PEET Workshops 2021

Televisions: 21 October 2021

- Attached is the discussion document prepared for the 4E PEET discussions on Televisions.
- Participation in the online forum is limited to 4E Member countries, although each Member is allowed multiple participants.
- All participants will need to **register in advance** to attend. Please register on the 4E Members site here:

  https://www.iea-4e.org/events/members-peet/peet-workshops-2021-electric-motors-509/
- Once you have registered, meeting details and the Agenda will be forwarded to you

	21 October *Start times*
New Zealand	23.30
Australia	21.30
Japan/Korea	19.30
China (Beijing)	18.30
EU	12.30
UK	11.30
Nth America (East)	6.30

The following questions arise from the discussion document on televisions produced by Paul Waide and may be worthy of further consideration.

In addition, if you have any specific questions relating to policies for televisions that you would like answered, please forward these to Mark Ellis (mark@energyellis.com):

Q1: There are considerable differences between the scope of regulation in 4E countries with respect to TVs, monitors and signage. Should we try to harmonise the scope, including defined exclusions, and should this be based on functionality or on technology?

Q2: There is some potential to extend the coverage by regulating panels and/or other components individually instead of the entire product. Would this approach have further advantages or do we think that these are outweighed by the disadvantages?

Q3: There appears to be differences in the regulatory treatment of new technologies such as MicroLED, in 4E countries, which have efficiency potential but may struggle to reach current thresholds initially.

In general, should these be included (to provide a driver to improve) or treated as a distinct category? For example, one approach is to set technology-specific MEPS for specific emerging technologies that are progressively ramped up, perhaps based on learning curves, until they can be safely treated on the same as more mature technologies.

Q4: We see large differences in the thresholds used in different 4E countries for essentially the same products, which are not fully explained by differences in test methods and metrics.

Is this mainly due to the differences in the revision cycle (i.e. performance of products at the date of implementation), or differences in the way that MEPS and label thresholds are determined (i.e. based on market or economic factors)?

Background document to PEET 2021 discussion of televisions and electronic displays

September 2021

Prepared for IEA4E by:

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PEET efficiency trends analysis 2021

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Glossary

ABC	automatic brightness control
AV	audio-visual
HD	high definition
HDR	high dynamic range
IEA	International Energy Agency
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization
MEPS	minimum energy performance standard
NA	not available (or applicable)
PEET	Product Energy Efficiency Trends project
Rating	the set of rated values and operating conditions
Rated value	a quantity value assigned, generally by a manufacturer, for a specified operating condition
TR	Top Runner
UEC	unit energy consumption
VOIP	Voice over Internet Protocol

1. Introduction

This report presents 2021 findings of the IEA 4E Product Energy Efficiency Trends (PEET) project. This work follows upon previous PEET projects but applies a different methodological approach as follows. For the PEET 2021 work a survey was sent to each 4E member economy to request information on:

- changes made to product energy efficiency regulations and test procedures in the period of July 2020 to June 2021
- pending changes to product energy efficiency regulations and test procedures in the period of July 2021 and beyond.

In order to ensure a consistent approach when discussing application of policy measures and test/methodological standards the convention applied in this report is to reference them based on when they enter into effect and not when they are first issued.

Based on the findings received and processed in July 2021 it was decided to conduct in-depth investigations into the developments in energy efficiency regulations and test procedures applicable to the following four product groups:

- Electric motors
- Televisions (and when relevant) electronic displays
- Domestic refrigeration appliances
- Room air conditioners

which constituted the set of products where the greatest changes in 4E economy regulations had occurred or were pending within the periods in question.

The analysis presented in this report addresses each of these products in turn and is being developed according to the following indicative timetable.

Proposed Date (webinar)	Topic/scope	Draft Report	Final Report
4-8 October	Electric Motors	09-Sep	30-Sep
18-22 October	Televisions	17-Sep	04-Oct
15-19 November	ExCo week		
29 Nov-3 Dec	Domestic Refrigeration Appliances	08-Nov	22-Nov
13-17 Dec	RAC	22-Nov	06-Dec

For each product the analysis presents:

- A summary of the of the existing regulations in place per 4E economy and the recent or pending changes
- A comparison of the scope of the regulations in 4E economies
- A comparison of the efficiency levels applied in the 4E economies.

For the comparison of efficiency levels normalisation methods are applied (either as per previous PEET work or amended/updated as explained in each case).

Whenever relevant a synthesis of necessary information on test procedures and/or product types is provided but only to the extent that it facilitates the above analyses and their communication.

The intention of this work is not to produce a definitive account or public facing report but to foster and facilitate a common basis for discussion of the issues addressed among 4E members. This report will not be published and is solely for 4E member's use. It is also a living document being added to per the schedule outlined above.

This specific report presents background information to inform the discussion on televisions and other electronic displays.

2. Findings for televisions and electronic displays

This report discusses the status of 4E policy measures (MEPS/Top Runner/labelling) for televisions (TVs) and other electronic displays including recent or pending changes. In doing so it considers and compares the policy measures in terms of:

- the type of regulation (MEPS/Top Runner, Energy Labels)
- the principal type of TV/electronic displays addressed
- the characteristics of the principal TV/electronic display types which are within or without of scope
- the level of stringency of the policy requirements.

For the purposes of this exercise the following principal types of display are considered:

- televisions (TVs)
- computer monitors
- digital signage displays.

These distinctions are used because they correspond to the main display types that are treated within 4E economy regulations which in-turn map to the most important types of display types found in the market; and, consequently, that have the greatest energy savings potential from the adoption of energy saving regulations. However, it should be remembered that there are other, less important, electronic display types that are currently not subject to energy efficiency regulations in 4E economies. Often product energy efficiency policy measures are related to the existence of replicable standards for measurement and the rating & classification of energy efficiency. Thus, the discussion considers test procedure and standardisation developments when relevant to the policy development and comparison discussion. The remainder of the report is structured as follows:

- Section 3 provides a summary of electronic display types and major standards
- Section 4 summarises the status of the regulations in the 4E economies
- Section 5 compares the scope of the electronic display regulations in place for each of the principal display types
- Section 6 reports findings on the comparison of the stringency of the TV regulations in force (or that are pending)
- Section 7 proposes potential topics for discussion among 4E policymakers.

3. Summary of electronic display types and major standards

Before exploring the developments in electronic display energy efficiency regulations its useful to consider the major types of electronic displays and how they can be grouped for comparison of regulatory measures.

Electronic displays cover a very wide variety of products and technologies and are integrated into a wide range of products. They can encompass a small 8 segment status display at the smaller end of the size scale up to a 100m long digital billboard display.

To simplify the comparison applied in this report, the following five broad categories are defined although there will be some overlap among them:

- Televisions – for display of AV signal
- Computer monitors – for close and single person viewing connected to a computer
- Signage/ambient displays – for public and/or non-focussed viewing, often long range
- Specialist displays – with specific industry/professional applications
- Integrated/combined – The display in an integrated/combined display is integral to the primary function but not in and of itself the primary function. Two different names are included due to different naming within legislation. This includes the whole range of personal computing devices from smartphones to all-in-one desktop computers, but also conference calling and other products. The display also makes a significant contribution to the product power consumption.
- Sub-component displays refers to the display sub-component in any product type, including the categories above. It also covers the whole array of products which incorporate a display but with ever decreasing role in the primary function of the device (and will likely affect its significance to power consumption).

The main distinction between the TV, monitor and signage display product types is the distance, number of viewers and the room illuminance levels. This will mainly affect the screen brightness, pixel density and viewing angles which in turn influence the screen technologies used.

However, the definitions in regulations are not written to provide a clear and consistent distinction between products categories. Computer monitors are defined in the EU as being 'intended for close-viewing' but TVs do not mention viewing distance at all. Instead TVs must have a tuner and be intended for viewing audio visual signals. This creates potential overlap such as a close viewing device with a tuner, and gaps such as a large display not suited for close viewing but with no tuner. How this impacts regulation depends on how the requirements are formulated for each category.

The latter two categories are defined in a number of 4E jurisdictions but are not regulated.

The differences in display function for televisions, monitors and signage displays can be reduced to the following set of technical factors:.

- Screen size which is already addressed by all jurisdictions
- Sustained screen brightness which is related to viewing distance and addressed in many test methods but is only treated as a variable in China's efficiency metrics
- Screen technology which is partially addressed in some jurisdictions and also determines many of the image quality factors below.
- Image quality

  - Screen resolution and pixel density
  - Colour gamut (and accuracy)
  - Peak brightness (for small regions and short periods of time) and ratio peak:sustained brightness
  - Native refresh rate
- Lifetime (signage is used continuously).

The effect of screen size on power is best understood - power increases linearly with area[1] - and is the most significant factor because size varies so much within a display category. It is clear that screen brightness is equally as significant (power increases slightly quicker than linearly with luminance) but historically there has been less variation within a category. Screen technology and pixel density also play a smaller role and are not addressed in all metrics. While these factors are similar within a product category (e.g. TVs have similar brightness and almost all use Vertical Alignment[2] LCD panels) this may not be true across product categories. As a result, it is hard to get an accurate understanding of efficiency patterns across these categories.

These factors are also important for the displays in integrated devices but less so for sub-components displays which are not critical to the product functions. Specialist displays by definition have special requirements that play an over-riding factor on the design and possibly power consumption (e.g. colour accuracy for professional photo/video editing displays). Consequently, they are more likely to be outliers when compared to displays with more typical feature-sets.

Undertaking a larger data collection effort could be useful to establish how much these factors influence efficiency across all display types since much of this data is currently unavailable for use within regulatory processes or is not comparable. There remains the question of how to establish a large enough dataset and how accurately each factor needs to be measured to fulfil the regulation-making process for establishing a relationship between each factor and power consumption. This level may differ in each 4E jurisdiction. Nonetheless, it is clear that sustained brightness is increasing across all consumer devices (in addition to screen size) and will influence power demand. The availability and consumption of 4K video and higher screen resolutions as well as marketing, e.g. 'Retina', HDR display, has also driven image quality much higher for mid- to high-end consumer devices and they are tending to converge. This may mean comparison is becoming simpler across display types, however, low-end devices still exist such as basic computer monitors suited for office work and not video.

