirement and testing terms (e.g. the US EPA ENERGY STAR label which has an independent display specification and a test method for displays referencing IEC 62087 for some key parts), the European Commission is now considering displays for inclusion alongside televisions in the same minimum energy performance and labelling regulation revisions (2014/2015). In this case, the same test international test method (IEC 62087), formula and requirements would be applied to both products[2]. Therefore, whilst non-commercial displays have not been a focus of this work, it is likely that at least in Europe many of the findings of this work will also apply to display products in future.

[2] Note: In its current edition, IEC 62087 specifically refers only to display products defined as televisions.

Note that commercial displays, such as for signage and advertising in public places, are not considered in this study due to the complexities in addressing such displays in test methods[3] and the fact that they do not tend to be included in current test methods. Static displays such as those used to show the status of control systems or largely static rather than dynamic display content are also excluded from this study.

# Background

## Policy context

Energy efficiency plays a key role in addressing concerns regarding increasing global energy consumption and the risk of climate change. Policies such as Minimum Energy Performance Standards (MEPS – effectively regulations that require certain levels of energy efficiency), endorsement schemes for high efficiency products, energy rating labels and green public procurement can drive products toward energy efficiency. Harmonised test methodologies provide the foundation for these policies.

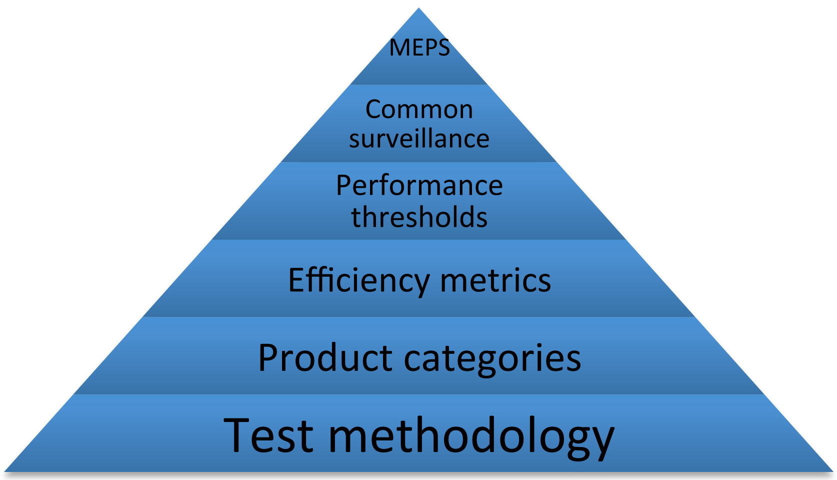


**Figure 1 - Hierarchy on which harmonized MEPS are built**

Whilst efficiency initiatives can be driven by a select few regions with budget available to dedicate to the activity, global cooperation needs to be fostered in order to influence the production and sale of inefficient products in other regions. Some highly populated regions currently have low stringency policies in place. If these regions are not engaged in efficiency initiatives to facilitate the development of policies, sales of low efficiency products in these regions could dilute the progress being made elsewhere.

Work toward resolving the major differences in test methods and policies internationally is often referred to as harmonisation, and offers the following benefits:

- **Drivers for efficiency improvements:** Empowerment of policy makers and consumers to demand greater stringency over time, and effective messages to manufacturers to drive the design of products toward best practice efficiency.
- **Information:** Clarity and comparability of efficiency information on products, both domestically and internationally.

[3] These displays can have built-in servers and unique functions for multi-screen assemblies. They have a very wide range of display luminance (250 to over 3000 Cdl/m²) that demands specific testing methodology to support efficiency classification metrics based on lumens / Watt rather than Watts/unit area

- **Policy development:** Easier policy development through improved comparability of international policies and their impacts, and reduction of the length and workload of regulatory policy development processes through making evidence and analysis from other regions more easily transferable.
- **Test method development:** Lowering development costs for test methods.
- **Trade:** Decreasing barriers to trade.
- **Compliance:** Reduced costs of compliance i) in terms of product testing by manufacturers involved in multiple markets, Ii) in terms of market verification and enforcement for authorities.

Obtaining comparable data is the first step. This includes use of harmonised test standards, and public declaration of sufficient test data to assist with comparison and normalisation. There are currently two distinct approaches to TV testing, and this presents a challenge to closer harmonisation. One approach as in the Chinese test standard and the second is that of IEC 62087 (used in most other regions). Without comparable test results, as discussed in Report 1, policy comparison with this large market is not possible.

Global cooperation between policy-makers via SEAD can help establish standards and policy principles for cost-effective adoption by all participating economies. Tools such as internationally comparable energy performance benchmarks can facilitate consistent approaches to policy design, whilst allowing governments flexibility to specify performance thresholds that are appropriate to their own market and economy. Comparative label approaches can be particularly useful policy tools for harmonisation since they do not restrict the sale of products in regions where local economies require a broader spectrum of products.

The television area is exceptional in that global harmonisation of test methodologies, and even performance levels, could be made a reality within a few years.

## Test methods

Whilst there appear to be several competing television test methods in APEC countries, they all rely on the test methodology of the dynamic broadcast-content video signal (the audio-visual input sequence run during the testing procedure) for basic power measurement that is the foundation of IEC 62087, including Japan and China. However, challenges in the detail of test methods remain: despite the dynamic broadcast-content video signal being harmonised and featuring an average picture level (APL) representative of worldwide broadcasting (to which average power demand is proportional), the testing results from this study suggest it may need to be updated to keep pace with recent developments in technology. In addition, there are issues with the testing set up of TV samples in different regions, that currently prevent the comparison of results between these regions, and a primary weakness in all the current test standards is that luminance needs to be set, tested and declared in some way. This is prone to errors and is particularly relevant in the Chinese approach as it is this variable to which the efficiency metric is tied.

## Terminology

Measurements of illuminance and luminance are referred to in this document. **Illuminance** is used to refer to the ambient room / background lighting conditions in which the television is viewed - measured at a surface in the room and stated in units of lux (lx) or lumens per square metre (lm/m$^2$) . **Luminance** is used to characterise the emission of light of a television display in terms of the measured intensity of light emitted from the display surface per unit area in a given direction and stated in units of candelas per square metre (cdl/m$^2$) sometimes referred to still as "nits" The display luminance setting is usually the most significant determinant of how much power will be required for the display product. For both illuminance and luminance the term brightness is often used erroneously since brightness is a subjective assessment of visible light energy and should not be used in the context of measured units of light.

In relation to light sources used in testing, colour temperature and directionality are referred to. **Colour temperature** is a characteristic to describe the relative intensity of the individual colours (wavelengths) that make up the spectrum of visible light, expressed in degrees Kelvin. The typical light spectrum that consumers watch TV in is likely to contain varying colour temperatures – for example components of UV and IR as well as visible light. **Directionality** relates to the alignment of the illuminance light source with the principal axis of the ABC sensor, perpendicular to the screen.

## Technology foundations to television testing and policy

**Automatic Brightness Control (ABC)** functionality is referred to frequently in this document. ABC reduces television power demand by adjusting the brightness of the screen in response to changes in background lighting conditions. TVs are tested with ABC enabled so that the on mode power demand can be adapted to allow for savings due to this functionality. Policy measures handle ABC technology in different ways. Policy in the EU and US incentivises ABC technology as it can result in savings, as summarised below:

| Region | Initiative | Illuminance levels | Requirements |
|---|---|---|---|
| **USA** | US DOE rulemaking | 3,12, 35 and 100 lux | On mode power with ABC is calculated using an equally weighted ratio of 25% per illuminance level. |
| **EU** | EU Energy label | 0 and 20 lux | The on-mode power is reduced by 5 % for TVs that have luminance set in home mode (or the on-mode condition is automatically reduced between an ambient light intensity of at least 20 lux and 0 lux and ABC is activated in this mode). |

**Table 1 – ABC requirements in policy**

Further discussion around ABC is contained in report 3 of this project.

**Sample preparation** relates to the way the settings on the TV are changed before testing is undertaken. Variations in sample preparation between regions makes it difficult to compare test results and policy metrics.

A **luminance ratio** of the maximum ("shop") to the "home" picture mode luminance is specified in some television policy regions (usually at the level of 65%). This is to prevent manufacturers enabling out of the box (home) TV settings with very low luminance levels in order to pass policy requirements ('gaming' requirements).

## Market overview

Global television sales continue to grow, particularly in major domestic markets such as China and Africa. Sales are spurred on by the continuing fall in product prices (the selling price per TV fell by 43% between 2008 and 2011[4]). At the same time, televisions currently account for an estimated 3% to 8% of global residential energy use. Considering the global nature of the television supply chain and potential environmental impacts of continued growth in the sector, it is important that a level playing field is established internationally in terms of testing methods and performance requirements relating to energy efficiency.

[4]Display search statistics:
http://www.displaysearch.com/cps/rde/xchg/displaysearch/hs.xsl/100524_even_with_high_led_premiums_2009_lcd_tv_asps_fell_twice_as_fast_as_2008.asp,
http://www.displaysearch.com/cps/rde/xchg/displaysearch/hs.xsl/120710_lcd_tv_forecast_lowered_to_216_units_solid_growth_still_expected.asp

## Range of efficiency

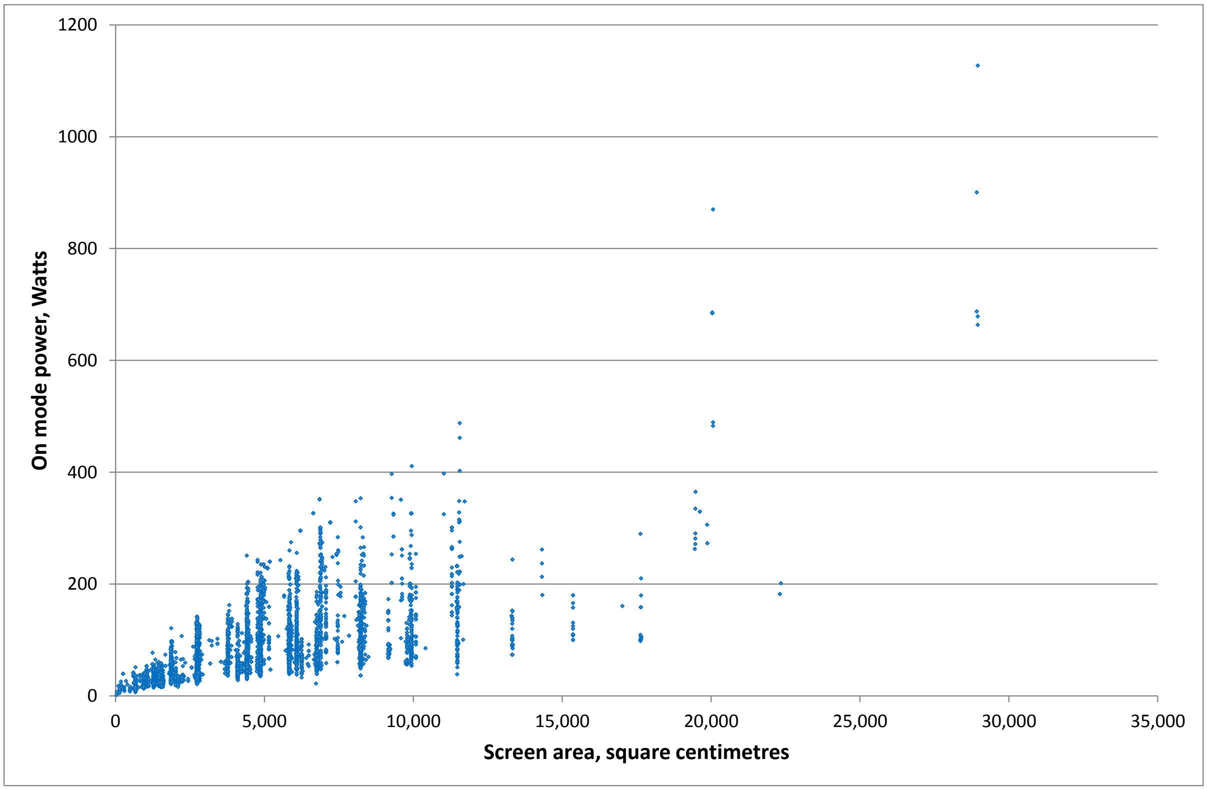


**Figure 2. All product data, from Australia and New Zealand, California and US ENERGY STAR showing the whole range of screen sizes and on mode power levels.**

The scatter chart in Figure 2 illustrates the wide range of efficiencies between TV models. For example, comparing 42"screen TVs (those with a screen area of approximately 5000cm$^2$), the worst performing TV demands seven times more power than the best performing TV[5]. On-mode power is strongly correlated with screen size. The general trend, as observed in Figure 2, is for TV power demand to increase with screen size. However, the range in efficiency is such that a poorly performing 24" (1600cm$^2$) TV can demand as much as 60W, which is similar to the best 60" (10 000cm$^2$) TV.
Some of the variation in efficiency can be attributed to the different screen technologies, with newer LED backlit LCD TVs generally being the most efficient and older plasma TVs the least – see Figure 3 below:

[5] From the Australian and New Zealand dataset: average power consumption is 105W whilst the best performing TV of this size demands only 33W, and the worst around 230W.