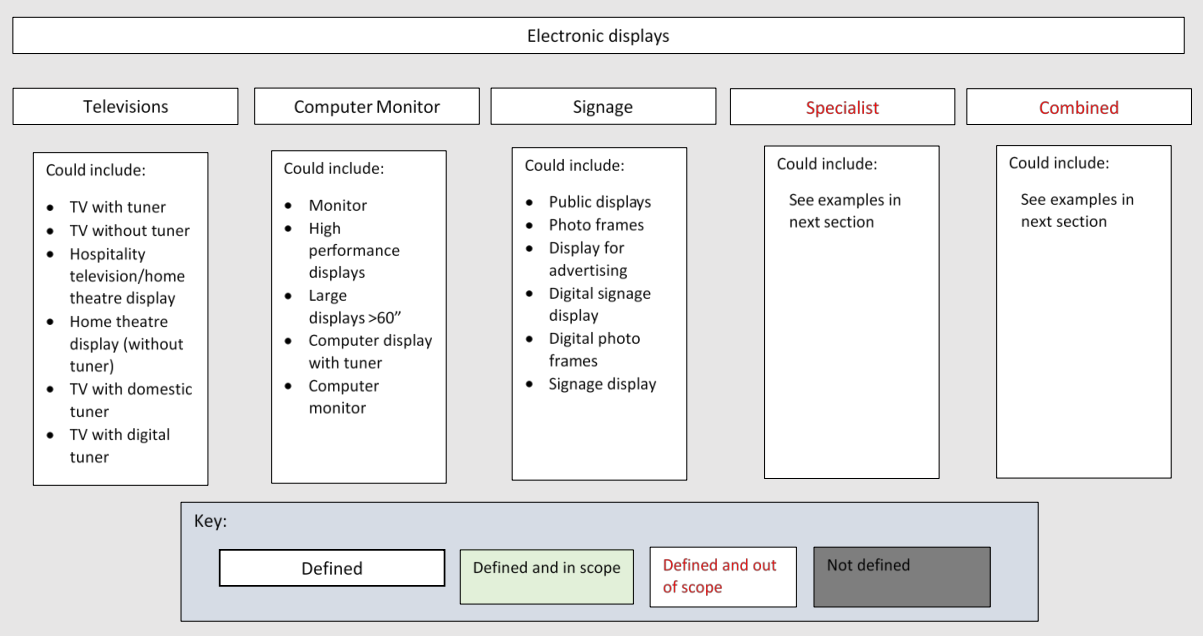
Figure 1 shows the classification of electronic display types applied in this report which shows they can be broadly divided into:

- Televisions
- Computer monitors
- Signage displays
- Specialist displays, and
- Combined/integrated displays

Each of these in turn can be further subdivided into sub-types. More details on this classification and its rationale are provided in the Appendix.

[1] Non-linear metrics such as EU tanh function is accounting for pixel density.
[2] A type of LCD technology offering good viewing angles and colour gamut for TVs

Figure 1: Types of electronic display considered in this report



Approach to electronic display type groupings applied in this report

As mentioned in section 2 the following principal types of electronic display are considered in the summary of 4E policies presented in section 4:

- televisions (TVs)
- computer monitors
- digital signage displays.

But the discussion of policy scope presented in section 5 considers all the types of display shown in Figure 1. This is for pragmatic reasons as to the best of the authors knowledge there are currently no 4E member policies targeting the specialist and combined display types.

For the practical reason that a benchmarking (normalisation) method has only been developed for TVs the comparison of the stringency of the policies in section 6 only addresses TVs.

Summary of developments in test and rating standards relevant to electronic displays

See section A.2 in the Appendix.

4. Summary of TV and electronic display policies in 4E economies

Due to regional regulatory harmonisation for the purposes of comparison the following groupings of economies can be applied:

- Australia and New Zealand
- Canada and the USA
- The EU, Switzerland and the UK

Thus, these economies are grouped under the same colour coding and are believed to have the directly aligned policies in place.

The status of MEPS/TR requirements is summarised in Table 1. The full list of regulations and related links can be found in the Appendix.

Table 1: MEPS/Top Runner and label requirements currently in place for TVs and electronic displays

	Televisions			Computer monitors			Digital Signage Displays		
Region	**MEPS (and Toprunner)**	**Mandatory Label**	**ENERGY STAR**	**MEPS (and Toprunner)**	**Mandatory Label**	**ENERGY STAR**	**MEPS (and Toprunner)**	**Mandatory Label**	**ENERGY STAR**
Australia/ New Zealand	✓	✓		✓	✓				
Canada/ USA		✓ (USA)	✓			✓			✓
China	✓	✓		✓	✓				
EU/ Switzerland/ UK	✓	✓		✓	✓			✓	
Japan	✓								
Korea	✓	✓					✓		

From this table it can be seen that:

- All 4E economies have MEPS/TR requirements in place for TVs except Canada and the USA
- Australia/New Zealand, China and the European economies have MEPS requirements in place for computer monitors
- Korea is the only 4E economy that has MEPS/TR requirements in place for digital signage
- All 4E economies have energy labels in place for TVs except Japan
- Australia/New Zealand, Canada/USA, China and the European economies have energy labels in place for computer monitors
- Canada/USA and the European economies have energy labels in place for digital signage.

Changes in these regulations have either recently occurred or are due to occur in most 4E economies as set out in sections 4.1 and 4.2.

4.1 Changes in the period of July 2020-June 2021

Table 2 shows for which 4E economies changes in electronic display MEPS/TR, energy label, test procedure, policy scope, product categorisation and energy efficiency metric occurred in the period from July 2020 to June 2021.

Table 2: Changes in MEPS or Top Runner for TVs and electronic displays in the period July 2020-June 2021

	MEPS/TR	Mandatory label	Test procedure	Scope	Product categorisation	EE metric
Australia/ New Zealand						
Canada/ USA						
China						
EU/ Switzerland/ UK	✓	✓	✓	✓		✓
Japan						
Korea						

The European economies recently updated both the MEPS and labelling regulations for electronic displays, including TVs. This includes new transitional test methods, a broadening of scope (to encompass electronic displays as a whole), and the adoption of a new energy efficiency metric.

4.2 Pending changes after June 2021

Table 3 shows for which 4E economies changes in electronic display MEPS/TR, energy label, test procedure, policy scope, product categorisation and energy efficiency metric are set to occur in the period post June 2021.

Table 3: Pending changes in MEPS or Top Runner for TVs and electronic displays in the period post June 2021

	MEPS/TR	Mandatory label	Test procedure	Scope	Product categorisation	EE metric
Australia/ New Zealand						
Canada/ USA						
China	✓	✓	✓	✓		
EU/ Switzerland/ UK	✓					
Japan				✓		✓
Korea			✓	✓		

China has updated its test method and MEPS/labelling efficiency thresholds for TVs but not the efficiency metric.

Japan and Korea have also updated their TV regulations but to a lesser degree. Scope changes reflect changing features and technologies in the market, removing old screen tech such as CRT and Plasma while addressing new technologies such as OLED and microLED and ultra-high screen resolutions. Korea is also noted for regularly updating the test procedure, but this simply recognises that the most recent ISO test procedure is always applied and this is being updated currently.

Note, although not mentioned in this table (which only reports the survey findings) the Energy Star criteria for TVs (applied in Canada and the USA) is currently being revised and Australia and New Zealand have started to investigate revising their TV/electronic display regulations.

5. Comparison of scope of TV and electronic display policies in 4E economies

This section reviews the scope of electronic display MEPS/TR and labelling efficiency regulations in place in 4E economies. It provides a general overview of policy coverage for the display types introduced in Figure 1 in section 5.1 and then present a more detailed comparison for the specific case of TVs in section 5.2 and 5.3.

5.1 Scope of electronic display policies in 4E economies

Figures 2 to 7 present diagrams which summarise the full range of electronic display sub-categories that are referenced in the various MEPS/TR and energy labelling regulations for each 4E jurisdiction. For each type of electronic display these indicate whether the regulations define the type of display, define it and include it in their scope, define it and exclude it from their scope, or do not define it at all.

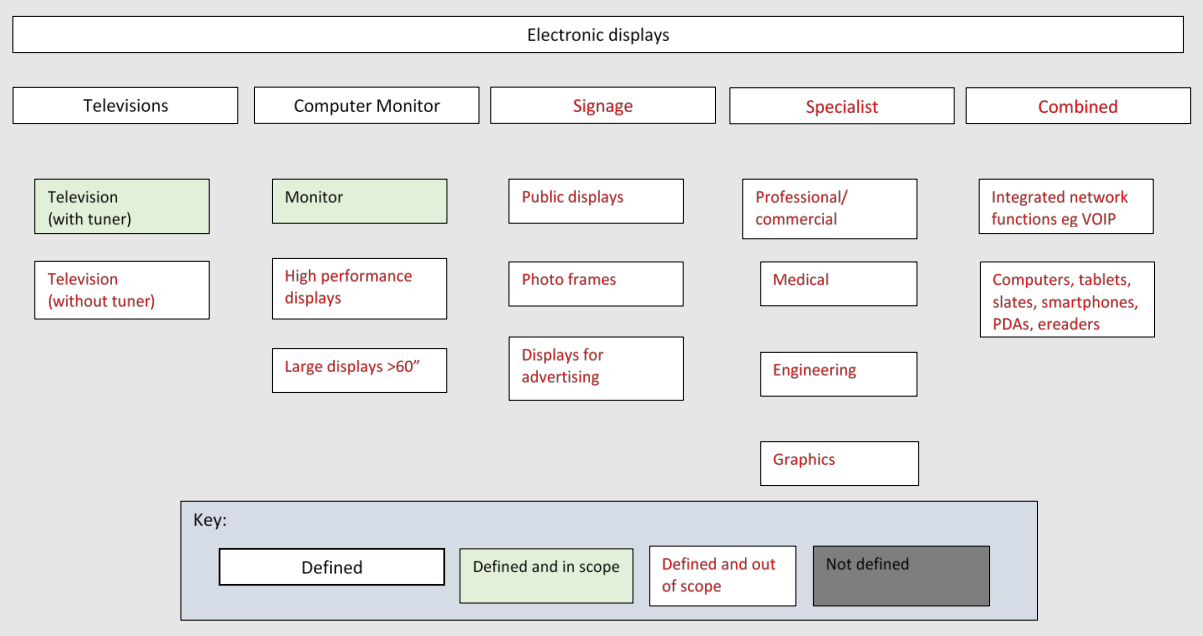
Because displays cover a wide range of products, the scope and out of scope definitions cover a confusing array of displays and other equipment types. Furthermore, each jurisdiction will define a different array of devices using slightly different naming conventions for a total of 30 different types. These diagrams provide a faster visual representation of what (and how much) has been defined, included and excluded.

Generally, TVs with tuners are covered and sometimes TVs without tuners, computer monitors and signage displays which account for around 5 of the display types defined. The remaining 25 types are only to specify what is out of scope. The East Asian 4E jurisdictions define very few out of scope display types while the more 'Western' 4E jurisdictions specify more display type definitions that are out of scope. This is probably due to the historical and cultural roots of the legal systems. However, as broader definitions are used which capture more product types then more exemptions must be defined to avoid unintended regulation.

	Televison (with tuner)	Television (no tuner)	TV (other)	Computer monitor	Signage displays	Other
Australia/ New Zealand	✓	×	*undefined*	✓	× 3 types	× 8 types
Canada/ USA	✓	✓	✓ hospitality	✓	✓	× 7 types
China	✓	✓	*undefined*	✓	*undefined*	× 4 types
EU/ Switzerland/ UK	✓	*undefined*	*undefined*	✓	✓	× 14 types
Japan	✓	× no domestic	*undefined*	✓	*undefined*	× 3 types
Korea	✓	×	*undefined*	*undefined*	✓	*undefined*

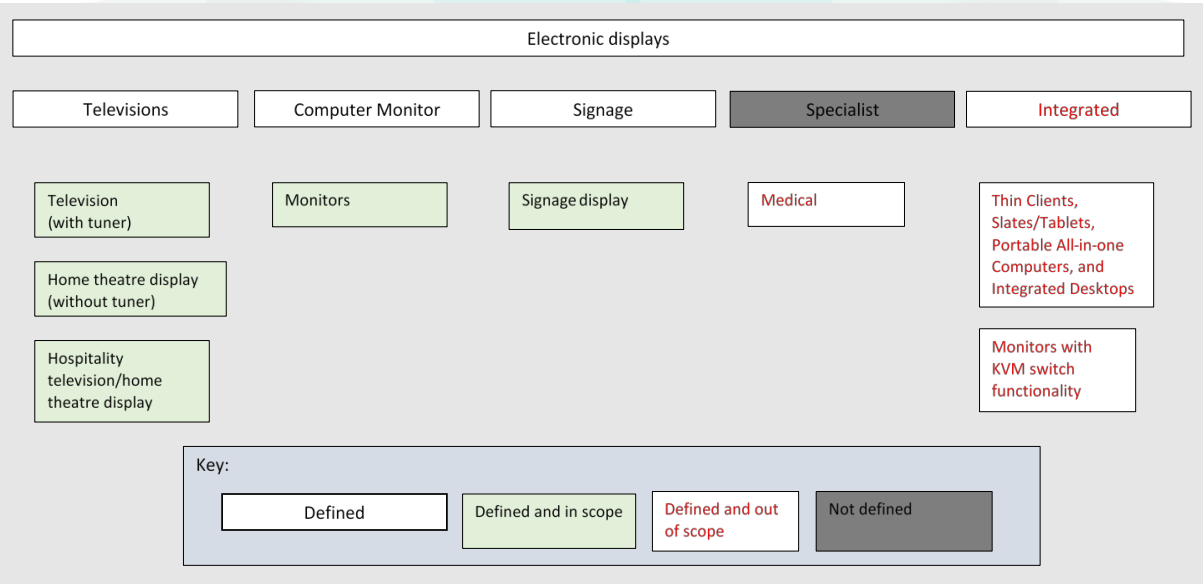
Australia and New Zealand

Figure 2: Scope of electronic display efficiency policies applied in Australia and New Zealand



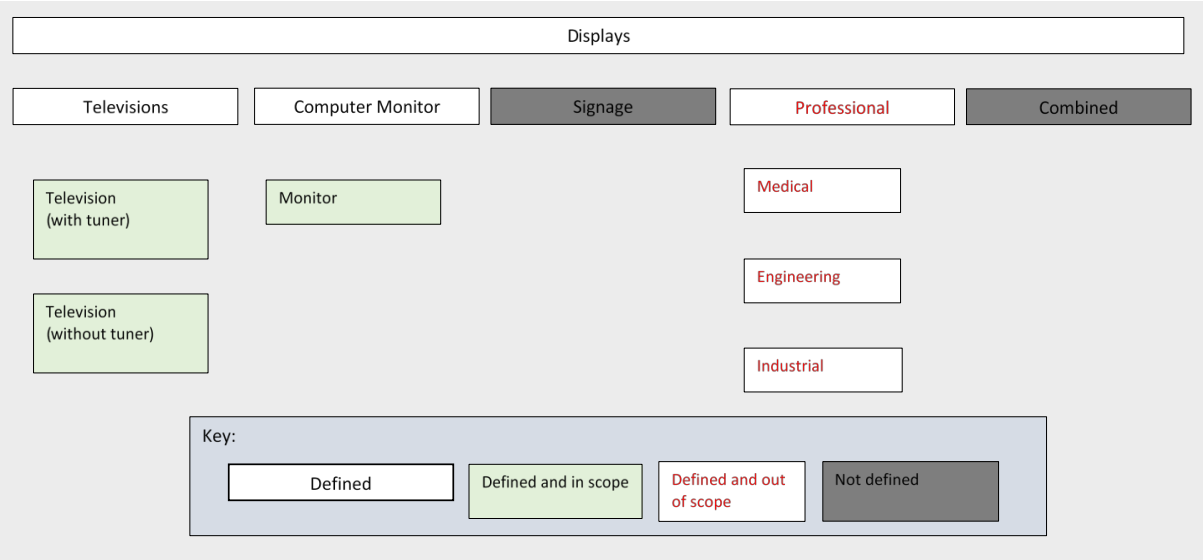
Canada and the USA (Energy Star)

Figure 3: Scope of electronic display efficiency policies applied in Canada and the USA (Energy Star)



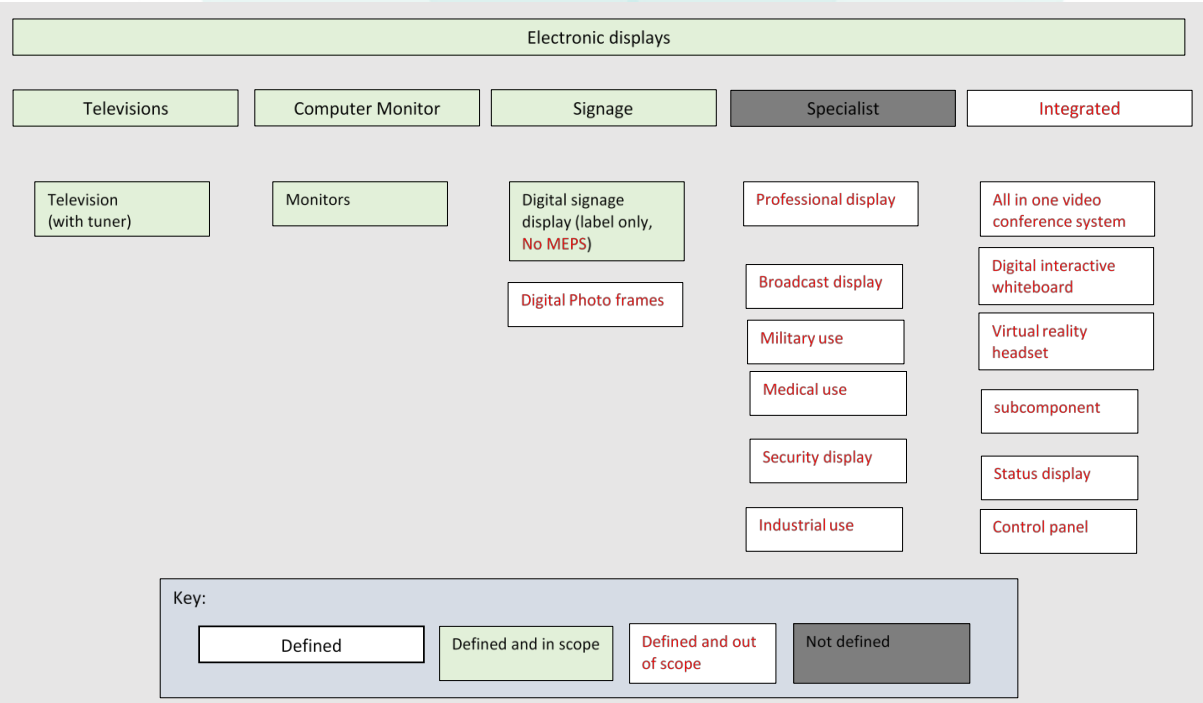
China

Figure 4: Scope of electronic display efficiency policies applied in China



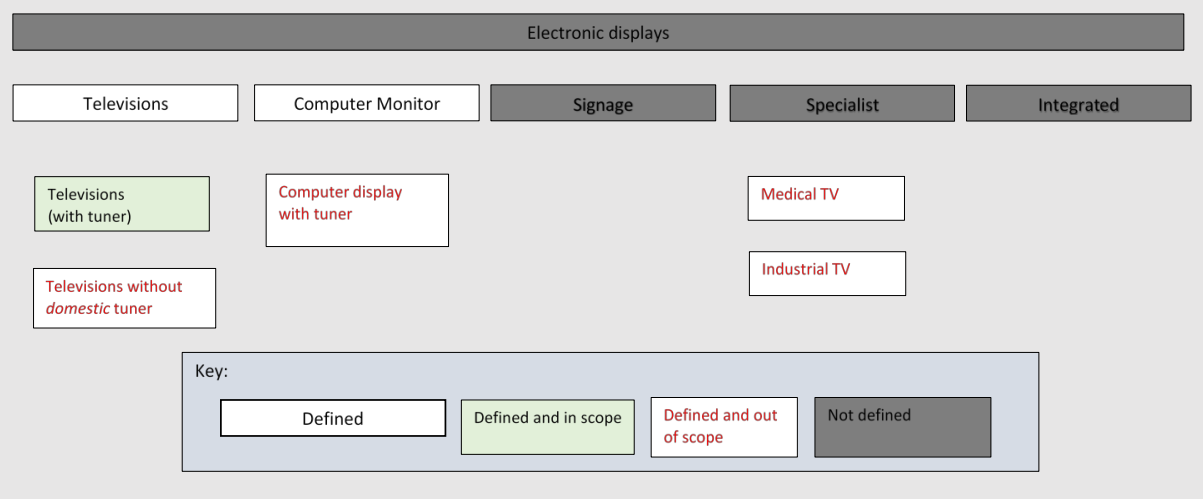
European Economies

Figure 5: Scope of electronic display efficiency policies applied in the European economies