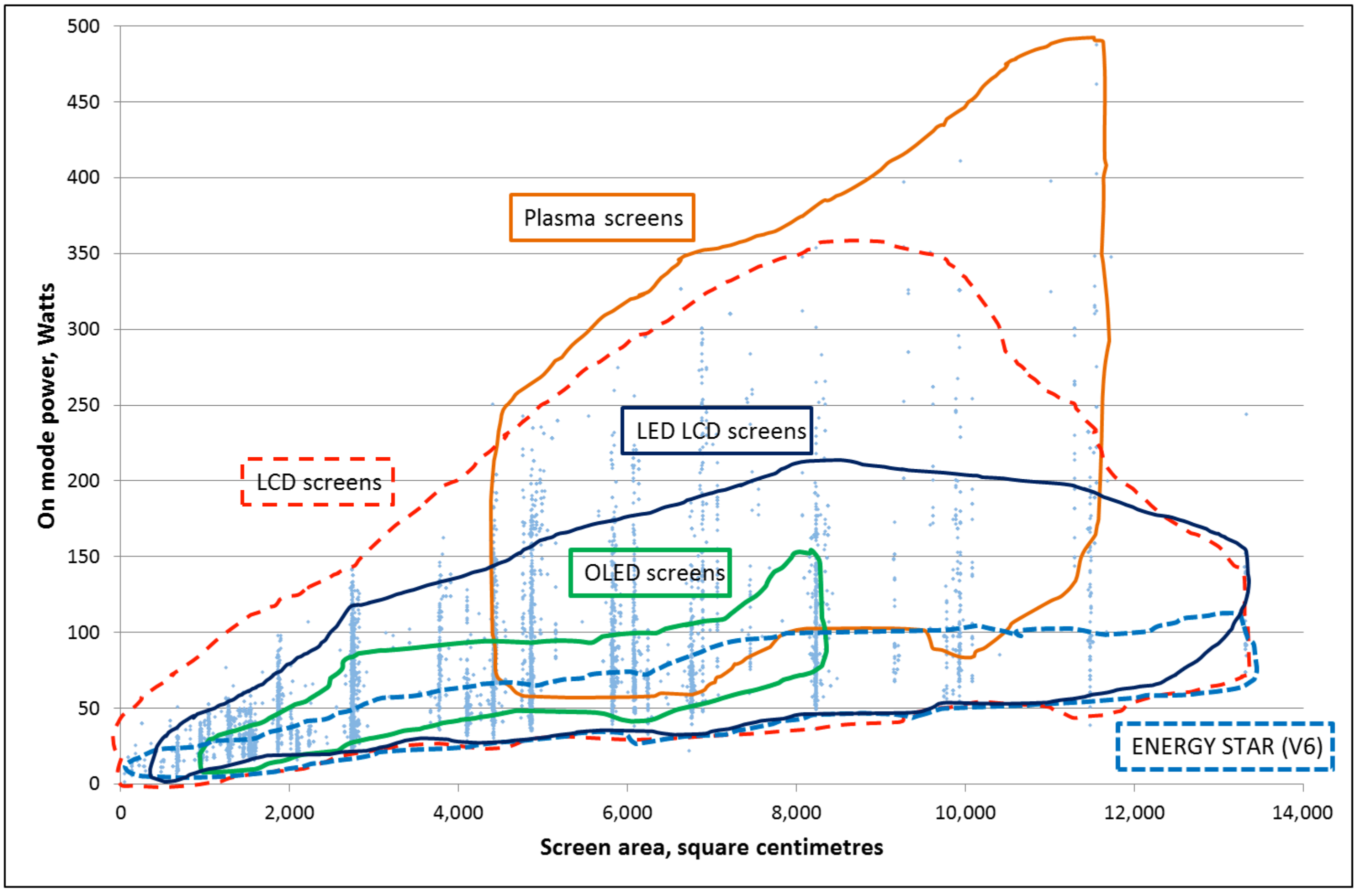


**Figure 3 - On mode power of television models by screen type**[6]

The following points on TV technology are worth noting:

- **LCD vs Plasma:** LCD models now cover the entire size range previously dominated by plasma at the larger size end, but LCD sets do not demand as high power at that larger end. It is expected that plasma TVs will be completely withdrawn from the market soon - Panasonic and Samsung have already announced that they will be ceasing production. This means that the efficiency of plasma screens should not be an important consideration when setting policy levels.
- **High efficiency super-sized TVs:** At the largest screen sizes above 10,000cm$^2$, the energy consumption range for LCDs falls dramatically. This is due to the very limited number of TVs in this range, which are all designed with the most advanced and efficient screen technologies.
- **OLED:** This is the newest TV technology. It has excellent potential to improve upon the efficiency of current technologies but it is not yet mature - investment and development are necessary to bring it to market as a feasible alternative. Manufacturers have suggested that in the early years of OLED commercialisation some televisions using this screen technology may struggle to meet stringent efficiency regulations in the short term, before the longer-term improved efficiency levels can be reached.
- **UHD:** Whilst 4K or UHD TVs were not included in the core analysis, they are a fast growing market segment. At one end of the UHD market they can have a power demand similar to comparable screen-size plasma displays,

[6] Note: Loops show the locus of television model data points for each screen type as labelled and also for all product types qualified under ENERGY STAR V6 at July 2014. LCD screen technology shown is CCFL backlight only.

and at the other end of the market they can be more efficient than some equivalent screen size HD LED-LCD TVs[7].

Insights on the best performing TVs on the market can be gained from various data sets[8]. Topten[9] data for the USA and the EU shows best performing product televisions that are very similar, suggesting a degree of consistency between global markets. Efficient TVs in these data sets demand around half the power of the average TV. Improvements in the market are rapid. For example, the most efficient models on the market identified by Topten in 2014 already consume around 10% less power than the models that won the SEAD awards for most efficient nominated TVs in 2012, See Report 4 for more details.

[7] For example, a large Korean manufacturer's 2014 internet site declared power demand of 32W for a 28" UHD TV (at 370 cdl/m² display luminance). For a similarly sized HD LED-LCD TV by the same manufacturer, the power demand was specified as 50W (27.5" with 300 cdl./m² screen luminance).

[8] Data sets assessed include: high efficiency models from the Topten (USA, EU and China) data sets ("European TV market 2007 – 2013, Energy efficiency before and during the implementation of the Ecodesign and Energy Labelling regulations" Second report, complemented with 2013 sales data, Anette Michel, Sophie Attali, Eric Bush, Topten International Services, Zurich, Switzerland, 21th July 2014. www.topten.eu/uploads/File/European_TV_market_2007–2013_July14.pdf) as well as the USA ENERGY STAR, California (CEC) and Australia and New Zealand data sets, and the SEAD medal winners (most efficient nominated models on the market in 2012).

[9]. Topten is an independent international program to create a dynamic benchmark for the most energy efficient products. Topten presents the best products in the national markets of 20 countries for a wide range of electric products.

# 2. Current test method harmonisation

## Overview of international standards

In comparing different test methods for televisions, the focus has been on those methods that are in current usage. Versions that have been superseded are not generally discussed unless they are referred to by current policy measures. In a few cases, information may be provided on test methods that are under development. Although the specific test procedures vary from country to country, the following IEC standards are partly referenced (with regional variations) or directly adopted by most existing international test standards:

- **IEC 62087 Ed. 3.0 and Ed. 2.0, Methods of measurement for the power consumption of audio, video and related equipment:** A major rewrite of the IEC 62087 standard is in the process of being finalised and should be published in 2014[10]. Our findings are relevant to the subsequent revision.
- **IEC 62301 Ed 2.0 2011, Household electrical appliances - Measurement of standby power:** This addresses standby testing for a wide range of products without specific language on TVs.

The map below shows the countries that are consistent with their application of IEC 62087, those that align on some aspects, and those that do not align with IEC 62087:

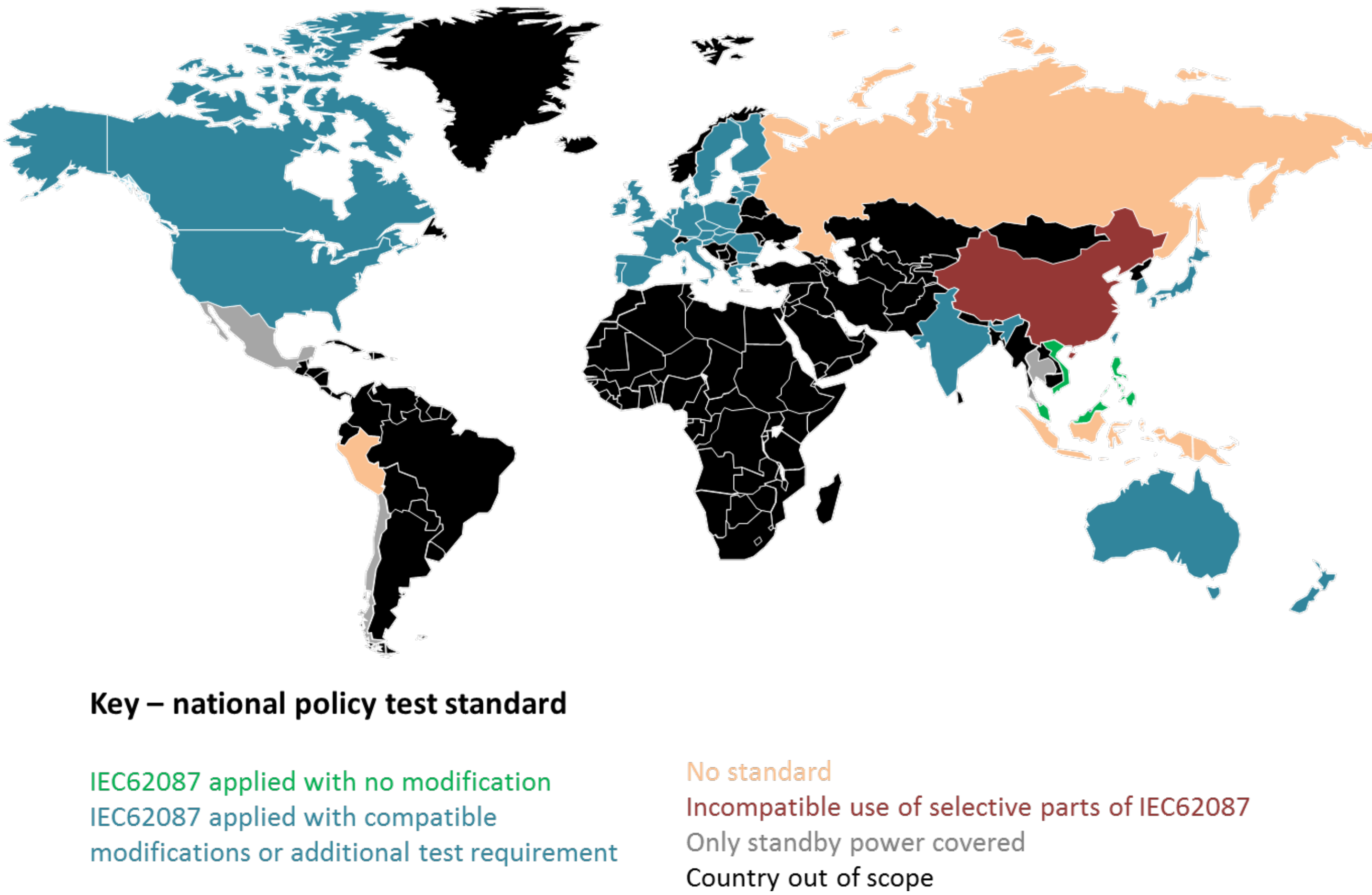


**Figure 4 - World map showing IEC 62087 harmonisation**

[10] The TV relevant content will be in three parts: IEC 62087-1 Ed. 1 (General), IEC 62087-2 Ed.1 (Signals and media) and IEC 62087-3 Ed.1 (Television sets)

A total of 6 test methods for televisions were examined in detail, plus an additional 2 that had been superseded but were still referenced in some areas. Countries without standards, where work could be done to improve engagement on TV–related energy efficiency initiatives include Brunei Darussalam, Indonesia, Papua New Guinea and Peru.