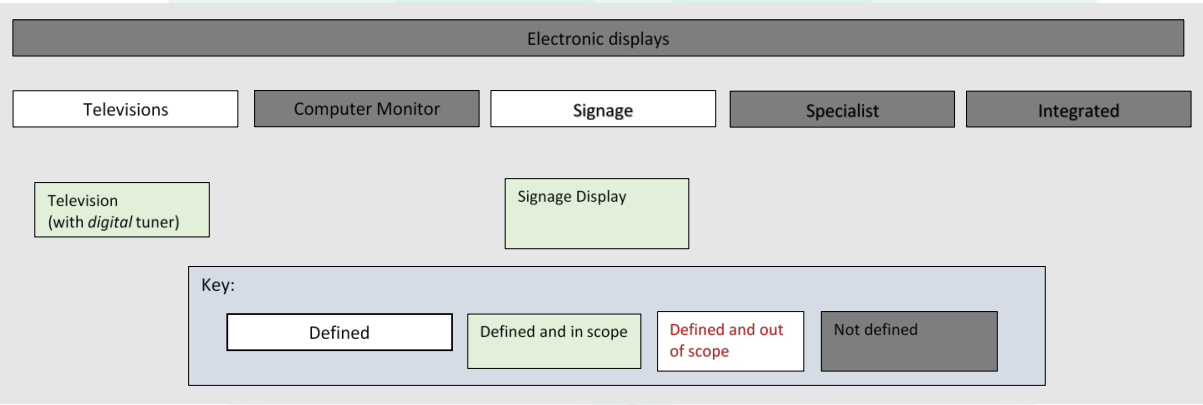
Japan

Figure 6: Scope of electronic display efficiency policies applied in Japan



South Korea

Figure 7: Scope of electronic display efficiency policies applied in South Korea



5.2 Scope of TV regulations

The basic definition for a TVs in all 4E jurisdictions includes wording that states it is designed/used/marketed/sold primarily for display and reception of AV signal and includes a tuner/receiver.

An additional product definition exists for displays that are *used as* a TV but do not include a tuner/receiver – these are sometimes called TV monitors or home theatre displays. These are explicitly included as product sub-categories in China and in Energy Star (Canada and the USA).

The scope within each jurisdiction then varies based on:

- Screen size – specifying lower size limits is common while only South Korea specifies an upper limit

- Screen resolution – resolutions higher than 4K are commonly excluded
- Screen technology – outdated technologies including CRT, Plasma, and rear projection TVs are excluded as well as new MicroLED screens.

There are considerable variations between what is explicitly excluded and included within the regulatory scope. For example, Europe does not state which technologies are covered by the regulation, implicitly including all screen technologies, but then explicitly excludes MicroLED in the current MEPS. China, however, states explicitly that only LCD and OLED TVs are included in the regulation, therefore MicroLED are implicitly excluded. Furthermore, some technologies are not excluded from scope but since there are no requirements they are effectively excluded. Japan does not explicitly exclude MicroLED TVs from the scope but since there are no requirements, they are effectively excluded. This has implications for if and how technologies are defined in the regulation and whether new technologies will be covered.

Table 4 indicates the scope of TV efficiency regulations applied in 4E economies.

Table 4: Scope of TV EE regulations applied in 4E economies

	Screen technology						Screen size		Screen resolution
Region	**CRT**	**LCD**	**OLED**	**MicroLED**	**indirect/ projection**	**Plasma**	**min**	**max**	
Australia/ New Zealand	✓	✓	✓	✓	✓	✓	no limit	no limit	no limit
Canada/ USA	✓	✓	✓	✓	× explicit	✓	no limit	no limit	no limit
China	×	✓ explicit	✓ explicit	×	×	×	no limit	no limit	no limit
EU/ Switzerland/ UK	✓	✓	✓	✓ but no MEPS until 2023	× explicit	✓	100cm2	no limit	8K MEPS excluded until 2023
Japan	× explicit	✓	✓ but no criteria until 2026	✓ but no criteria	× explicit	× explicit	10inch diagonal visible display	no limit	8K excluded
Korea	× explicit	✓	✓	× explicit	× explicit	× explicit	47cm diagonal	216cm diagonal	<4320 vertical resolution (excludes 8K)

5.3 Significance of differences in regulatory scope

In general, the most common screen sizes, technologies and resolutions currently found in the market are all covered in every jurisdiction. In addition, TV monitors are mostly not included in the scope.

The most significant difference is the lack of OLED TV requirements in Japan's current Top Runner regulations, which are to be attained in 2026. Online news[3] suggest that internationally OLED will account for 10% of the TV market by the end of 2021. However, if the thresholds were similar to the current Top Runner requirements for LCD (similar to Configuration 2 – see next section) it is very unlikely to affect the market (see next section).

The risk of limiting the scope is that the regulatory coverage of TVs could diminish in response to relatively quickly changing market preferences but this will also depend on how frequently the

[3] https://www.hdtvtest.co.uk/n/OLED-TV-shipments-forecast-to-grow-80-in-2021

regulations are updated. Conversely, the intentional exclusion of a new technology from the regulatory scope in the near term could allow it to become sufficiently established for it to attain a much higher efficiency as it matures – MicroLED technology could be such a case. Potentially, it may also help major manufacturing centres to compete globally by providing exclusions that enable development of new technologies and create new markets for them.

6. Comparison of TV policy efficiency thresholds in 4E economies

This section presents the findings of policy benchmarking analysis for TVs. This exercise has not been attempted for other types of electronic displays due to data and resource constraints.

Overview of testing and comparability of efficiency thresholds

To compare the efficiency thresholds, we assume that the default TV viewing mode provides a reasonable experience for the viewer (consumer surveys suggest that this is prioritised over efficiency for TVs) and to do otherwise would harm the brand and sales. This means the default mode is above the minimum brightness thresholds and provides a reasonable image as defined in the various regulations. However, more testing and more access to detailed datasets, especially based on China's experience which requires the changes to brightness and contrast to be recorded, could help to confirm the validity of this assumption. This also does not mean that TV models and their test results are comparable between jurisdictions, at least without detailed data on screen brightness levels and picture quality to make necessary adjustments, since the metrics and test method may favour different default image configurations. When comparing test results it is also worth noting that regulatory enforcement mechanisms rarely penalise inaccurate results as long as efficiency is not lower than claimed (other than potentially a lower energy label rating).

In general, changes to the test method aim to address three key factors:

- Improve reproducibility and unintended variability
- Prevent deliberate manipulation of test results
- Address representativity, new features and characteristics.

The recent changes made to the test method used in the European economies appear to primarily address the first factor. This means that differences including adoption of the new dynamic display patterns should not have a sufficiently significant influence on the *intended* results and should not influence comparability of the thresholds. Furthermore, this dynamic display pattern is only used to ensure a sufficient screen brightness level above a certain threshold to prevent manipulation. The specific brightness level is not a variable in the energy efficiency metric itself and therefore some variation would not affect the calculated efficiency (again assuming the brightness level is sufficiently higher than the minimum level to provide a good user experience). The European economies test method and the draft IEC 62087 test method also include new methods for testing High Dynamic Range (HDR) video, but these are not used in the efficiency metric or policy thresholds and therefore are not relevant.

Most jurisdictions specify minimum screen brightness levels when testing to prevent manipulation, however, the Chinese test method no longer sets absolute screen brightness levels but differs from other jurisdictions by requiring brightness and contrast adjustment to ensure basic greyscale levels can be distinguished.

The final difference is the illuminance level used to disable Automatic Brightness Control (ABC), if this cannot be achieved through the control menu. This ranges from 100lx to 300lx illumination at the light sensor, but testing suggests this has no impact on the screen brightness and hence power demand. However, the result of disabling ABC via the menu may not be equivalent to disabling ABC through high illuminance (see Benchmarking approach section below).

This leaves the question of how much manipulation of the test method has been occurring and if the differences in the static/dynamic displays used to assess luminance and adjust brightness/contrast result in a significant difference. If manipulation is significant then it would need to be quantified and corrected. It is not clear how this is to be achieved without first examining the data available.

6.2 Benchmarking approach

The efficiency thresholds applied in the 4E regulations are dependent on the set of TV technology features that are present in addition to the TV screen size. As there are a very wide range of potential TV features and technology characteristics it is not feasible to calculate the efficiency thresholds applied on a common basis for all combinations of features that could be found in the market. Therefore, to enable a comparison to be made an analysis was conducted of the most common combination set of features by assessing the frequency of features found in the 2018 US Energy Star database and the 2018 TV dataset from Japan (both as used in the previous PEET project). From this analysis a set of the most prevalent TV feature configurations (called C1 to C5) were determined, see Table 5 (the full analysis is summarised in the Appendix).

Table 5: Characteristics of common TV configurations considered for the policy benchmarking exercise

	C1	C2	C3	C4	C5
Screen tech	OLED	LCD	LCD	LCD	LCD
Screen size (inch)	55	55	43	43	32
Screen resolution	4K	4K	4K	4K	768p
Screen refresh rate (Hz)	60	120	60	60	60
Screen brightness (cd/m^2)	360	360	191	242	150
ABC enabled by default	Yes	Yes	No	Yes	No
Additional tuner (2K only)	Yes	Yes	No	No	No
Integrated recording device	No	No	No	No	No

For each of, these feature configurations the power allowance (in W) as well as the efficiency (expressed in W/m^2) were calculated (see the Appendix for the regulatory formulae applied and the assumptions made to permit normalisation).

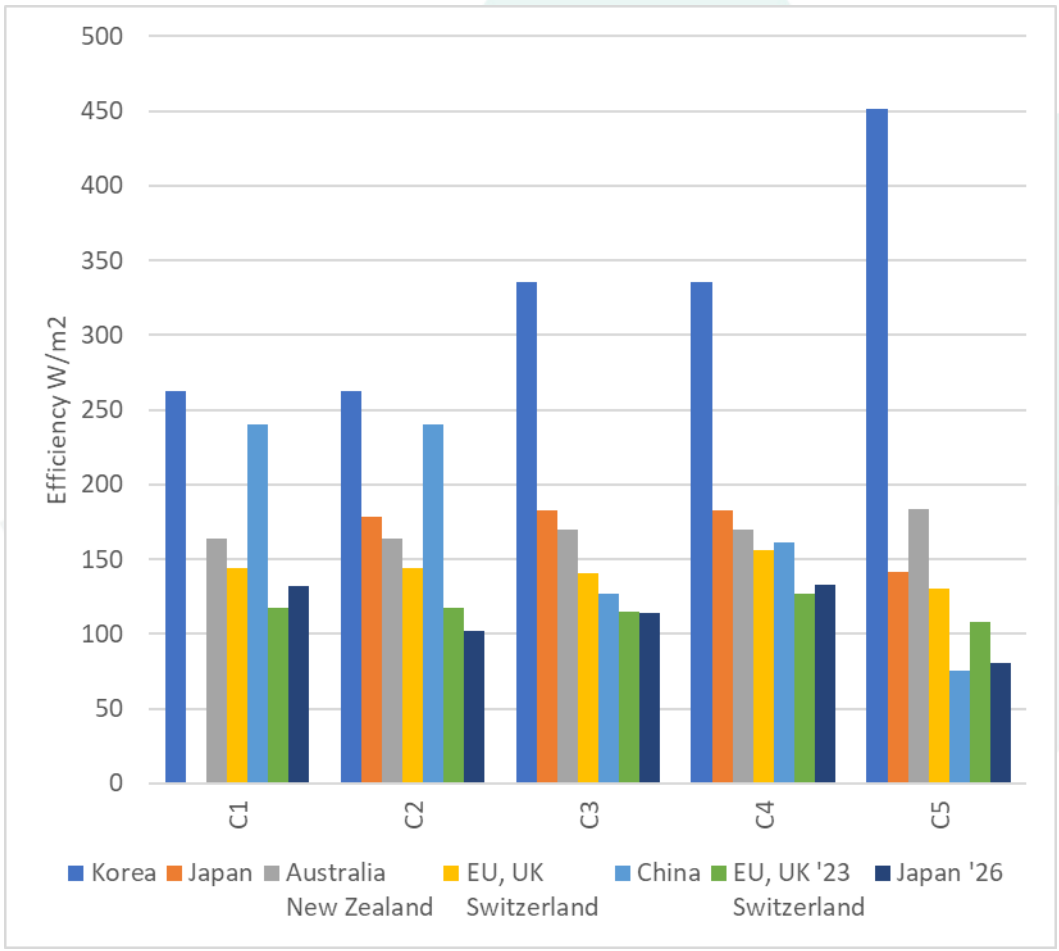
As expected, larger screens generally have more features and higher performance. This also extends to the screen brightness. In addition, TVs with ABC enabled have higher brightness and manufacturers are taking advantage of the additional allowance to increase screen brightness levels. This may suggest that most current thresholds are limiting the preferred brightness level from a consumer perspective in order to achieve target efficiency ratings. The difference in screen brightness could also mean that that the two methods for disabling ABC are not equivalent and will result in very different efficiency results, i.e. the power measured and used in the metric from directing 100lx/300lx at the ABC sensor will result in a screen brightness closer to 360lm and higher power compared to the 200+lm screen brightness achieved by disabling ABC via the menu.

The setups for the TV units under test in the updated regulations are converging on similar screen brightness requirements which in theory makes metrics between all jurisdictions, including China, more comparable. The biggest difference is that the declared power applied in Energy Star (Canada and the USA) is based on the average power at different room illuminance levels, while all other jurisdictions measure at high room illuminance only. This is adjusted for in the normalisation process based on an analysis of TV models in the Energy Star database, which includes both the declared power and power at high brightness (see Appendix).

6.3 Comparison of efficiency thresholds

Figure 8 shows the normalised MEPS/TR thresholds for each of the configurations shown in Table 5.

Figure 8: Comparison of normalised TV MEPS/TR thresholds for the 5 TV configurations in Table 5



From this the following observations can be made:

- not surprisingly, the stringency of the MEPS thresholds are most strongly influenced by the year they come into effect (the order in which the regulations are listed is from oldest (on the left) to most recent (on the right))
- the variation in the stringency of the thresholds also varies widely across the configurations
- thresholds applied in Korea exhibits the most apparent variation across configuration and this appears to be the result of the metric being applied across different screen sizes.

- The smallest TV (the 32" C5 case) also shows the most variability. There is a significantly lower allowance for Japan, while in Australia it has the highest (excluding outlying Korea) and potentially shows the advantage of accounting for resolution (or pixel density) in the metric. However, 32" TVs have a relatively low number of models and due to their small size consume relatively little energy. Therefore, this variability is of less concern than for larger, 4K screens.
- In the cases of Japan, Australia/NZ, European economies (currently in effect) and European economies coming into effect in 2023 the MEPS/TR thresholds exhibit a narrower spread for the other four configurations from Table 5.
- The Australia/NZ regulations have no allowances for different features such as screen resolution and ABC whereas the new EU regulations coming into effect in 2023 do.
- The application of allowances for features seems to have resulted in some divergence in the efficiency requirements, particularly for Japan's Top Runner requirements to be attained in 2026. The biggest divergence between the thresholds applied to the configurations in these regulations are for configuration 1 and 2 and are mainly the result of the difference in screen technology used in these two cases, although refresh rate also contributes. While configuration 1 is treated relatively leniently in Japan's 2026 requirement, the requirements for configuration 2 is significantly more stringent than for the European economy MEPS in 2023. If LCD TVs remain the majority screen technology in the market (currently over 90%), the net effect of the technology specific Top Runner requirements will be to lower the market average energy consumption. However, newer Quantum OLED[4] technology could potentially achieve similar efficiency levels to LCD but without stringent MEPS there may be no pressure to do so.

The variation in China's MEPS thresholds across the various feature configuration cases is due to the large difference in screen brightness. Note, the normalisation method assumes the brightness levels recorded by Energy Star at high illuminance are equivalent to those under the China test method with ABC disabled via the menu or high illuminance (see section 6.1). Larger screens and TVs with ABC enabled by default are significantly brighter (see configurations). This means the thresholds for 55" TVs are some of the most lenient while those for the 32" configuration 5 case are the most stringent. This also assumes that manufacturers choose to set up the default picture mode in the same way in all regions. However, it still raises the question of what is the best approach to address screen brightness?

The large variation between the 4E jurisdictions cannot be explained just by the technical factors. Other necessary considerations appear to have come into play which include:

- Complexity of energy performance metrics and formulae. A complex metric is used because it should provide a better description of the relationship between the technical factors and power. If simplification ignores a critical factor or does not describe the relationship accurately, it will lead to divergence with the complex metric. The metrics used for TVs are primarily derived via empirical data analysis and hence developed with less consideration of TV engineering principles. The nature of the dataset and analytical approach (and other policy considerations) can have a large impact on the final metric unconstrained by the relationships described by engineering
- Desired efficiency rating of the market Most jurisdictions set thresholds based on what proportion of TV models they believe should fall into each efficiency class for the policy to be effective. These proportions are not based solely on technical factors

[4] Note, OLED technology is more mature than MicroLED technology

- Economic considerations
- Frequency of regulatory revision.

The most important considerations are the influence of screen brightness and frequency of regulatory revision. The level of variation in requirements between jurisdictions within a relatively tightly defined product also raises questions about how successfully regulation could be expanded to cover all electronic displays using one metric, especially for effective MEPS.

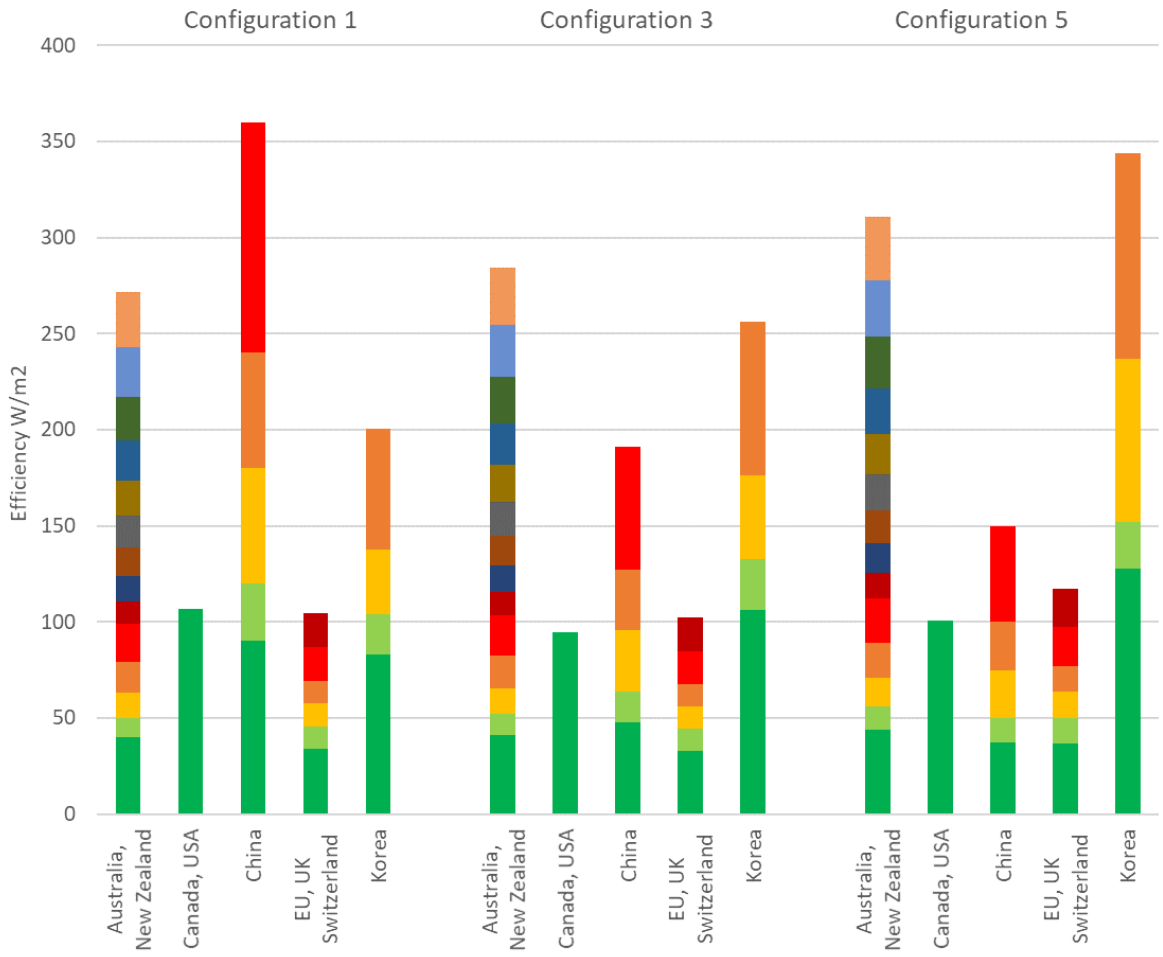
Figure 9 shows how the normalised energy label efficiency thresholds vary for Configurations 1, 3 and 5 in Table 5.