# Key findings from comparing test methods

A summary of the national test methods is contained in "Appendix A – Global test methods". The comparison between the test methods found the following:

## TV test methods are constantly evolving

The rapid rate of TV technology development means that test standards are likely to need to be revised relatively frequently. TVs have increasingly sophisticated energy efficiency and picture optimisation algorithms such as auto brightness control (ABC). To ensure the testing results are representative of actual in-home energy consumption, test standards are becoming more complex and as a result can be more time consuming and costly for laboratories.

## Sample preparation is key

The issue that has the biggest disruptive influence on comparability of energy test results is the difference between how televisions are set up for testing under standard GB 24850-2013 (as used in China) compared with the set up approach used in most other countries (IEC 62087). The sample preparation for GB 24850-2013 depends on luminance configuration and adds an unquantifiable variability to tests. Ideally, this aspect would be globally harmonised (say by using the most common approach of testing products for power requirement as supplied from the manufacturer, 'out of the box', as a precursor to any other testing requirements).

## Regional variations in testing approaches occur due to policy

There is a good level of harmonisation on the foundation of test standards, as the majority of energy efficiency policies refer to IEC 62087. However, national and regional policies often dictate variations and additions to this test standard. The most common addition is the measurement of peak luminance levels in order to establish a luminance ratio, which was introduced to ensure the out of the box test settings would be reflective of the normal use case, and would not impact user experience.

## Largest variations between most policy-active regions

As would be expected, the largest differences between test methodologies exist between the largest markets most active in policy development, EU, USA and China. Smaller markets then tend to align with these policies, although there is no clear pattern to which market they align with. The exception to this is Australia, which was the first region to regulate TVs in 2009, and to use the maximum luminance ratio approach in their policy (see report 4 for details).

## Some variations are low impact

There are a number of small variations that are often compatible, e.g. different but overlapping testing environment temperature ranges. Some incompatibilities necessarily exist such as the input voltage, which varies over regions, but is only a concern when comparing test results between regions.

## Barriers exist to normalising test methods

Use of calculations and assumptions to normalise differing test methods so that the results of individual tests using different test methods can be compared may be useful, but practically speaking it is not a feasible means of dealing with the major differences between the key television test methods. This is due to a lack of test data, the multiple areas in which test methods vary, and the inconsistent influence the specific testing variations have on test results.

# Harmonisation progress to date

## Already harmonised aspects of test methods

Aspects on which there is already good alignment include:

- Measuring equipment requirements;
- The broadcast content test video signal; and
- Confidence level requirements for measurement of uncertainty.

The current dynamic broadcast-content video signal as specified in IEC 62087 has been successfully harmonised upon internationally - where APEC countries have test methods in place, they all rely on the IEC 62087 dynamic broadcast-content video signal for basic power measurement, including Japan and China. However, due to advanced picture technology developments, the dynamic broadcast-content video signal would now benefit from a revision.

## Low priority divergence in test methods

Harmonisation on considerations that cause less than 5% variation in energy measurements is not a priority, but would still be helpful for consistency. These include:

| Divergence area | Explanation |
|---|---|
| **Power supply requirements** | Wide variations in both frequency and voltage have a low impact (1% to 3%) on energy measurements, which is within the limitations of the test equipment. Such variations will only impact test results when comparing across different geographical regions. |
| **Environmental conditions** | Two countries show a slight variation in temperature requirements, but this has no major impact on test results. |
| **Standby mode definitions and test** | There is alignment on the use of IEC 62301 for measuring standby, with the exception of small differences in GB 24850-2013 (used in China), and some variations between countries in definition of modes. There is scope for standby measurement and definitions specific to TVs to be brought under IEC 62087. Standby accounts for less than 2-3% of the energy rating index and annual power consumption of a TV, although has potential to increase with larger network standby allowances now being specified in policy. |
| **Scope** | All test methods appear to cover at least all standard screen technologies and typical types of television. Some test methods do not cover televisions with integrated video player/recorders but these represent a very small number of TVs sold, perhaps around 1 to 2%. Not likely to have major impacts on test results. |
| **TV product definition** | Definition of TV varies, with some countries defining TVs in much more detail. This is a policy rather than testing issue. |

Table 2 - Areas of low priority divergence in test methods

It should be noted that whilst there is minimal divergence with regard to standby testing, this is with a focus on passive standby modes. New active and network standby modes are emerging, for which there is an absence of test methodologies, without which it is difficult for policy measures to address these higher power-demand modes.

## High priority considerations for harmonisation

The high priority issues for harmonisation, are summarized in order of importance below:

| Divergence area | Magnitude* | Explanation |
|---|---|---|
| **Illuminance levels and calculations (on- mode-with-ABC testing)** | H | The illuminance levels chosen for ABC testing and used to calculate the on-mode-with-ABC power should be as representative of standard viewing conditions as possible. Whilst these levels have an impact on testing activity, they tend to be specified in policy rather than something included directly in the test method, although test methods may contain informative references to metrics or programme requirements. Levels/calculations will impact the on mode energy figure used in performance level classification. There is no current harmonisation on illuminance levels for testing TVs with ABC. The US DOE approach tests at 4 illuminance levels that are technically robust for regions similar to the US. |
| **Luminance setting in TV sample preparation for on mode testing** | H | Test method GB 24850-2013 (used in China) requires luminance to be set on samples before testing, using a test pattern, whilst other countries use out of box settings. Testing evidence shows the GB 24850-2013 approach is vulnerable to subjective adjustment, with repeatability implications. Different test labs configure TVs in different ways, and this inconsistent variation of potentially large magnitude can have a direct impact on energy test results. Testing found an average of 15% lower declared power with GB 24850-2013 sample preparation when compared to values that would be measured under IEC 62087. This luminance variation significantly degrades the comparability of the GB 24850-2013 energy efficiency metric against other global metrics. |
| **Need for revision to dynamic broadcast-content video signal** | H | Whilst this test signal is currently well harmonised, developments in TV technology mean that it may no longer encourage representative energy results. Televisions now react to the short footage compiling the test video signal in a very different way to a video signal containing a single dynamic picture, and as a result TV power demand may be under-stated in test results [see Report 2 Appendix C]. |
| **Light source colour temperature** | M | Colour temperature can cause an inconsistent variability on results when testing TVs with ABC functionality enabled. If the lamp type (and therefore colour temperature) to be used for testing is not clearly specified in the test procedure, the worst-case variation of on mode power between different light source colour temperatures was found in testing to be around 8% [see Report 3 Appendix D]. The variability of the colour temperature of light sources due to dimming to reduce illuminance is not accounted for in currently published standards. US DOE specifies the use of a specific lamp type, but does not specify the colour temperature. The new revision of IEC 62087 may address this. |
| **Light source directionality** | M | The US DOE test method requires a lamp with beam angle of 30 degrees (plus or minus 10 degrees) that is set up so that the centre of the lamp is aligned perpendicular to the centre of the ABC sensor. Careful lamp and illuminance meter positioning is necessary to adhere to these requirements and ensure correct luminance levels are obtained at the ABC sensor otherwise tests may be inaccurate and incomparable due to illuminance variations. Further specifications on placement and alignment of the light source could be considered to limit this variability. |
| **Test video signals for new formats (UHD and 3D)** | M | Whilst the IEC 60287 test video signal provides a harmonised foundation for testing, there are no standardised test video signals available in new formats such as 3D and 4K/8K resolutions. As such, comparative testing between such TVs may be carried out with custom non-harmonised test video signals potentially resulting in inconsistencies in testing of these emerging formats. IEC resolved this issue in |

| | | |
|---|---|---|
| | | the transition to HD from SD standards by publishing an HD (BrD) test clip and in the interests of International standardisation should be encouraged to produce 3D and UHD test material in the Standards maintenance activities. |
| **Luminance testing approach (on mode testing)** | **L** | Luminance testing can be necessary due to the inclusion of luminance ratio requirements in policy, as well as sample preparation requirements in some test methods (discussed below).<br>There is no current harmonisation on luminance testing, and measurements can vary considerably between labs, even where test patterns have identical peak white levels. These variations are unquantifiable, depending on TV design. Where default settings are used, this issue does not impact energy measurement directly. |
| **Identifying ABC sensor location** | **L** | For ABC testing, it is important to identify the ABC sensor location, so that accurate illuminance measurements can be made at this point. There is no current guidance or agreement on manufacturer provision of information on sensor location. Identifying the sensor location can be time consuming, and if not correctly located, could result in a lower illuminance of the sensor. This will result in a lower power measurement. |
| **Impact of TV stands in low illuminance (on-mode-with-ABC testing)** | **L** | The US test method states that if a stand is provided, measurements can be made with the TV attached to it. This can result in two issues: i) Lack of consistency between tests depending upon whether a TV stand has been used or not. ii) un-representative test results due to ABC reacting differently to ,reflections from the TV stand due to the vicinity and intensity of the artificial light source used in testing which is not the same as the natural illuminance that would be present in real life usage . |
| **Use of RF vs HDMI inputs in sample preparation** | **L** | Test method GB 24850-2013 (used in China) references an analogue RF input where available whilst IEC 62087 references digital HDMI input in preference.<br>Testing shows that i) HDMI inputs are likely to result in less variation (be 'better calibrated') between manufacturers than RF ii) There can be a small variation in results due to the use of different inputs, with RF resulting in generally lower on mode test results, but this can vary considerably from one TV to another. |
| **Definitions and calculations relating to uncertainties** | **L** | Approaches to uncertainties seem to be well harmonised, but there is scope for additional guidance with regard to definitions and calculations. Uncertainties have been found to be frequently misinterpreted, mis-stated and miscalculated. Uncertainty has little real impact on power demand, but can have an impact on variability in results between labs. |

*High (H) means could cause more than 15% variation in measured power demand, Medium (M) means could cause 5% to 15% variation in measured power demand, Low (L) means causes less than 5% variation in measured power demand.

**Table 3. High priority test methodology considerations for harmonisation**

In summary, the comparison between the test methods found the following:

- TV test methods need to be constantly evolving due to the rapid rate of TV technology development.
- TV sample preparation (luminance configuration) is the biggest disruptive influence on comparability of energy test results, and normalisation approaches are unlikely to be sufficiently robust to enable the results of IEC vs GB tests to be translated into comparable results.
- Policy approaches can introduce additional variances in the application of testing approaches in some countries.

# Exploration of underlying reasons for divergence in test approaches

In some cases, aspects of test approaches are not harmonised simply because they had yet to be addressed within an international standards process. In other cases, where different approaches are used, this is often because the different parties had technical studies to support their respective approaches. In these situations, new studies are sometimes available to support harmonisation on one specific approach.

Expert observations suggest a high degree of consistency in laboratory set up between countries, in terms of both capability and capacity. Most use exactly the same equipment and have well-trained staff. Therefore, regional variations in test approaches are not likely to be due to testing laboratory facilities (technology, capacity etc) or due to cost burden of testing. Where variation occurs in a lab-by-lab basis, it is usually down to a training issue that has resulted in misinterpretation of a test standard.

Some variations in test standards may be due to cultural differences. For example, the use of RF rather than HDMI inputs in China may be due to a lag in digital switchover and the avoidance of HDMI licensing costs by low budget TV manufacturers. Another example is the television sample preparation - out of the box settings in the IEC standard trust that manufacturers would provide televisions in an out of the box configuration representative of actual use (to avoid disappointing the customer by requiring them to alter any settings after initial purchase). However, in China, a subjective setting of luminance rather than reliance on out of the box settings may be due to manufacturers having more scope to alter out of the box settings to achieve favourable test results, as Chinese consumers may be more accustomed to adjusting out of the box settings to their requirements.
In practical terms, the opportunity to change or adjust existing test methods is constrained by a number of factors including:

Regional issues:

- The lack of timing synchronicity in the regional revision cycles for test methods meaning that revisions are often made without knowledge of the activities of other regions.
- Variations in regional priorities for test method application.
- The lack of a formal mechanism for closer alignment between regions, including the prioritising and co-ordination of research.

Resistance to change:

- Understandable resistance by industry to change test methods that have existed for many years and used as the basis for the development and rating of products.
- The creation of uncertainty while new test methods are under development.
- The cost to industry and end-users from testing products according to a new method.
- Concern on behalf of industry that changes in procedures may impact the availability and cost of products.
- The loss of insights gained from accumulated data according to a particular test methodology - which manufacturers and policymakers depend on to understand trends.
- The costs involved in adopting significantly different test methods, in terms of investment in test infrastructure, re-testing models and potentially changes in the design of equipment. This can be considerable and represents a large barrier to change.

# 3. Current policy harmonisation

This section discusses the main variations in policy approaches to TV energy efficiency.

## Efficiency metrics

Efficiency metrics are all related to the on-mode power consumption and the screen size. However, this still enables a variety of different approaches with regards to how the screen size is measured - most commonly by area but also by screen diagonal and square root of screen area. Additional TV functions and other power modes are also taken into account.

### Power per unit area

The basis of most metrics is the on-mode power consumption (the main energy impact of the television), per unit of screen area:

$$\frac{power_{on}}{screen\_area}$$

This is because the screen size has the biggest influence on the on-mode power consumption. The output is a metric of efficiency that is independent of screen size, quantified as power consumed per unit area of screen. In practice an additional allowance is given for the fixed (baseload) power such as the electronics and tuner.

The combination of a per-unit-area power metric combined with a baseload power provides the basis for majority of policies, including those of the EU. The EU also uses different baseload allowances depending on the functions of the TV, such as the number of tuners and hard drives. Other policies, such as ENERGY STAR, vary the power allowance per unit screen area based on the actual screen size. This is because larger screens tend to be more efficient when measured using the metric.

### Annual energy consumption (AEC)

An alternative metric is annual energy consumption (AEC), which takes into account the passive standby power and in some cases the active standby power. The AEC is calculated based on a standard annual usage scenario of a certain number of on hours and standby hours. The hours specified will vary between policies. Policy requirements based on AEC allow manufactures more flexibility in the way they meet requirements by addressing energy efficiency in the on-power and/or standby power.

### Alternative metrics

Other metrics represent variations on the above approaches – for example, the Malaysian efficiency metric using AEC, the Korean metric using screen dimensions, and the Chinese metric using screen brightness (in candelas) per Watt. With the Chinese approach, a more efficient screen has a higher value ('luminous intensity'). From a purely technical perspective, measuring the light output per Watt is an accurate measure of screen and TV efficiency. However, the service provided by the TV is actually the quality of the image, regardless of screen light output, and so a focus on brightness can penalise TVs that achieve an improved quality image by other means (such as psycho-visual algorithms). In addition, as highlighted in the section on testing, measuring the absolute brightness (luminance) is a difficult process that is hard to accurately reproduce across different labs.

The Japanese Top Runner approach is based on the on mode power/screen size but takes a differing approach to the market. It uses the screen diagonal rather than screen area and sets mandatory energy efficiency standards based on the most efficient ('top runner') products on the market. Products are assigned to categories on the basis of their features (e.g. screen size, screen technology, screen refresh rate, resolution, and additional functions). When a manufacturer produces an appliance with the best energy efficiency performance within its Top Runner category, all other appliances are required to reach that level within a specified time scale.

### Standby power metrics

Standby power requirements are usually set independently of the on–mode power, and tend to be fixed across all types of TVs and screen sizes (except where standby is a feature of the calculation of annual energy consumption). Some policies only cover standby power, and one policy has comparative labels based on standby power only. However, as standby power can represent a very small proportion of total energy consumption of a TV, a focus on such approaches would be discouraged in favour of those that include consideration of the on mode of the television.

## Policy types

There are four main policy approaches used to address TVs:

1. Mandatory minimum energy performance standards (MEPS)
2. Mandatory comparative efficiency label
3. Voluntary comparative energy efficiency label
4. Voluntary high efficiency endorsement label

"Appendix B - Global television policies" provides an overview of the different policies relating to televisions for the economies investigated.

Mandatory policies require that all TVs sold must comply with the regulations set. MEPS set a low threshold that all TVs must meet and ensure the least efficient TVs on the market are removed.

A comparative energy label provides an easy method for consumers to choose between the products available on the market on the basis of energy efficiency. This is more useful when there is a wide range of efficiencies between models. Labels may also be more effective at driving higher efficiencies especially for products with a high rate of technological development[11]. MEPS and labels are often applied together.

Voluntary policies in theory enable more ambitious criteria to be set and may reduce the regulatory burden and costs to manufacturers. However, without sufficient market competition such an approach may allow low efficiency products to be sold on the market.

A number of policies specify current criteria, and in addition specify planned updates to criteria to be introduced over time. This provides policy certainty to manufacturers who can therefore plan long-term product development and research. However, new product features can lead to changes in television operation and energy consumption, and such forward looking approaches require that efficiency improvements are realistically projected over a 5-10 year period to ensure a suitable level of ambition. This can be a tall order for high-tech products such as TVs, and therefore adjustment of later tiers of requirements to account for technology developments can be required nearer to their implementation.

[11] "Impact of Ecodesign and Energy/Tyre Labelling on R&D and technological innovation - Final report", Project number: DESNL13606, Braungardt, McAlister et al, 23 May 2014

# Policy development principles

The policy development process for televisions will be influenced by the broader policy framework – for example, what policies can be applied, the number of levels in an energy label and how often they are reviewed. Setting of efficiency thresholds tends to be based on a statistical analysis of the existing market, supported by a technical understanding of the underlying technology that influences the efficiency.

Setting different criteria based upon screen technologies (i.e. plasma, CFL backlit LCD and LED backlit LCD) is a common policy addition. While it is possible to show that the technology influences efficiency, the impact of technology on the actual service delivered is usually too small to justify making this distinction. For example, if the energy label classes are allocated separately for different technologies, a consumer choosing between a cheaper CFL and more expensive LED backlit TV may be misled to believe the TVs consume the same energy because the efficiency labels show the same class. In fact the CFL is more power consuming and likely delivers a worse image quality. A policy that is over prescriptive increases complexity and may result in policies that are difficult to understand, unable to take into account new features or require constant updates.

A number of additional requirements are set to ensure that the product is sold in a usable state, in particular with regards to default luminance and auto power down[12].

# Relative stringency of requirements

This section compares stringency of policy requirements in relation to on mode / efficiency requirements. Standby requirements are discussed separately in Report 4, as these were not a core focus of this analysis.

Figure 5 is presented to illustrate the enormous diversity of television policy approaches. It shows labels and minimum requirements across 13 regions, which between them specify over 70 different performance thresholds. Whilst some regions followed similar approaches, very few specific lines actually coincide. The chart emphasises the need for rationalisation – especially considering that television products are globally very similar. In order to rationalise the large number of policies and individual threshold lines, “Appendix B - Global television policies” groups the policies based on similarities. It shows the relative positioning of the lowest and highest efficiency classes of each policy, and the relative

[12] Auto power down settings generally have a long default delay time to ensure that the TV does not switch off during normal viewing, so that the efficiency function is not disabled.

ambition of any MEPS (if applicable).

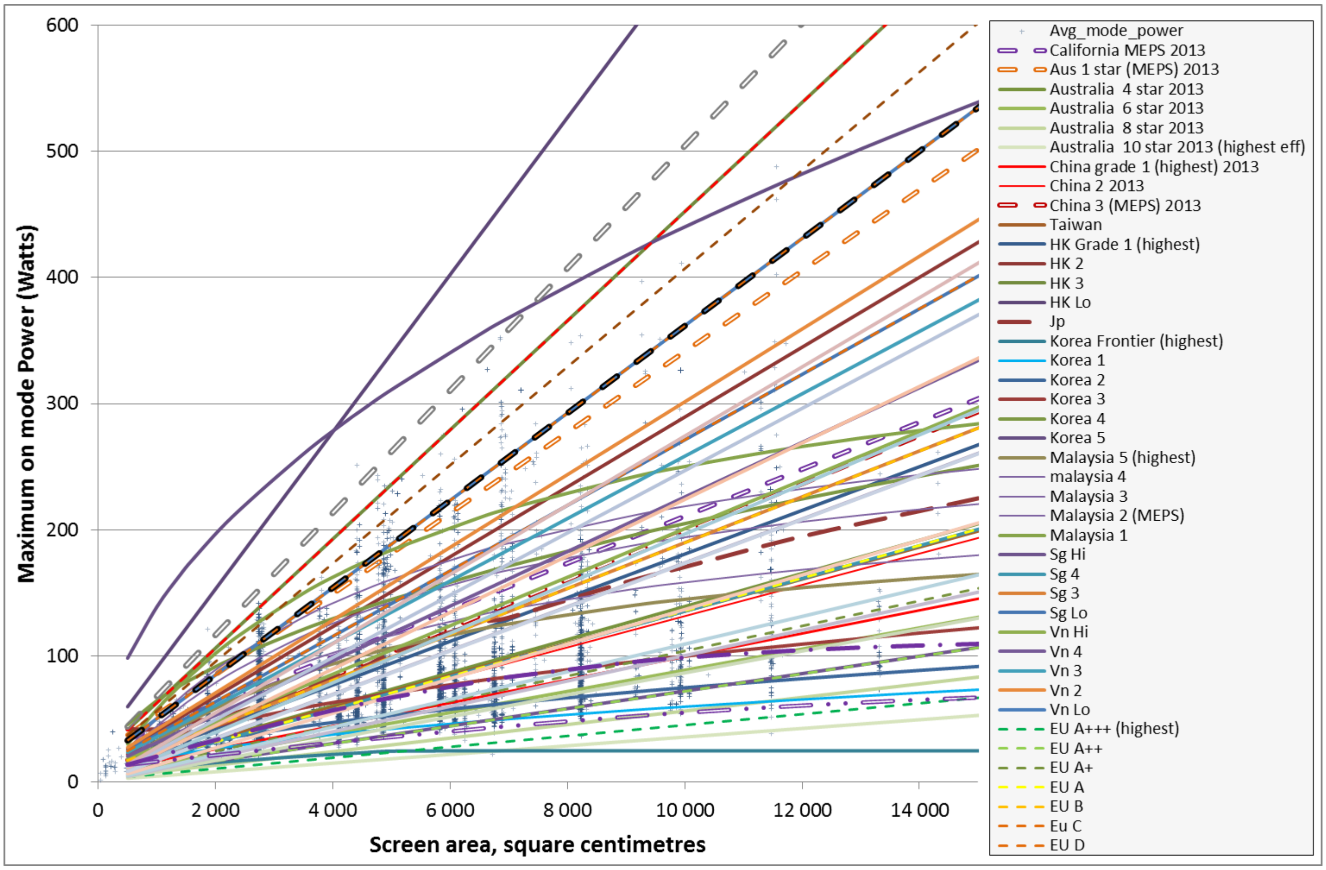


**Figure 5 - Policy thresholds from 13 regions shown together[13] – a total of over 70 policy lines. Note that the legend box is not large enough to show all of the lines.[14]**

## Stringency of baseload power allowance and small TVs

The baseload power allowance is represented as an offset in the policy threshold line to account for electrical demand to drive the signal processing and other circuitry which must occur regardless of the screen size. This baseload generally dictates what proportion of small TVs can meet the efficiency requirements - a higher baseload allowance enables more small TVs to meet the criteria.

The level of allowance varies between policies without a clear pattern. Since statistically most policies tend to allow a higher proportion of larger TVs to pass than smaller TVs, this could imply that the typical baseload allowance is too low. The distortion (over stringency) toward smaller TVs becomes more pronounced at higher efficiencies because most policies reduce the baseload power proportionally with the classes. Use of a fixed allowance and suitably curved policy threshold could allow a more appropriate pressure on consumption of both small and larger TVs.

[13] Thresholds include: Australia (10 levels); China (3 levels); EU (9 label classes plus 2 MEPS); Hong Kong (4 levels); India (20 levels, including 4 or 5 for each screen technology); Japan; Malaysia (5 levels); Republic of Korea (5 levels); Singapore (4 levels); Taiwan; USA – California; USA – ENERGY STAR (version 6 and 7); Vietnam (5 levels)

[14] Note that the policy thresholds plotted in the charts include the following additional assumptions: i) For the EU, only curves for televisions with a single tuner and no hard disk are shown. ii) Californian MEPS only apply up to screen area of 9,000 $cm^2$.