The energy labels thresholds can be grouped into two distinct pairs. The first pair of Australia/NZ[5] and the European Economies have similar thresholds for the most efficient grades across each configuration. The most efficient grades are also similar between USA/Canada and Korea who compose the second pair. Between these two pairs, there is a very large difference and the most efficient grade for the Korean pair is equivalent to the least efficient grade for the European economies.

The thresholds applied in China show the most variation across the configurations due to the falling screen brightness levels as the screens gets smaller. While China's C5 thresholds compare to those in the European economies for the C1 configuration they are more similar to Korea's. It should also be noted that the MEPS threshold applied in China will cut off the most lenient label levels depending on the TV features.

[5] There are 10 levels from 1 to 10 stars as well as half star levels, 1.5, 2.5, 3.5 and 4.5 for TVs. There are no half stars above 5.5.

Figure 9: Comparison of normalised TV energy label thresholds for the 5 TV configurations in Table 5



Appendix

A1. List of regulations

Australia	Greenhouse and Energy Minimum Standards (Television) Determination 2013 (No.2) Test method: AS/NZS 62087.1:2010 (commercial link not added) Efficiency criteria: AS/NZS 62087.2.2:2011 (commercial link not added)
	Greenhouse and Energy Minimum Standards (Computer Monitors) Determination 2014
Canada **USA**	ENERGY STAR Version 8.0 TVs Program Specification
	ENERGY STAR Displays Version 8.0 Program Requirements
USA	TV definition 10 CFR 430.2 TV test standard: 10 CFR Appendix H to Subpart B of Part 430 - Uniform Test Method for Measuring the Power Consumption of Television Sets TV label: 16 CFR 305.25
China	TVs: GB 24850-2020 平板电视与机顶盒能效限定值及能效等级
	Monitors: GB 21520-2015计算机显示器能效限定值及能效等级
EU	Electronic displays label: EU 2019/2013
	Electronic displays MEPS: EU 2019/2021
	Amendments and transitional test standard: EU 2021/341
UK Switzerland	See equivalent EU regulations
Japan	TV Top Runner: トップランナー制度テレビジョン受信機
Korea	Equipment efficiency regulations: 효율관리기자재_운용규정(산업통상자원부고시_제2020-225호)

A2. Standards development

The most widely used standard to measure TV energy performance in 4E economies is IEC 62087-3:2015: *Methods of measurement for the power consumption of audio, video and related equipment*.

IEC 62087-3 is currently being updated and has been approved for Committee draft as of 27-Sept 2021. It should then go to vote by the committee then final approval and publication. It is forecast to be published in 21-12-2022[6]. Since the development process is closed, we do not have access to the changes. However, it is understood that the major changes are in line with the EU transitional methods.

This specifies the general requirements for the determination of power consumption of audio, video, and related equipment. Requirements for specific types of equipment are specified in additional parts of this series of standards and may supersede the requirements specified in this standard.

[6] https://webstore.iec.ch/publication/22583#workinprogress

Moreover, this part of IEC 62087 defines the different modes of operation which are relevant for determining power consumption.

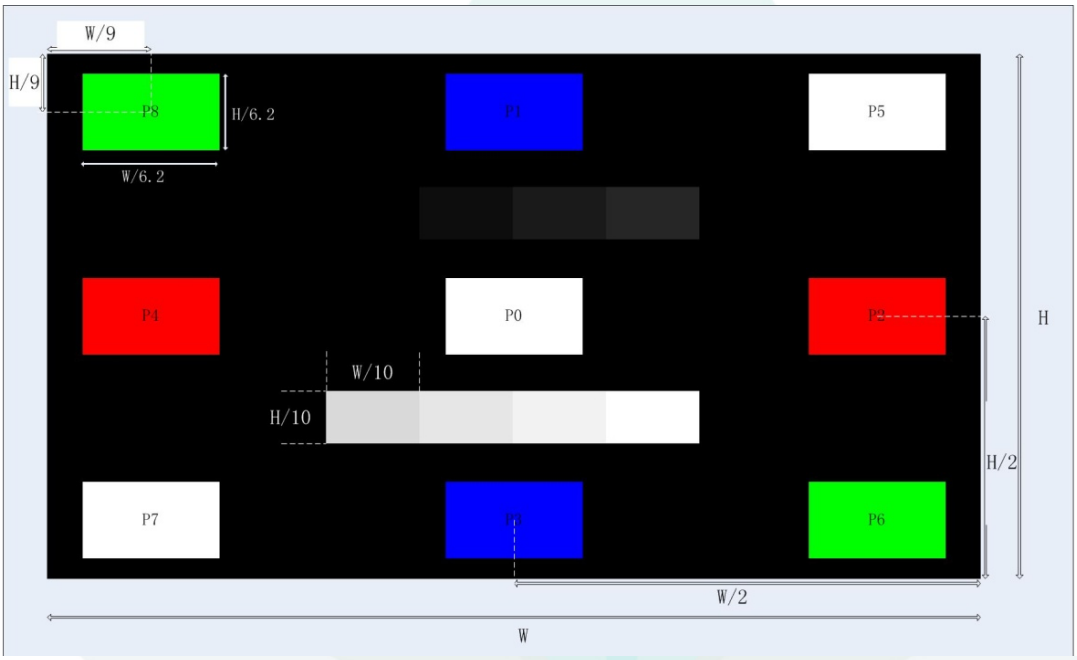
The main areas of interest are:

- **Unit under test setup**
- **Determining and setting screen luminance levels**
- **How to test ABC by simulating different light illuminance levels**

The actual test for on-mode power is the same across all regions.

The unit under test setups in the 4E economies are now becoming more similar. However, the newer transitional methods require a Wi-Fi or LAN connection to be enabled and connected but not to access the internet. Therefore, this is unlikely to significantly affect the power demand.

Determining TV screen luminance requires the use of different display patterns, which are applied to measure the screen brightness. An example pattern from China's GB24850 regulation is shown below.



TVs now have a large difference between peak and sustained brightness. When the proportion of the screen showing white increases, the brightness can drop after a short period of time to protect the screen. Therefore, the IEC 62087 display pattern is shifting from a large static white screen to a dynamic screen with a new method to determine the optimal coverage area. In principle, this should reduce variability in test results caused by brightness dropping; however, this would need to be established with access to evidence that is not currently publicly available.

All the 4E jurisdictions except Australia/New Zealand set the minimum brightness at 65% or 228lm.

The test method used in China only uses three smaller white rectangles and is less likely to have the same issue. Again, this would need to be established through the assessment of test data.

The test setup in China does not set a minimum test brightness but applies an adjustment to ensure the greyscale is clearly distinguishable. The process is recorded to make it repeatable, and the brightness measured. This could be used to determine if the unit setups applied in China and other 4E economies are sufficiently comparable.

A3. Testing ABC

How the 4E jurisdiction test methods address ABC is summarised in Table 6.

Table 6: Testing ABC for TVs

Jurisdiction	Test standard	Screen luminance	ABC test levels	HDR enabled
Australia New Zealand	IEC62087:2012	50% of brightest mode	ABC disabled (or 300lx)	
Canada USA	Appendix H to Subpart B of 10 CFR Part 430 Uniform Test	65% of brightest mode if brightest mode is less than 350cd/m2, otherwise min 228cd/m2	100lx, 35lx, 12lx, 3lx	enabled if an option in default picture mode
China	GB 24850-2020	Brightness and contrast adjusted to show clear greyscale pattern	ABC disabled (or 300lx)	
EU Switzerland UK	transitional methods for 2021/2019 (similar to draft IEC 62087)	220cd/m2 or at least 65% of peak white luminance.	disabled (or 120lx) Also tested for ABC allowance: 60lx,35l, 12lx	
Japan	62087:2015	65% of brightest mode if brightest mode is less than 350cd/m2, otherwise min 228cd/m2	disabled (or 300lx) and 0lx	
Korea	latest' IEC 62087 and detailed in regulation	65% of brightest mode if brightest mode is less than 350cd/m2, otherwise min 228cd/m2	ABC disabled (or 300lx)	

The Canadian/US and older test methods require the light source to be placed perpendicular to the ABC sensor. They use a halogen light source. The newer draft and European transitional methods place the light source at 45 degrees from horizontal and above the light sensor. The specific light source used and method to control the luminance level can vary. The angle of the sensor can impact the screen brightness, however, most of the 4E efficiency metrics are based on ABC being disabled or highly illuminated to force the product to achieve maximum screen brightness and therefore the difference in angle is unlikely to have an impact on the results.

The test method used in China does not specify how the sensor is illuminated.

A4. Updates to efficiency metrics

EU

The EU energy metric was updated to use a method similar to Energy Star. An empirically derived tanh function is applied which recognises that power consumption does not increase linearly with screen area. An allowance is given for ABC. The MEPS allowance also takes into account resolutions above 4K and MicroLED technology.

Japan

Japan's efficiency metric has been substantially updated. The previous 64 individual formulae based on screen diagonal, resolution, technology and number of additional functions has been changed to four formulae based on screen area and an additional nine adders.

The formulae for calculating the AEC has also been updated to account for power saving functions, including ABC, and TV recording modes.

Table 7: Features considered in TV efficiency metrics applied in 4E economies

	ABC	Screen size	Screen Technology	Screen resolution	Screen luminance	Video signal source	EPG	Standby	2 or more 2K tuner	2 or more 4K tuner	3.5 inch HDD recording device	2.5 inch HDD recording device	SSD recording device	4K optical disc recorder	less than 4K optical disc recordr	Video double speed (4K and above)	Video double speed (less than 4K)
Australia New Zealand		✓					✓	✓									
Canada USA	✓	✓		✓													
China		✓		✓ MEPS Only	✓	✓											
EU Switzerland UK	✓	✓	✓ MEPS only	✓ MEPS only													
Japan	✓	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Korea		✓	✓	✓													

A5. Feature analysis to determine TV configurations for policy comparison

This analysis was completed based on 2018 data from Japan and Energy Star. These datasets were used because they are the most complete recent datasets available. While more recent data is available for Energy Star the list of certified TVs is very limited and does not include many of the largest brand names. This is therefore not considered to be representative of the market and was not used.