## Stringency of MEPS

Figure 6 shows the MEPS in force in Australia, the EU, California and China, from the least efficient (EU 2010) to the most stringent (China 2013). It should be noted that the China MEPS is based upon a different test methodology and also sets different requirements depending upon the screen technology – the lines plotted in Figure 5 and Figure 6 are the China standards for LCD screens using HDMI input, which were considered those most appropriate for comparison with other regions. The MEPS set in China for plasma screens are significantly less stringent than those for LCD screens[15]. Compared to the prevalent TV efficiencies on the market, most MEPS have a limited impact on the 2014 market (see Table 4).

**Table 4 - Proportion of TVs in data set failing to meet national MEPS**

| Australia | California | China | Malaysia | EU 2012 |
|---|---|---|---|---|
| 10% | 15% | 36% | 7% | 3% |

The EU 2010 MEPS threshold has been easily surpassed by current TVs. Even recently announced MEPS such as those in China would only remove around 30% of the current market. The California MEPS is significant for the level of ambition, especially since it was developed during 2010. MEPS tend to be set at a level three or four times less efficient than the best models on the market. The wide range of efficiency in the market, especially at popular screen sizes, allows significant scope to tighten MEPS whilst retaining a wide consumer choice.

[15] Study on the energy efficiency of flat panel televisions in china; implications for energy efficiency standard, china energy labelling program, and national incentive policies, LI Jiayang, HU Bo, ZHENG Tan, ZENG Lei CLASP and TOP10 China, EEDAL 2013, Table 1.

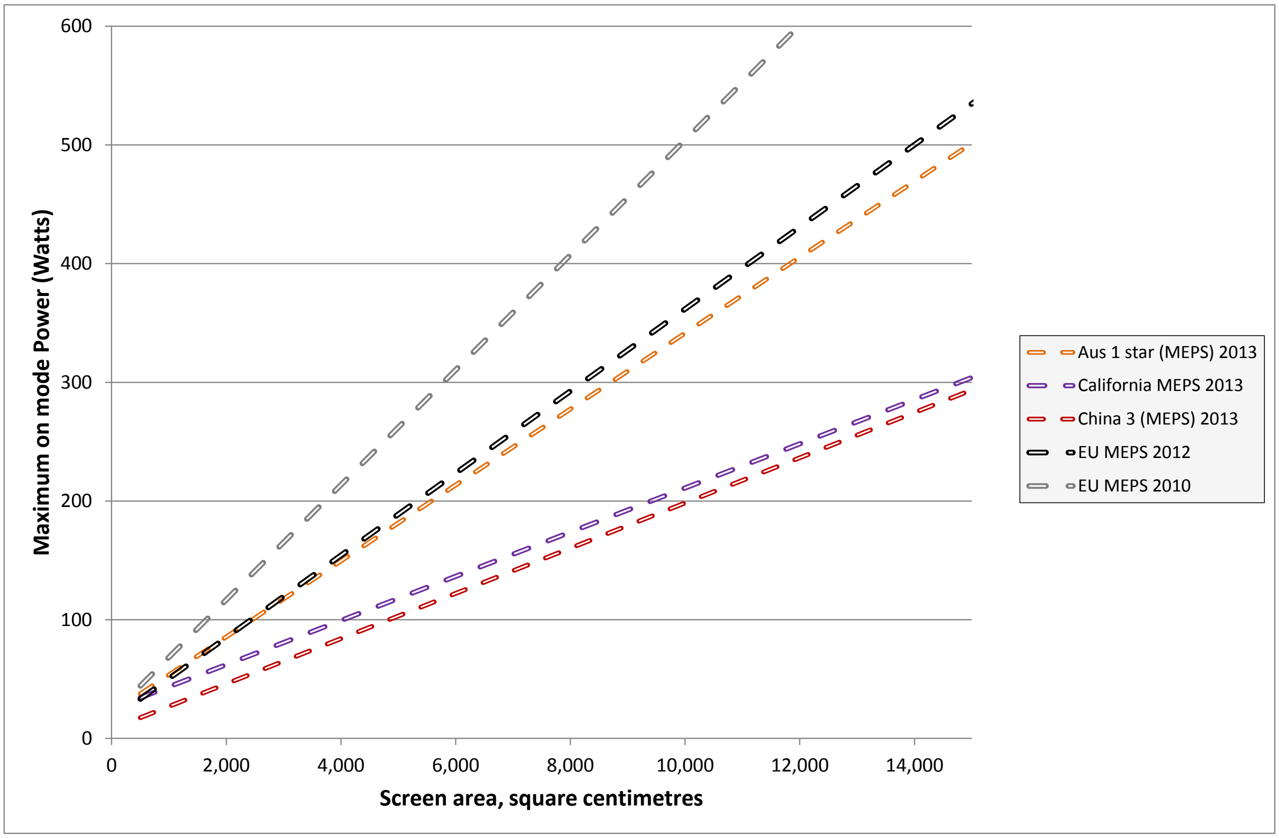


Figure 6 - MEPS in force in EU, California and China.

## Stringency of endorsement and comparative labels

Figure 7 shows the highest efficiency classes / thresholds used in current labels. These high efficiency classes can provide indicators of the level of performance that might be expected from future technology developments. The chart shows some curved reference lines, which are applied in Korea, Malaysia and under US ENERGY STAR. These lines become more horizontal as the screen size increases, to better mimic the performance of televisions on the market. For curved-line policies, a larger screen with the same efficiency rating as a smaller screen will be expected to have lower power consumption per unit screen area. This avoids awarding many larger TVs with a higher efficiency rating, which could otherwise cause the consumer to mistakenly interpret that a larger TV is an environmentally better option despite its higher absolute energy consumption. Further detail on use of curves in labels is given in report 4.

China has only three label classes, whereas Australia and New Zealand has 15 (one to ten stars, plus some half star levels). The number of levels is generally dictated by the policy framework in which the label is developed, to maintain consistency across different products labels. The wide range and number of levels in the EU and Australia / New Zealand policies gives scope at the stage of scheme design for TVs to be fairly evenly distributed between the efficiency levels, allowing clear differentiation of the products.

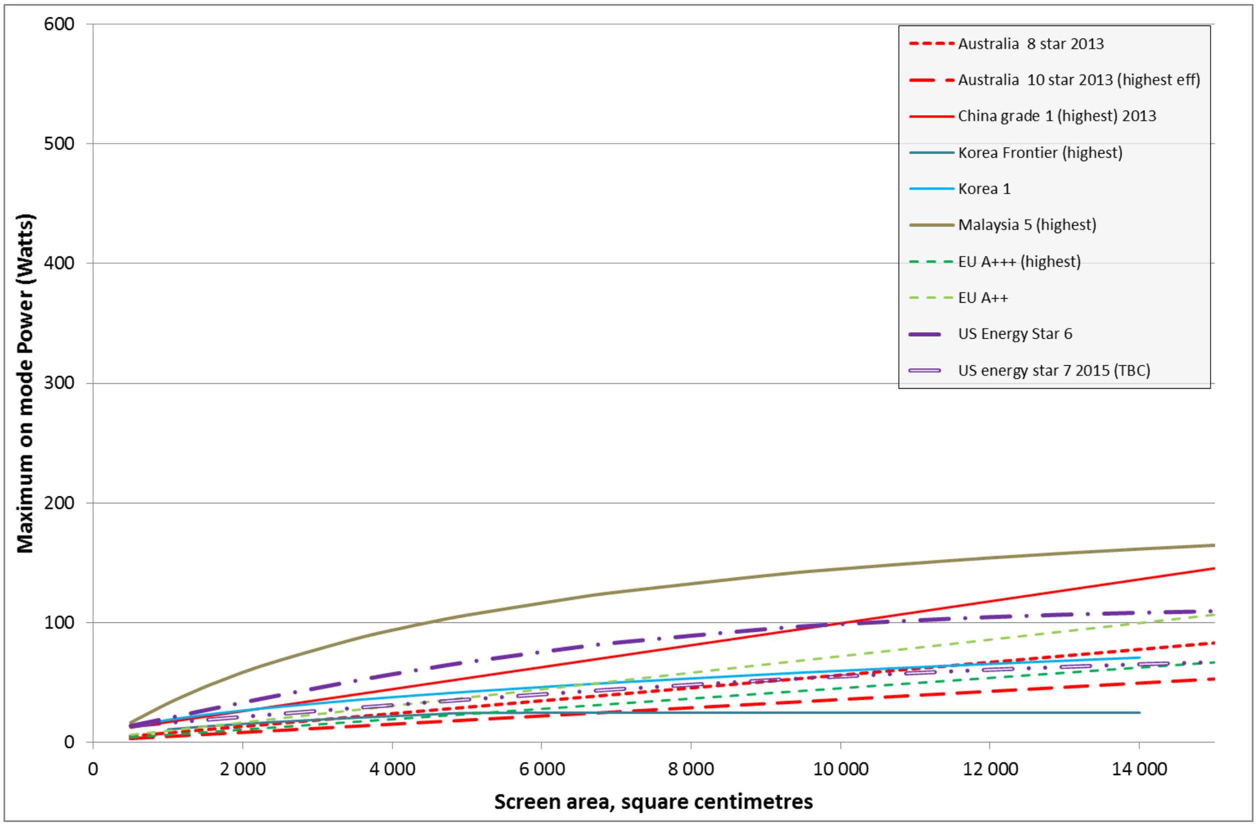


**Figure 7 - High efficiency and endorsement level policies.**

The EU label classes have a wide span in terms of efficiency range - mainly as a result of the relatively early introduction of the label (2010). It features low efficiency classes (that rapidly became redundant) combined with an ambition to be relevant until 2020, Due to the high rate of efficiency improvement, by 2013 nearly 70% of EU sales were in classes A and better, and 24% of TVs were already in classes A+ and A++[16] (for additional insights on the rapid progression of TV energy efficiency see report 4). Although there were no televisions with A+++ label at August 2014, the best TVs on the market had an EEI close to this threshold and it is likely that A+++ class TVS will appear on the market soon. As a result it was recognised that the ability of the label to drive further innovation and differentiate performance may not extend to 2020 as intended, and therefore adoption of a revised labelling scheme with more ambitious class thresholds is expected during 2015.

A few regions, including EU and Malaysia, already have MEPS that are located at reasonably high levels in their local label scale, and so have lost some of the effective range and a number of efficiency classes from their label. In order to avoid this, the entire range of efficiency classes in Australia and New Zealand was recalibrated in 2013.

As shown in the figure below, the Australia and New Zealand 10 star class is now the most ambitious criterion, followed by the 9 star class of the same policy, and the EU A+++ levels which are at the limit of 2014 TV efficiency. For screens above 7000cm$^2$ (50 inch diagonal), the Korean Frontier level is the most ambitious because it applies a maximum on

[16] European TV market 2007 – 2013, Energy efficiency before and during the implementation of the Ecodesign and Energy Labelling regulations Second report, complemented with 2013 sales data, Anette Michel, Sophie Attali, Eric Bush, Topten International Services, Zurich, Switzerland, 21th July 2014. Available from www.topten.eu/uploads/File/European_TV_market_2007–2013_July14.pdf.

power cap of 25W. These policies allow continued differentiation into 2015 and beyond as efficiency continues to improve.

The v7 ENERGY STAR criteria appear very ambitious, with only around 2% of 2013 TVs qualifying. However, the consequence of their new equation to calculate ABC is a reduction in the declared on-mode power, which is likely to result in a higher compliance rate. The analysis undertaken for ENERGY STAR criteria development suggested that 14% of TVs certified under the ENERGY STAR v6 criteria would qualify accounting for the new ABC approach9[17], with the selection of qualifying models being even greater by the time the specification comes into effect in October 30, 2015.

Other labelling policies show 60-70% of products qualifying for the highest rating, allowing little differentiation between product performance levels. The least ambitious criteria are seen for India, Vietnam and Malaysia. These levels were published in 2013 but already qualify around 75% of all models in the highest efficiency class. Their threshold for the highest class in fact coincides with the most stringent MEPS from China and California.