The final configurations are not solely based on the frequency analysis of features from the data but are in part also chosen to illustrate common feature differences to allow comparison of how the metrics vary.

Figure 10: TV feature analysis of Japan's 2018 database

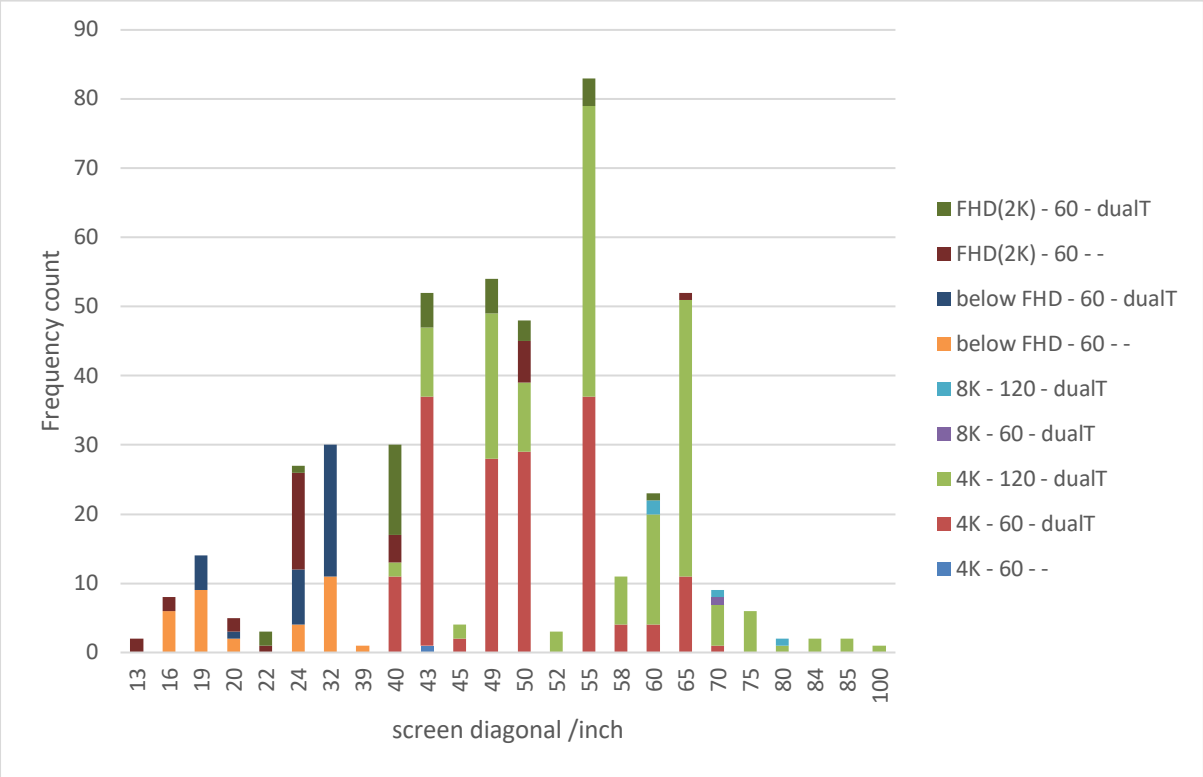
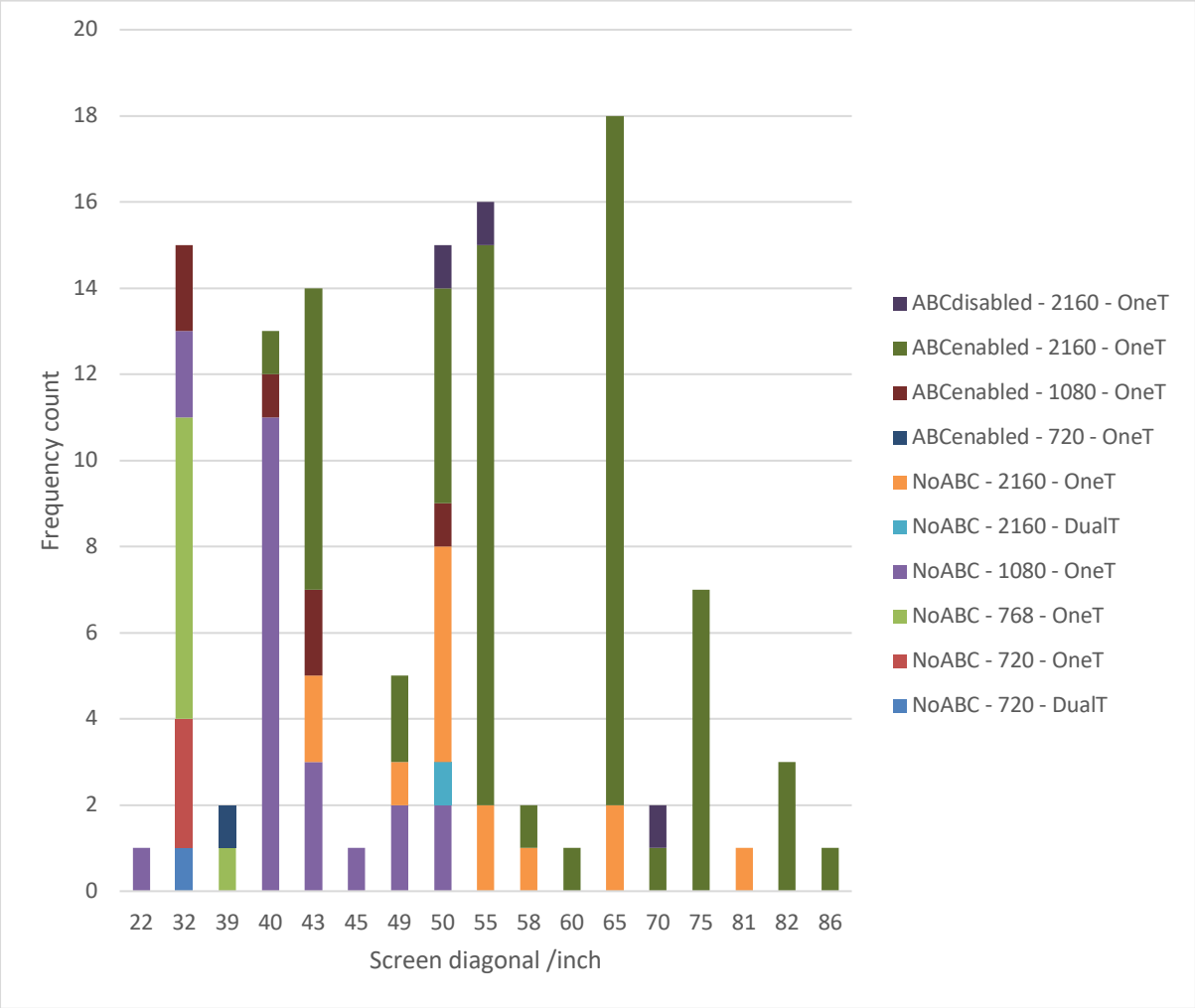


Figure 11: TV feature analysis of the Energy Star 2018 database



The figures above show the frequency of TVs by screen size disaggregated by screen resolution and the presence of Dual tuners. Each column is further disaggregated by the screen refresh rate (60Hz or 120Hz) (Japan) and whether ABC is enabled (Energy Star). This is due to differences in the data collected but both are required to create the example configurations reported in Table 5. 65" and 55" are clearly the most common screen sizes. These are very similar in configuration - almost all 4K TVs have ABC enabled but vary in the screen refresh rate. The presence of dual tuners seems to depend on the country. Based on this, configurations 1 and 2 in Table 5 were created using the 55" screen size. Dual tuners are assumed since this is only accounted for in the efficiency metric used in Japan, where they are extremely common.

No OLED TVs were found in either the Japan (out of scope) or Energy Star databases (it is unclear why). Nonetheless, this screen technology is included as configuration 1 due to the increasing availability of OLED TV's now and to illustrate Japan's 2026 Top Runner threshold for OLED TVs.

43" TVs were chosen since they are very common, have a distinct size difference from 55" and tend to have fewer features. These are 4K but have 60Hz refresh rates and it is more common for ABC to be unavailable. Dual tuners are excluded to provide additional variation for comparison.

32" is the most common small size that represents TV's with a resolution below 4K. These are in fact below full HD resolution, and also highlights the absence of full HD resolution TVs in the market now.

A6. Power allowance threshold calculations

Australia and New Zealand

$$P_{on} = \frac{1.1 * (65.41 + 0.0934 * A_{cm}) * 10^{(SRI-1)*log_{10}(1-0.2)}}{10 * (0.365 - 14 * P_{standby})}$$

Where P_{mode}= Power in mode

A_{units} = screen area in units^2

SRI = Star rating index

The Australian Annual energy calculations include allowances for electronic programme guide update or similar modes. These were not included due to lack of data and the passive standby power was instead increased to 0.6W to compensate. While the Australian regulations includes a calculation to compensate, this is considered to be based on outdated information. No recent data on EPG energy consumption was found. Research in 2009 estimated that a TV consumes 0.02kWh (20W for 1hr) per day on average. Accounting for efficiency improvements this is assumed to have dropped closer to 0.006kWh but this also depends on regional differences in the TV broadcast system. If this assumption is incorrect and EPG energy consumption is still 0.02kWh, the calculated on power is overestimated by 3W.