## Conclusions based on analysis results

In summary, the analysis of the policy initiatives and global data has suggested the following:

- **MEPS:** Tend to be set at a power demand three or four times lower than the best models on the market, but the wide range of efficiency allows significant scope for them to be tightened whilst retaining a wide consumer choice.
- **Labelling:** Ambition is essential in such a fast improving market, but often lacking. The highest efficiency classes in some areas coincide with the most stringent MEPS in others, and high proportions of products are quickly able to populate these classes. Some regions lose a number of efficiency classes from their label scheme due to local MEPS being specified higher up the labelling scale.
- **Policy threshold lines:** The approaches that have the best market distribution involve i) reasonably flat curved thresholds (based on technically relevant and easy to use formula), ii) fixed baseload allowances that don't reduce as thresholds become more stringent. Since there is no significant change in TV service or functionality as the screen technology changes, policies should not in principle discriminate by technology, otherwise they run the risk of inadvertently restricting research and innovation or even in promoting the deployment of less efficient technologies. Efforts to combine the display products and televisions in a single policy approach could provide a more level playing field but there is a risk of increased complexity and potential difficulty catering to the detailed technical needs of displays.

# Exploration of underlying reasons for divergence of policy

A considerable global variation in TV energy efficiency policy has been identified. There are many underlying reasons for differences in the level of ambition between EU, US, Australia, Singapore and others such as Korea, Vietnam, Malaysia which result in a different target level for the high efficiency class. This variance is likely due to:

- **Resources:** Expert insights have suggested that whilst laboratory capacity and technology can have an influence on policy and test method variance, in fact, testing facilities are similar the world over. However, variance could be due to limited budgets available to assess the market and develop requirements.
- **Policy and market evidence:** Insights available to policy-makers at time of setting policies.
- **Regional politics:** Both due to the prioritisation of energy efficiency concerns by government, and due to any political influence of local manufacturers resistant to change. A goal of policy frameworks may be to take a

[17] https://www.energystar.gov/products/specs/sites/products/files/EPACoverLetter_Draft1V7TVs_June2014.pdf

consistent approach – for example the 10 star classes of the Australia / New Zealand label. This may limit to what extent policy approaches can be harmonised.

- **Policy schedules / revision cycles:** Policies tend to become more ambitious over time, in line with the increasing efficiency of new TVs. If some regions do not update their requirements on a frequent basis they are likely to have less influence on the market. In addition, if policy schedules do not align with other global policy timings, inconsistent interim approaches may be adopted in order to meet deadlines.
- **Product mix and cost concerns:** There may be a reluctance to revise requirements toward greater stringency due to assumptions that this may impact product availability and cost.
- **Entrenched alternative approaches:** In some regions, alternative approaches may be the accepted norm or could be viewed as technically superior. There may be concerns about the impact of shifting to a harmonised approach, in terms of the loss of a historical body of testing data, doubts regarding the robustness of the approach and in terms of the cost of retesting.
- **Local technology availability:** For example a greater prevalence of the use of RF inputs in China (see Report 1)
- **Local economics:** Cost of TVs, electricity and compliance.

# 4. Toward greater harmonisation

## Improving test method harmonisation

Potential actions to work toward greater harmonisation on the various high priority issues are summarised below:

| Divergence area | Magni-tude | Explanation |
|---|---|---|
| **Illuminance levels and calculations (on- mode-with-ABC testing)** | H | I) Support harmonisation on illuminance testing levels in line with US DOE approach, whilst considering any potential refinements for international adoption.<br>ii) Support harmonisation of on-mode calculation accounting for ABC in line with US DOE approach, and inclusion of informative notes in test methods as appropriate.<br>iii) Test using US DOE approach to identify any potential refinements to test approach [see Report 3 Appendix B]. |
| **Luminance setting in TV sample preparation for on mode testing** | H | i) In the interim, consideration could be given to using only the central area of the luminance test pattern, or using an alternative luminance test pattern such as that being developed in CENELEC (see Report 2).<br>ii) In the medium term, options to reduce the frequency of adjustment during sample set up could include a minor revision of the Chinese GB standard to require that the tester to checks the default home mode and only adjusts it if the greyscale pattern is not displayed to an acceptable level.<br>ii) In the longer term, the work of standards bodies and stakeholders toward a more comparable, repeatable and preferably harmonised approach to sample preparation could be supported by appropriate studies building evidence on the repeatability of different international approaches and taking into account how these match with viewing requirements in the home. |
| **Need for revision to dynamic broadcast-content video signal** | H | i) Interim further testing to prove the need for a revised dynamic broadcast-content video signal, including development and testing of a sample dynamic broadcast-content video signal meeting the APL requirements to prove the solution of longer footage.<br>ii) (Via IEC formal processes) Creation of a test video signal with internationally sourced longer segments of footage that do not trigger picture technology in an unrepresentative way (see Report 2 Appendix C). |
| **Light source colour temperature and directionality** | M | Lamp specifications in international use should be further examined in order to find a harmonized method that is simple, repeatable, and reproducible. Approaches to consider could include alternative light sources such as projectors and/or refined approaches using lamps,that allow for consistent colour temperature during testing and resolve directionality issues requiring mechanically complex test rigs. Sample test material (where necessary) and test guidelines can be produced to act as a basis for test method refinement discussions. |
| **Test video signals for new formats (UHD and 3D)** | M | Compile and trial new test video signals with appropriate APL and share material internationally for interim use, providing any sample material to standards bodies to facilitate their revisions – see Report 2 report for further suggestions. |
| **Luminance testing approach (on mode testing)** | L | i) Definition of a clearly described international test approach for luminance testing. ii) Refinement of a luminance test pattern with a dynamic element - work on alternative test patterns in Europe (CENELEC group) could provide a starting point. There is an overview of recommendations on test patterns contained in "Appendix C – Test pattern / video signal recommendations" and Report 2 contains further details on testing results and suggested refinements. |

| | | |
|---|---|---|
| **Identifying ABC sensor location** | **L** | Provision of best practice guidance to manufacturers on how to specify accurate location coordinates of sensor location. |
| **Impact of TV stands in low illuminance (on-mode-with-ABC testing)** | **L** | i) Interim guidance on covering stands with non-reflective covers.<br>ii) Longer-term strategies relating to configuration of light sources to resolve the issue, and/or specifying the need to test without the stand.<br>Report 3 contains further details on testing results and suggested refinements. |
| **Use of RF vs HDMI inputs in sample preparation** | **L** | I) Interim suggestion of best practice guidance to encourage matching of calibration of inputs between manufacturers to reduce variation, as well as universal testing and declaration of HDMI tested results, even where RF results might be used in policy.<br>ii) Longer term, testing and research to determine the most relevant and robust approach to signal inputs and work toward harmonisation on this approach. |
| **Definitions and calculations relating to uncertainties** | **L** | Additional guidance in test standards and policy with regard to definitions of uncertainty for practical measurements and how uncertainty should be calculated. See draft guidance wording in Report 1 Appendix C. |

**Table 5 – Actions to move toward greater test method harmonisation**

This research has highlighted that one of the most beneficial developments in the test standards area would be the potential shift to a light source such as a projector, which (accompanied by appropriate test material) would allow for simplified and more robust setting of illuminance. It could reduce the severity of some of these aforementioned issues, due to the following:

- Easy, quick and precise setting of illuminance levels using computer-sourced test material slides
- Test material at very exact and easily adjustable light colour temperature,
- Easy control of illuminance without impacting light colour temperature between 0 lux and ABC cut off level,
- Illuminance can be readily changed in small increments between required testing points to characterise ABC control curve,
- Simplified test rig as no directionality issues
- Reduced problems with TV stand and other housing reflections due to projected image precisely framed to a small area around the ABC sensor

Other key areas for harmonisation include standardisation on the illuminance levels used for ABC testing, and incentives for ABC, and harmonised approaches to peak luminance levels in policy.

Above all, greater harmonisation of test approaches between Chinese and IEC approaches (principally in terms of screen luminance levels) is essential in order to allow future comparisons between China and other regions. There is no sufficiently robust current method to translate the results of individual tests between the two test approaches to be compared.

It is recommended that SEAD generate further discussion on the proposals put forward in this report and gain consensus on the way forward through active dissemination of this report to those within international, regional and national standardisation organisations concerned with televisions. SEAD could engage with relevant television test standard staff and committees particularly in China to make them aware of the report findings. Coordination with other initiatives in the area such as the EC funded ComplianTV project would also facilitate results dissemination.

# Improving policy harmonisation

## The benchmark 'reference threshold' concept

Based upon the implemented analysis, this study proposes a series of benchmark performance levels that policy-makers could use to set their own local MEPS and labels. For the purposes of this report, these are called 'reference thresholds' (RT) and are numbered RT1 for the highest power demand (poorest efficiency) to RT5 for the lowest power demand (best efficiency). Further reference thresholds could, of course, be added once technology emerges to merit it (RT6, RT7 etc).

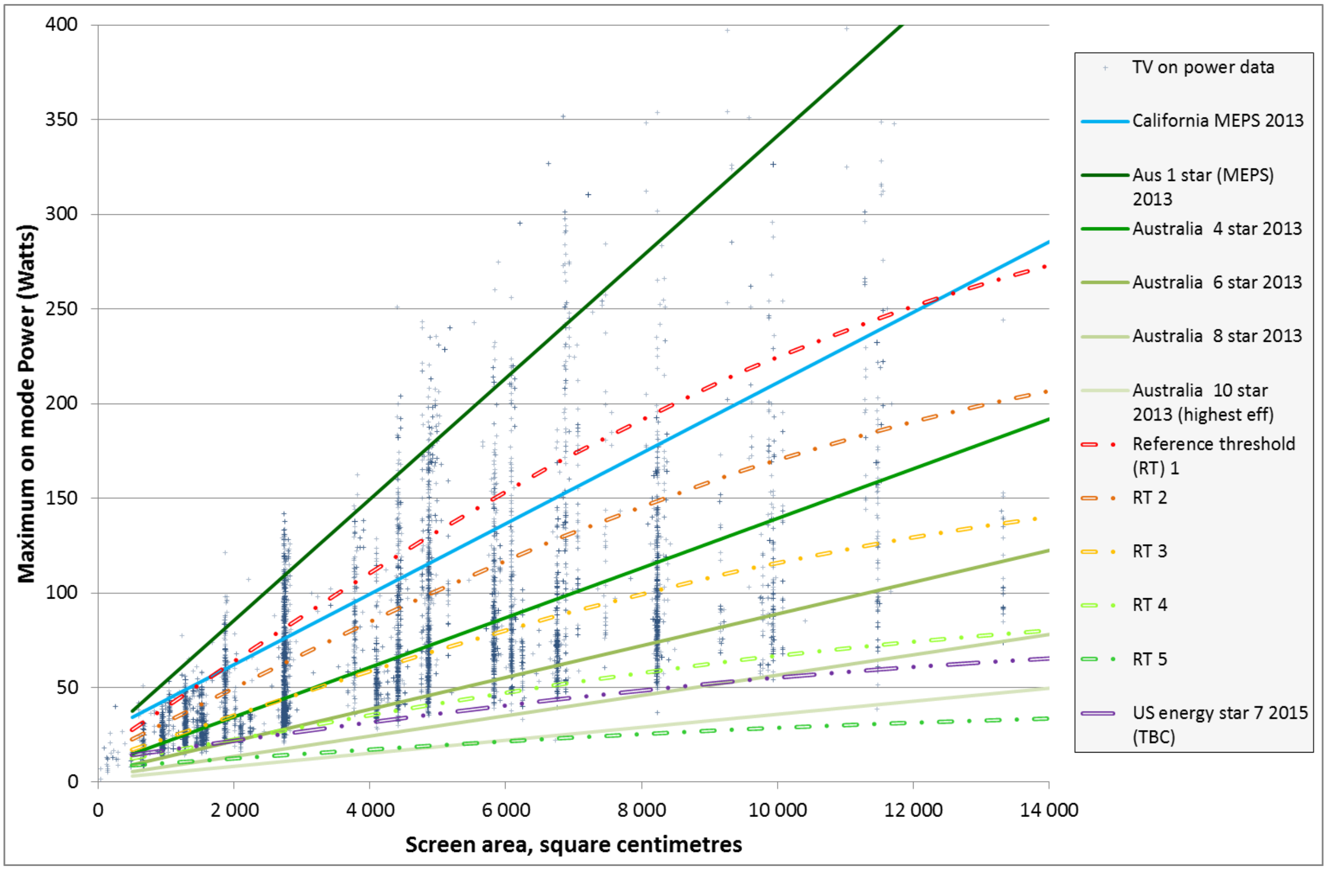


**Figure 8 - Proposed globally relevant reference thresholds (RT) for policy-makers compared with selected policy thresholds from Australia and the USA (California)[18].**

The five classes of benchmark performance levels provide an 'international ladder of performance', ranging from minimum requirements for a current average global market (class RT1) up to incentive performance levels for 2018 (class RT5). Labels and MEPS can be set at levels suitable for local economics and product availability, but if they are based around these reference thresholds, they will be globally coherent and easier and more cost-effective to enforce - benefitting both manufacturers and policy-makers.

[18] Data points for TV on power are from Australia & New Zealand, California and Energy Star data sets not including ABC.

The least ambitious reference threshold, RT1, is intended to act as the foundation for an introductory MEPS capable of removing the least efficient TVs from the market, particularly those of more popular screen sizes such as 42”. The other reference thresholds (RT2 to RT5) are designed around the following principles:

- **Reasonable lower thresholds:** moving up through RT2 and beyond, the intention is that these levels are not too restrictive, so that they allow for new technology developments such as OLED and Ultra High Definition. They should account for local economic demands, and allow reasonable product performance differentiation at higher power regions of the spectrum.
- **Ambitious upper thresholds:** RT5 has a high ambition and is sparsely populated at 2014, so allows headroom to accommodate market improvements as more TVs reach the current best technology efficiency levels.
- **Options to expand top thresholds further:** The approach taken allows for an unpopulated aspirational class better than RT5 to be developed to provide an incentive level to accommodate future technology and efficiency improvements.
- **Wide threshold range:** Reference thresholds have been designed for a wide range between the highest and lowest levels.
- **Screen-size and technology neutrality:** Thresholds include an appropriate baseload allowance that does not reduce as efficiency classes become more stringent so that they differentiate efficiency fairly across the range of screen sizes and technologies. However, as screens 13” and below appear to be significantly more efficient it is possible that these could be excluded from policy initiatives. There is no upper screen size limit, although the data used to set the levels only covers screens to approximately 70”.
- **Technically relevant and usable formula:** The curved threshold formula (based upon a hyperbolic tangent / “tanh” approach) has been chosen, based on ENERGY STAR criteria Version 7 equation. The basis is a reasonably flat curve using a simple equation to mimic the average performance curves for current and emerging technologies.
- **No functionality allowances:** There are no allowances for the number of tuners or for additional functionality such as hard drives as such ancillary functionality is not considered a core part of the TV service. Evidence does not suggest that these are widely available or widely demanded by the consumer.

For further technical details on the design of the thresholds, please see “Appendix E – Technical details of proposed reference thresholds” and Report 4.

## Regional considerations in applying reference thresholds

The data basis for the reference thresholds is mainly from Australia and USA, and whilst representing a wide range of efficiencies, it may not provide an accurate representation of all markets. Therefore, when applying the reference thresholds to different regions, the variability of product mix and power demand by region would need to be taken into account.

TVs are a globally traded product, and for the large brands, such as Sony, LG, Samsung and Panasonic, the same products are generally available globally with little regional variation. However, there is still potential for regional variation where there are regional manufacturers or variations in market composition. There may be a number of smaller brands and manufacturers with more limited regional markets. Examples of regional brands include Onida (India), Haier (China). Kogan (Australia), and Vizio (USA). Countries still involved in the production of older-technology TVs which may even still feature CRT models include India and China, with some assembly and distribution possibly occurring in Chile and Mexico. Due to the skilled workforce in India, it is possible that plasma and even CCFL LCD TV production lines may be dismantled from Taiwan and Eastern European countries and become established in India over the next few years. However there is now a very fine balance between the profitability of transporting an old technology TV production line and that of setting up a new technology assembly line. The manufacturing cost of LED–LCD displays is falling rapidly and therefore there is an opportunity for APEC government policy to incentivise new technology in favour of old technology manufacturing and assembly.

Regional brands generally, but not exclusively occupy the lower end of the market[19] with lower efficiency models. This is particularly the case in China where there are a number of smaller regional brands that have much larger market share in their respective domestic markets and limited international sales. However, higher efficiency regional suppliers can be found in the US, where average efficiencies appear better than Australian data sets despite Australian TV models being more recently registered. The difference appears to be due to variations in the small screen TV market, where more efficient models that are available in USA do not appear in Australian, European or Indian markets. In the US these TVs tend to be manufactured by small 2nd-tier or more local brands, so the higher efficiency may be due to differences in screen technologies (e.g. TN instead of VA or IPS panels) or lower default luminance settings used by these smaller companies[20].

While the proposed thresholds are believed to be a good initial balance, it is possible to adjust all the factors in the proposed formula. In particular, if a starting MEPS is being considered at the RT1 level in a country where there has been no previous TV policy activity, a less stringent line might be more appropriate. In order to account for market differences, at a basic level, policy makers could compare national average television consumption or efficiency data with the thresholds. Ideally a more detailed analysis would be undertaken to gather data on the current and pre-market models of regional brands and superimpose the reference thresholds over these data sets. RT parameters[21] could then be adjusted, if necessary, for a fit that ensures an appropriate minimum coverage of these brands for the policy type

Factors that can be considered in the context of such an analysis include:

- **Cause of market composition differences:** The extent to which any market differences are justified - for example due to availability of technologies or local economics (especially product prices).
- **Appropriateness of the fixed baseload:** At 7W in the suggested reference thresholds this is relatively high for a small TV compared to other policies that have consumption limits of 5W for the entire TV. The chosen value was based solely on the data available, rather than a technical analysis, and implicitly assumes an integrated tuner. The proportion of qualifying small TVs is extremely sensitive to this value – a 1W change can increase the number of TVs by 10%.

## Key policy harmonisation messages

The ideal approach to TV policy would be a foundation of a single global MEPS based on a harmonised test method. Production lines for CFL backlit (older LCD) screens have largely been shut down and only existing stock is filtering through the supply chains. Setting up global MEPS would help avoid dumping of old product into developing markets.

However, it is possible that some locally adjusted and transient standards that are less stringent may be justified if a legacy product is necessary for economic reasons. However, with regard to newly manufactured products, the goal of

[19] Unfortunately, the test data available was limited to Australia and USA, and did not cover markets such as China and India where the greatest variation is expected. While TV efficiency data is publicly available for the Chinese market, the test standard means that the data is not comparable. In addition, the efficiency data does not include additional information such as actual power consumption and screen size, which is needed to make accurate comparisons.

[20] While the brightest picture settings for most medium and large TVs are in a range of 300-500 cd/m2, there is less rationale for such a high luminance setting for smaller TVs as these are i) mostly viewed from closer distance and ii) typically bought by more price sensitive consumers than larger TVs. As such, the highest luminance for small TVs is set typically in a range of 200-300 cd/m2). Input from Won Young Park, Lawrence Berkeley National Laboratory, Oct 29 2014.

[21] In particular the Zclass factor to move the entire curve, and the fixed baseload to adjust the smaller TV threshold – see "Appendix E – Technical details of proposed reference thresholds" for details.

MEPS for all TVs should be to set these at global stringency. Where there are significant differences in market composition and regional manufacturers there may need to be some degree of short-term adaptation of the reference threshold approaches, but with appropriate policy signalling (including APEC government drive toward production of more efficient TVs), models produced locally to developing markets should all be able to meet the global MEPS. The end goal should be to strive to the RT1 level as a minimum. This will also have the advantage of ensuring lower compliance and market surveillance costs to both manufacturers and enforcement authorities.

Guidelines could assist policy makers in initiatives to achieve cost effective efficiency improvements in televisions – for example:

- Information on the trend toward larger screen sizes, and the impact these have on increasing energy consumption of televisions.
- Insights on the ranges of energy efficiency in the television market by technology and screen size.
- Detail of potential risks of failure to implement energy efficiency policies – such as the risk of un-regulated markets becoming flooded with the least efficient products that cannot be sold elsewhere.
- Information on policy cost and potential savings to support a shift toward specification of a highest energy efficiency level that is feasible but not expected to occur in the absence of further policy action[22], including:
    a. The efficiency improvement and cost savings that may occur even in the absence of further policy action.
    b. The additional efficiency improvement and cost savings that could be achieved through improved harmonisation and standardisation.
- Steps to apply the Reference Threshold approach in their region, supported by the provision of electronic tools and training.

# Dissemination of project results

It is recommended that CLASP disseminates the findings of this report to key national policy makers and those within international, regional and national standardisation organisations, particularly the IEC/ISO and regional committees concerned with televisions. This will help to generate further discussion on the proposals put forward in this report and gain consensus on the way forward.

The following specific initiatives, on-going in Q3 2014, present opportunities to address actions from this report[23]:

- **EU TV regulation development:** Revision of EU ecodesign and energy label requirements for TVs, led by the Directorate-General for Energy (DG ENER) of the European Commission. Interim results of this work have already been communicated to the team undertaking technical policy research work for DG ENER, and further dialogue could be beneficial to ensure that recommendations are taken into account by DG ENER
- **US ENERGY STAR endorsement label development:** The update of the US ENERGY STAR criteria for TVs to version 7 was completed in December 2015. Some level of alignment of these recommendations is already achieved since the form of equation proposed in the Reference Thresholds is the same as that used by ENERGY STAR.
- **EU funded research in TV testing:** EU funded project ComplianTV[24] has the objective to assess the compliance of TVs in the context of up-coming new Energy Labelling and Ecodesign regulations. The project aims to clarify interpretation of test methods and to educate test labs – picking up several of the key issues identified in this

[22] Suggestion from Won Young Park, Lawrence Berkeley National Laboratory, Oct 29 2014.
[23] Note that China updated its TV requirements in 2013, with no further update in current view.
[24] http://www.compliantv.eu/eu/about-the-project/home.

report. Links with the ComplianTV project managers have already been established, with reciprocal sharing of interim results.

- **Australia regulation development:** Australia completed a regulatory update in 2012. Requirements for 2018 and 2023 are currently in preparation.

# Appendices

# Appendix A – Global test methods

A list of international standards is shown in Table 6 - whilst many have different references, there are often areas that are harmonised with IEC standards.

| Economy | Test Method/Standard and consistency with IEC 62087 | Significant policy additions and amendments to test standard |
|---|---|---|
| **Australia** | AS/NZS 62087.1:2010<br>Harmonized with IEC 62087 | AS/NZS 62087.2.2:2010.includes the addition of peak luminance testing and home mode peak luminance requirements. |
| **California** | IEC 62087 ed2<br>IEC 62301 ed1 | Includes peak luminance testing and home mode peak luminance requirements |
| **Canada** | CAN/CSA-C62301-07 (Harmonized with IEC- 62301) | |
| **Chile** | IEC 62301 | Policy only covers standby power |
| **China** | GB 24850-2010<br>Luminance and contrast must be adjusted based on specified procedure and test pattern. | Requires testing of static image on-power |
| **EU - current** | IEC 62087 | Includes peak luminance testing and home mode peak luminance requirements |
| **EU - proposed** | No name<br>Expected to be harmonised with IEC 62087.3 | |
| **Hong Kong, China** | IEC 62087 ed2<br>IEC 62301 ed1 | |
| **India** | IEC 62087<br>IEC 62301 | Includes peak luminance testing and home mode peak luminance requirements |
| **Japan** | IEC 62087 Ed 2 Harmonised | |
| **Malaysia** | IEC 62087 Edition 2.0: 2008<br>MS IEC 62301:2006 | |
| **Mexico** | NMX-I-122-NYCE | Only sets standby power requirements |
| **New Zealand** | See Australia | See Australia |
| **Korea** | KS C IEC 62301<br>KS C IEC 62087 | |
| **Chinese Taipei** | ENERGY STAR Program; IEC 62087 (On Mode); IEC 62301 (Standby Mode) | |
| **Russia** | Not clearly specified. | Recommends aligning efficiency (and therefore testing) with EU but is not mandatory |
| **Singapore** | IEC 62087<br>IEC 62301 | |
| **Thailand** | IEC 62301 | Standby only |
| **The Philippines** | PNS IEC 62087:2013<br>PNS IEC 2301 | Proposed regulation is harmonised with |
| **The US** | 10 CFR Part 430 Subpart B App H , Includes peak luminance and ABC testing methodology | |
| **Vietnam** | IEC 62087<br>IEC 62301 | aligned with EU |

Table 6 - Countries with established TV test methods

# Appendix B - Global television policies

Table 7 - Overview of policies relating to televisions for economies investigated.