Energy Star (Canada and USA)

$$P_{on,ave} = 78.5 * \tanh\left(0.0005 * \left(\frac{A_{cm}}{2.54^2} - 140\right) + 0.038\right) + 14 * \begin{cases} 1 \; if \; R_X < 3840 \\ 1.5 \; if \; R_X \geq 3840 \end{cases}$$

Where $P_{on,ave}$= On-mode power averaged across illuminance levels

A_{units} = screen area in units^2

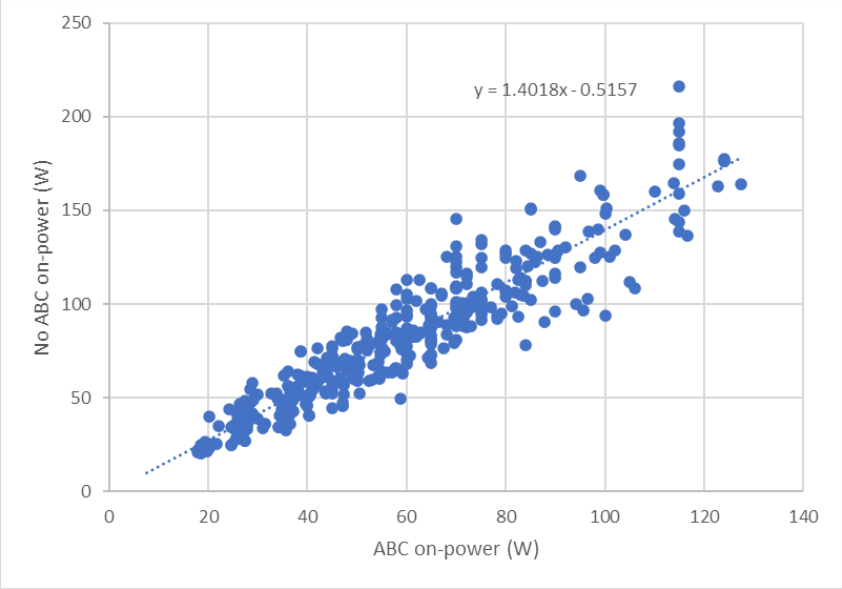
R_X = resolution in X-axis

Energy Star is calculated in square inches and is converted from square centimetres.

Energy Star is calculated from the average power across four luminance levels. To determine the power at high brightness for comparison against other jurisdictions, the correlation between average power with ABC enabled against power at high room illuminance (ABC disabled) was plotted from Energy Star 2018 data and linearly regressed.

$$P_{on} = 1.4 * P_{on,ave} - 0.5$$

Figure 12: Correlation in on-power consumed with no ABC and with ABC in the Energy Star 2018 database



ABC results in an average 30% reduction in power under Energy Star and is therefore highly desirable.

China MEPS and energy label

$$P_{on} = \frac{L * A_m}{Eff}$$

Where P_{mode}= Power in mode

A_{units} = screen area in units^2

Eff = Energy efficiency level for a given grade

To facilitate comparability, it is necessary to assume that the dynamic power can be used to calculate the threshold, which is likely always true. An Rf input is preferred but not required for testing and a power allowance of 4W to 8W is given in the efficiency metric. However, for comparability purposes it is assumed the test is performed with an HDMI interface and therefore there is no signal processing power allowance added.

European economies energy label

$$P_{on} = \left[EEI * (3 * (90 * \tanh\left(0.025 + 0.0035 * (A_m * 100 - 11)\right) + 4) + 3) - 1\right] * \begin{cases} 1 \; if \; ABC = enabled \\ 0.9^{-1} \; if \; ABC = off \end{cases}$$

Where P_{mode}= Power in mode

A_{units} = screen area in units^2

ABC = if auto brightness control default status

European economies MEPS

If R_X < 3840,

$$P_{on} = \left[0.9 * (3 * (90 * \tanh\left(0.025 + 0.0035 * (A_m * 100 - 11)\right) + 4) + 3) - 1\right] * \begin{cases} 1 \; if \; ABC = enabled \\ 0.9^{-1} \; if \; ABC = off \end{cases}$$

If $R_X \geq 3840$,

$$P_{on} = \left[1.1 * (3 * (90 * \tanh\left(0.025 + 0.0035 * (A_m * 100 - 11)\right) + 4) + 3) - 1\right] * \begin{cases} 1 \; if \; ABC = enabled \\ 0.9^{-1} \; if \; ABC = off \end{cases}$$

European economies MEPS from 2023

If $R_X < 3840$,

$$P_{on} = \left[0.75 * (3 * (90 * \tanh\left(0.025 + 0.0035 * (A_m * 100 - 11)\right) + 4) + 3) - 1\right] * \begin{cases} 1 \; if \; ABC = enabled \\ 0.9^{-1} \; if \; ABC = off \end{cases}$$

If $R_X \geq 3840$,

$$P_{on} = \left[0.9 * (3 * (90 * \tanh\left(0.025 + 0.0035 * (A_m * 100 - 11)\right) + 4) + 3) - 1\right] * \begin{cases} 1 \; if \; ABC = enabled \\ 0.9^{-1} \; if \; ABC = off \end{cases}$$

Where P_{mode}= Power in mode

A_{units} = screen area in units^2

R_X = resolution in X-axis

ABC = if auto brightness control default status

The ABC allowance requires specific screen brightness and power levels to be met. It is assumed that the TV would meet this.

Japan Top Runner

The Japanese MEPS includes a large number of formulae, only the relevant ones that apply to each configuration are given:

C1

No criteria

C2

$$P_{on} = \frac{(6.6 * D_{inch} - 111) * 1000 - P_{stby} * 7117.5}{1642.5}$$

C3

$$P_{on} = \frac{(6.6 * D_{inch} - 126) * 1000 - P_{stby} * 7117.5}{1642.5}$$

C4

$$P_{on} = \frac{(6.6 * D_{inch} - 126) * 1000 - P_{stby} * 7117.5}{1642.5}$$

C5

$$P_{on} = \frac{(2 * D_{inch} + 18) * 1000 - P_{stby} * 7117.5}{1642.5}$$

Where P_{mode}= Power in mode

D_{units} = Screen diagonal inches in units

The Japan Annual energy calculations include allowances for electronic programme guide update or similar modes. These were not included due to lack of data and the passive standby power was instead increased to 0.6W to compensate. The effect is estimated to be in the range of 0.1-0.5%.

Japan Top Runner in 2026

C1

$$P_{on} = \frac{\left(0.02136 * A_{cm} - 16.4 + T_{2K} + SR_{4K,120}\right) * 1000 - P_{stby} * 7117.5}{1642.5}$$

C2

$$P_{on} = \frac{(0.00728 * A_{cm} + 62.99 + T_{2K}) * 1000 - P_{stby} * 7117.5}{1642.5}$$

C3

$$P_{on} = \frac{(0.00728 * A_{cm} + 62.99) * 1000 - P_{stby} * 7117.5}{1642.5}$$

C4

$$P_{on} = \frac{(0.00728 * A_{cm} + 62.99) * 1000 - P_{stby} * 7117.5}{1642.5}$$

C5

$$P_{on} = \frac{(0.0407 * A_{cm} + 30.08) * 1000 - P_{stby} * 7117.5}{1642.5}$$

Where P_{mode}= Power in mode

A_{units} = screen area in units^2

T_{2K}=2K tuner allowance, 2.8kWh

$SR_{44K,120}$=120Hz, 4K screen allowance, 18.3kWh

The Japan Annual energy calculations include allowances for electronic programme guide update or similar modes. These were not included due to lack of data and the passive standby power was instead increased to 0.6W to compensate.

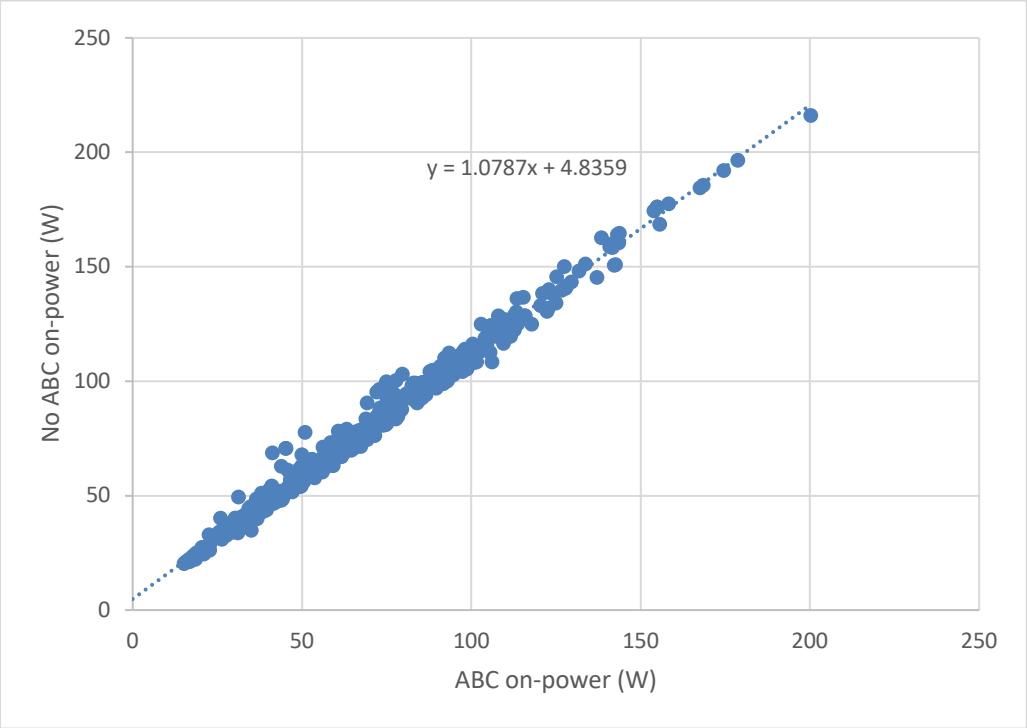
No recent data on EPG energy consumption was found. Research in 2009 estimated that a TV consumes 0.02kWh (20W for 1hr) per day on average. Accounting for efficiency improvements this is assumed to have dropped closer to 0.006kWh but this also depends on regional differences in the TV broadcast system. If this assumption is incorrect and EPG energy consumption is still 0.02kWh, the calculated on power is overestimated by 3W.

It is assumed that the tuner is FHD not 4K since this is more common globally.

The On power for TVs with ABC enabled is also calculated as $P_{on,\ JP}=P_{on,300}-P_{on,0}/4$. This was adjusted by calculating the Pon from Energy Star and correlating them.

The power is calculated as: $P_{on}=1.08*P_{on,JP}+4.8$

Figure 13: Correlation between On-power with and without ABC in the Energy Star 2018 database



South Korea MEPS and label

$$P_{on} = Eff_{grade,RY} * \sqrt[2]{A_m}$$

Where P_{mode}= Power in mode

A_{units} = screen area in units^2

$Eff_{grade, RY}$ = Efficiency allowance for each grade and Resolution

R_Y = resolution in Y-axis

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