| Economy | Policy type* | Year published | Policy reference source | Metric(s) used |
|---|---|---|---|---|
| | ***APEC economies*** | | | |
| Australia and New Zealand | Mandatory MEPS and comparative efficiency label | 2012 | ANZ 62087.2.2-2011 | Annual energy consumption calculated from on power and standby (active, passive), compared against reference TV energy of same screen area. |
| Canada | Mandatory MEPS | 2011 | | Standby power only |
| China | Mandatory MEPS and comparative efficiency label | 2013 | GB24850-2013 | On power compared against reference TV of same screen area, screen technology and luminance |
| Hong Kong, China | Voluntary comparative efficiency label | 2013 | Hong Kong Voluntary Energy Efficiency Labelling Scheme for Televisions August 2013 | Same as EU with minimum standby power requirements |
| India | Voluntary comparative efficiency label (mandatory from January 2015) | 2014 | Schedule No. 11 Color Televisions, Revision 4. | Annual energy consumption calculated from on power and standby, compared against reference TV energy of same screen area and screen technology. |
| Japan | Mandatory MEPS | 2010 | | On power compared against reference TV of same screen area, screen resolution, number of additional functions, screen technology and screen refresh rate |
| Malaysia | Mandatory MEPS and comparative efficiency label | 2013 | Electricity (Amendment) Regulations 2013 | Energy efficiency calculated from screen area per kWh annual energy consumed, compared against reference TV energy efficiency. Annual energy consumption calculated from on power and standby (active, passive). |
| Mexico | Mandatory MEPS | 2013 | NOM-032-ENER-2013 Limits for electric power equipment and appliances that require standby power. Test methods and labelling | Standby Only |
| New Zealand | Mandatory MEPS and comparative efficiency label | 2013 | ANZ 62087.2.2-2011 | See Australia |
| Russia | | | | |

| Economy | Policy type* | Year published | Policy reference source | Metric(s) used |
|---|---|---|---|---|
| Korea | Mandatory MEPS and comparative efficiency label | 2012 | MKE 2012-320, Regulation on energy efficiency standards and labelling | Energy efficiency index calculated as on-mode power per square root of screen area. |
| Singapore | Mandatory comparative efficiency label | 2013 | Singapore Statute 557 | On mode power requirement based on screen area |
| Chinese Taipei | Voluntary high efficiency endorsement label | 2009 | | On mode power requirement based on screen area. Standby power requirement. |
| The Philippines | | | | Still being developed |
| Vietnam | Mandatory MEPS and comparative efficiency label | 2013 | TCVN 9536:2010 | Energy efficiency compared against reference TV of same screen area. Includes passive standby limits. |
| USA | Voluntary high efficiency endorsement label | 2015 | ENERGY STAR® Program Requirements Product Specification for Televisions Eligibility Criteria Version 7 | On mode power requirement based on screen area. Includes standby power and Download Acquisition Mode energy requirements. |
| USA - California | Mandatory MEPS | 2012 | CEC-400-2012-019-CMF 2012 Appliance Efficiency Regulations | |
| | ***Non-APEC economies*** | | | |
| EU | Mandatory MEPS and comparative efficiency label | 2009 MEPS<br>2010 Label | | Energy efficiency compared against reference TV of same screen area. Includes passive standby limits. |

**Policy types: MEPS = Minimum Energy Performance Standards; CL = Mandatory Comparative Labels; VL = Voluntary Comparative Labels; VE = Voluntary Endorsement Labels; VC = Voluntary Certification; VS = Voluntary Specification; F = Financial Incentive; P Government Procurement; FA = Fleet Average.*
*Note: No data was found for Indonesia and Thailand so they are not included in the table.*

**Table 8 – Observations on similarities between TV policy approaches**

| Economy | MEPS efficiency threshold | Lowest efficiency class | Highest efficiency class | Comments |
|---|---|---|---|---|
| ***APEC economies*** | | | | |
| Australia | Low | Low | Very high | Most ambitious criteria and the highest number of efficiency levels (fifteen). |

| Economy | MEPS efficiency threshold | Lowest efficiency class | Highest efficiency class | Comments |
|---|---|---|---|---|
| Canada | | | | Standby only. |
| China | High | High | Medium | Comparison is based on IEC 62087 testing of on-mode power, however China uses a different test standard which means comparison may not be representative. |
| Hong Kong, China | | Very low | Low | Largely based on EU efficiency metric ranging from the labelling class G to B. |
| India | | Medium | Low | Staggered metric with specification of future efficiency criteria for 2014, 2015 and 2017. |
| Japan | Low | | | The large number of variables creates 20 CRT TV efficiency categories and 64 LCD and plasma TV categories |
| Malaysia | Low | Low | Low | Energy efficiency measured in screen area per unit energy - the inverse of the more common power/energy per unit screen area. |
| New Zealand | | Low | Very High | See Australia |
| Russia | | | | No mandated efficiency metric |
| Korea | | Very Low | Very High | Power per square root of screen area (unique). |
| Singapore | | Low | High | Based on EU efficiency classes from C to A++ |
| Chinese Taipei | | | Medium | Based on ENERGY STAR v5 |
| The Philippines | | | | Not yet published |
| Vietnam | | Low | Low | Largely based on EU efficiency metric ranging from the energy class D to B. |
| USA | | | High | ENERGY STAR is based on a revised ABC calculation which greatly reduces the TV on-mode power declared by manufacturers. One of the most ambitious criteria. |
| USA - California | Medium | | | Baseload allowance is high, allowing a high number of small screens to qualify |
| ***Non APEC economies*** | | | | |
| EU | Very low | Very low | High | New mandatory higher efficiency classes to be introduced in 2014, 2017 and 2020. One of the most ambitious criteria at the higher end. |

# Appendix C – Test pattern / video signal recommendations

The table below summarises the recommendations stemming from the Report 2 analysis of test patterns and test video signals for TVs in IEC 62087.

| Test pattern / Video signal | Interim recommendations | Recommendations for next IEC 62087 revision |
|---|---|---|
| Dynamic broadcast-content video signal (TV) | • Testing using a "mock-up" longer sequence test video signal to provide evidence to support revision.<br>• Gathering of internationally sourced footage<br>• Reassessment of global APL | • Revision to a global test video signal combining short and normal, longer pictures sequences, adjusted for global APL via active engagement with stakeholders in the revision process. |
| Dynamic broadcast-content video signal (internet) | • Re-examine global APL for internet usage via international testing. | • Specify same test video signal as for TV viewing, but with tailored internet APL. |
| Luminance test pattern | • Continued refinement of the European luminance test pattern and of test procedures around luminance to improve measurement reliability.<br>• Testing to provide supporting evidence for new procedures and test patterns. | Revision of the luminance test pattern to one that features:<br>• Proportionately-sized white area.<br>• Grey rather than black.<br>• Different patterns for different screen size ranges.<br>• Inclusion of motion. |
| 3D-content test video signal | • Convert existing dynamic broadcast-content video signal from 2D to 3D, whilst retaining a suitable APL, distributed to parties undertaking testing to ensure standardised results. | • Compile a representative 3D sequence adjusted for relevant APL by i) sourcing international 3D-content test video signal footage, ii) Gathering data on appropriate APL for 3D material. |
| UHD-content test video signal | • Create and distribute a test video signal from a standard HD-content video signal, up-scaled to native UHD resolution.<br>• A study to determine representative APL for UHD broadcast content. | • Produce a specialist UHD sequence, containing internationally-sourced outdoor and indoor sequences in UHD –either i) specially filmed or ii) sourced from broadcasters / service providers. Should be adjusted to relevant APL. |

Table 9 – Summary of test video signal and test pattern recommendations

# Appendix D - ABC testing and policy recommendations

This appendix contains a summary of the findings from an investigation into policy and testing around ABC technology contained in Report 3.

Key testing priorities are ensuring:

- Clarity of sensor location
- Elimination of variations caused by TV stands
- Light source without colour temperature variation of directionality issues

Different policy initiatives provide different incentives for ABC functionality being enabled as default. The table below summarises the findings of the assessment of these approaches:

| Policy initiative | ABC incentive | Comments | Recommendation |
|---|---|---|---|
| US DOE Rulemaking | Even 25% weighting at 3,12, 35 and 100 lux to calculate on mode with ABC. | Our analysis of data suggested the following distribution:<br>30% at 3 lux,<br>30% at 12 lux,<br>20% at 35 lux, and<br>20% at 100 lux<br>Therefore, the 25% assumption is reasonably representative (our modelling suggests it is only around 3% off) and conveniently standardised across the 4 levels. | Support harmonisation to US DOE approach.<br>Provide additional guidance on effective testing with ABC to ensure:<br>• Clarity of sensor location<br>• Elimination of variations caused by TV stands<br>• Light source without colour temperature variation of directionality issues |
| EU Ecodesign regulation and related energy label | The on-mode power consumption as established according to the procedure set out in Annex VII is reduced by 5% for ABC enabled TVs. | Results show that ABC can realistically save between 15% and 25%, and therefore a higher incentive could be considered. | Consideration should be given to incentivising ABC functionality via regulation – for example allowing a more favourable on mode calculation if "good ABC" is implemented in line with an ideal curve. |

Table 10 – Policy approaches to ABC incentivisation.

# Appendix E – Technical details of proposed reference thresholds

A proposed collection of efficiency classes has been defined based on the ENERGY STAR v7 equation, which is:

$$Power = 65\tanh\big(0.02 + 0.0005(screenarea - 140)\big) + 15$$

Where the screen area is measured in square inches.

In order to create a number of different reference thresholds, a variable called $Z_{class}$ is inserted. In addition the equation is converted to metric square cm units.

$$Power = ABCfactor * Z_{class}\big(65\tanh\big(0.02 + 0.0000775(screenarea - 900)\big) + 5\big) + 7$$

Where:

- *ABCfactor* is the adjustment to account for whether ABC is taken into account in the declared data or not – and/or to account for differences in the way ABC power calculations are specified under different regional policies.
- $Z_{class}$ is the multiplication factor used to set each separate reference threshold (one $Z_{class}$ factor produces the RT1 line; another produces the RT2 line etc).
- Tanh is the hyperbolic tan mathematical function used to define the curve; tanh provides a curve shape that correlates with what is arguably desirable from a policy perspective (see discussion below).
- *Screenarea* is the visible screen area measured in $cm^2$.
- '7' is representative of the fixed baseload in W which does not change with efficiency class (see discussion below).
- '5' is the variable part of the baseload which changes with the efficiency class (see discussion below).
- The other factors (65, 0.002, 0.0000775, 900) are proposed to define the curvature of the tanh function to match the data and fairly distribute the efficiency class across the screen sizes (see discussion below).

**ABCfactor**

ABC functionality can reduce the power consumption by one fifth or more[25]. The exact reduction depends on the technology used and the testing methodology. The policy thresholds proposed in any given situation must therefore take into account whether ABC functionality is allowed under the test methodology proposed to underpin the policy - and therefore whether the energy consumption declared by manufacturers has been reduced under the influence of ABC control. If a given data set does not allow ABC to be taken into account, then the reference thresholds must be raised (made less stringent) by around 20%. Hence the ABCfactor has to be set equal to 1.2, if the other numerical factors remain as proposed above. If the data set/market declares data that does take into account ABC then no adjustment is required and the ABCfactor is set to 1. The EU Energy label allows the power consumption to be reduced by 5% if ABC is enabled. Therefore, the ABC factor should be reduced by 0.05 from the no ABC case, ie ABCfactor 1.15.

[25] Examination of TV data that underpinned the ENERGY STAR v6 criteria suggests that including ABC functionality results, on average, in around a 20% reduction in energy consumption

| ABC approach | *ABCfactor* |
|---|---|
| If the policy and data set does not allow ABC to be activated when calculating on power | 1.2 |
| If the policy allowance for calculating ABC on power is the same as ENERGY STAR (ABC is allowed) | 1 |
| **EU Energy label policy with 5% reduction for ABC** | 1.15 |

Table 11 - ABC factor definition

In order to set the reference thresholds (RT1 to RT5), the $Z_{class}$ variable can be defined as in Table 12.

| Reference Thresholds | $Z_{class}$ value |
|---|---|
| **RT 5 Highest performance threshold (aspirational)** | 0.4 |
| **RT 4** | 1.1 |
| **RT 3** | 2 |
| **RT 2** | 3 |
| **RT 1 Lowest performance threshold** | 4 |

Table 12 – Reference thresholds as defined by the equation term $Z_{class}$.

This numbering approach allows for the addition of more ambitious classes over time through insertion of values for $Z_{class}$ lower than 0.4. The ambition of the classes is illustrated in the chart below, in relation to thresholds within the Californian MEPS and Australia / New Zealand star since these are both ambitious policies pitched appropriately for the 2014 market: