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Development of Efficiency Policy for Ultra High Definition Televisions in India

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PARTNERS

Environmental Design Solutions (EDS)

AUTHORS

Mohit Verma, EDS
Aditi Verma, EDS
P. K. Mukherjee, CLASP India
PVN Kishore Kumar, CLASP India

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Executive Summary

Televisions are ubiquitous electronic appliances that are popular around the world. Research by the Broadcast Audience Research Council (BARC) India suggests that nearly 200 million[1] Indian households own televisions, out of a total of nearly 300 million households, implying that around two thirds of Indian households have a television.

The total number of televisions purchased in India has been increasing, and the average number of hours that the TV audience is watching television has also been growing. As per BARC studies measuring viewership in India, in the year 2016, India recorded 35 trillion hours of television viewing, which grew to 48.4 trillion hours in 2019[2].

Recognizing the increase in energy consumption due to the increasing number of hours of television viewership compounded by the increasing number of televisions sold in India, the Bureau of Energy Efficiency (BEE) has established mandatory energy efficiency policies for televisions sold in the country that encompass Minimum Energy Performance Standards (MEPS) as well as energy performance labeling. The BEE's program also facilitates comparative energy performance of different television models to enable informed purchase decision making.

A new technology commercially known as Ultra High Definition (UHD) television is now available in the market, and sales of UHD televisions are growing every year. The UHD televisions are not covered under BEE's existing program for televisions and therefore, as more consumers replace their current television with UHD televisions, or purchase additional televisions which are UHD, television energy consumption is expected to increase significantly.

BEE, with support from CLASP, is expanding the scope of the existing television labelling program to cover televisions with UHD technology. To achieve this, BEE and CLASP worked with Environmental Design Solutions (EDS) to make a comprehensive assessment of the Indian UHD television market through primary and secondary research to support development of an energy efficiency policy for UHD televisions. The research focused on multiple aspects of the UHD television market, such as the overall size of the market, the distribution of sales among various size categories, the market shares of various market players, the performance data of the various models of each market player, the supply chain of the products, etc.

While researching the supply chains used in the market, it was observed that retailer stores accounted for 80-90% of sales of UHD televisions. Another pattern revealed by the research was the import dependency of the UHD television market players. It was found that while India imports close to 50% of total UHD television that are annually sold, most components used for manufacturing of UHD televisions are also imported in India. That means, the market players which have the facilities to assemble the UHD televisions in India, and which account for around remaining 50% of the annual UHD television sales, import between 60-70% of all parts used in their UHD TV product models. The main countries from which both components and Completely Built Units (CBU) imported are China, Malaysia, Vietnam, Thailand, and Indonesia.

[1] Number of homes with TV sets grows by 7.5% to 197 million, says BARC, https://www.financialexpress.com/industry/number-of-homes-with-tv-sets-grows-by-7-5-to-197-million-says-barc/1259631/
[2] Indians are watching TV for 3 hour 44 minutes every day: BARC India, https://economictimes.indiatimes.com/industry/media/entertainment/indians-are-watching-tv-for-3-hour-44-minutes-every-day-barc-india/articleshow/65151371.cms?utm_source=contentofinterest&utm_medium=text&utm_campaign=cppst

During the research, global energy performance standards for UHD televisions were studied to help find best practices from around the world. The energy performance program defined by the European Union, China, and the United States ENERGY STAR voluntary program have been reviewed and an overview is presented in the report. It was found that globally, such programs use IEC 62087:2015 standard to measure energy consumption of televisions. The applicable safety standard to UHD televisions in India is IS 616:2017, which is harmonized with corresponding IEC 60065:2014. Salient points of both these standards are presented in the report. The report also presents an overview of independent testing facilities in India and which are empaneled with BEE for testing of televisions and their accreditation status by the national accreditation body in India.

The study revealed that the average annual energy consumed by a UHD television is significantly higher than televisions currently regulated by BEE. It was therefore decided to develop a separate program for UHD televisions. It was further found that UHD TVs with 8K resolution consume significantly more energy per year (on average) than UHD TV with 4K resolution. It was therefore decided to develop different benchmarks are required for UHD 4K and 8K televisions.

Based on an assessment of the ON mode and Standby mode power consumption, Annual Energy Consumption of 123 UHD television models, energy performance thresholds are proposed for UHD televisions. Also, the energy savings as well as greenhouse gas reductions for the years 2021 – 2030 have been projected. It is expected that the labeling program for UHD televisions will benefit the nation by saving 9.75 TWh (billion Units of electricity) and reduction of 8 million ton CO_2e of greenhouse gas emissions by the year 2030.

Introduction

Televisions (TVs) are electronic devices used to receive signals, which may be black and white, colored, with or without sound, and two or three dimensional. Most televisions, in India, these days are color televisions. Television signals may be terrestrial or digital, but since the year 2000, most television channels have moved towards digital signals.

Television ownership and viewership have both grown in India over the years. The installed stock of televisions in India grew from the 21 community television sets to which the first television transmission was made, to 88 million sets in the year 2000 to 105 million in 2007[3] to 119 million in 2011[4] to 183 million in 2016 and 197 million in 2018.[5] It can be seen that there is not just an increase in the number of televisions owned by Indians, but also an increase in the rate of the growth. This growth was reflected in both, the availability of content to be shown on TVs as well as the number of manufacturers who sell televisions in India. As per the latest data (as on 30.09.2018), there were more than 800 permitted private satellite TV channels operating in India[6], and in the same year, there were close to 70 brands selling televisions in India, which was twice the number in 2016.[7].

Over the years, television technology has also kept up with this growth in television sales and viewership. Earlier televisions were bulky and were made with a technology called the Cathode Ray Tube (CRT) technology. CRT technology targets electrons at a phosphorescent screen to create images. More recently, televisions have slimmed down and are now made with “flat panel displays” and are usually not more than a few centimeters thick. These flat screen televisions use “Red Green Blue” or RGB color technology that are part of “pixels”, which are a tiny component of the screen, and each pixel is divided into Red, Green and Blue colored parts. Different combinations of these three colors are activated to form images on the screen. The number of pixels a television screen is called its “screen resolution”. The latest innovation in television technology available in India is called “Ultra High Definition” (UHD) television, which has a much larger number of pixels than what was available in the market up till now.

Standards and Labeling (S&L) program for televisions with screen resolution up to 1,920 x 1,080 pixels (called Full HD or FHD resolution) was launched by the BEE, national nodal agency for implementation of energy efficiency initiatives, in the country in 2009. The mandatory phase of energy performance regulation for these televisions began in 2016. UHD televisions have a much higher pixel count than televisions with screen resolution up to 1,920 x 1,080 pixels, and it was found that they consume much more energy than High Definition (HD) or Full High Definition (FHD) televisions. Recognizing the growth potential of the UHD televisions and associated energy consumption, it was decided by the BEE to regulate the energy consumption of these devices.

An energy efficiency standards and labeling program for UHD televisions is expected to mitigate a surge in energy demand in three ways- firstly, once the program is made mandatory, only UHD televisions that meet the minimum energy performance standards would be allowed to be sold in India; secondly, a comparative labeling program will enable consumers to choose between an efficient and inefficient product; finally, the star rating table is revised periodically by BEE, which means that television manufacturers are expected to improve the energy performance of their TV models over time. It is especially important to develop policy for UHD televisions as, it has been found in some markets that 4K televisions consume approximately 30% more energy than HD TVs, and one test result demonstrated that the HDR feature now becoming common with UHD televisions consumes 47% more energy than a simple 4K television.[8]

This study has therefore been commissioned by CLASP to help understand the Indian market for UHD televisions and propose energy performance thresholds for a labeling program. This report presents a comprehensive market and technical assessment of UHD Televisions, analyses international test standards and labeling programs, proposes energy performance thresholds for UHD 4K and 8K televisions, and evaluates the national impact of the program in terms of energy and GHG savings.

[3] In India, the Golden Age of Television Is Now, https://www.nytimes.com/2007/02/11/business/yourmoney/11india.html
[4] '46 million households to use free TV by 2020', https://economictimes.indiatimes.com/industry/media/entertainment/media/46-million-households-to-use-free-tv-by-2020/articleshow/59452071.cms?from=mdr
[5] Number of homes with TV sets grows by 7.5% to 197 million, says BARC, https://www.financialexpress.com/industry/number-of-homes-with-tv-sets-grows-by-7-5-to-197-million-says-barc/1259631/
[6] Ministry of Information and Broadcasting, Master List of Permitted Private Satellite TV Channels as on 30.09.2018, https://mib.gov.in/sites/default/files/Master%20List%20of%20Permitted%20Private%20%20satellite%20TV%20Channels%20as%20on%20%2030.09.2018.pdf
[7] Indian television market heads for a price war, https://economictimes.indiatimes.com/industry/cons-products/electronics/indian-television-market-heads-for-a-price-war/articleshow/65446969.cms?from=mdr
[8] What Do We Know Now About the Energy Use of 4K/Ultra High Definition (UHD) and “Smart TVs”? https://www.energystar.gov/sites/default/files/asset/document/1_Noah%20Horowitz_Ultra%20High%20Definition_FINAL.pdf

UHD TVs classification

UHD televisions may be classified by the size of their screen, screen resolution, or technology. Manufacturers, channel partners and consumers all use these classifications to differentiate between the television models that they are making, selling, or purchasing.

CLASSIFICATION BY SCREEN SIZE

UHD televisions come in various screen sizes. For a television, the screen size is the measurement of the diagonal distance of the area where the images are shown, and not including the frame of the television, as shown in Figure 1.

Usually, screen size of televisions is referred to in inches, however, the metric system of measurements has been used in this report. Table 1 can be referred to for conversions from centimeters to inches.

In the Indian market, UHD 4K televisions are available between 108 to 218 cm and UHD 8K televisions are available in sizes from 140 to 249 cm.

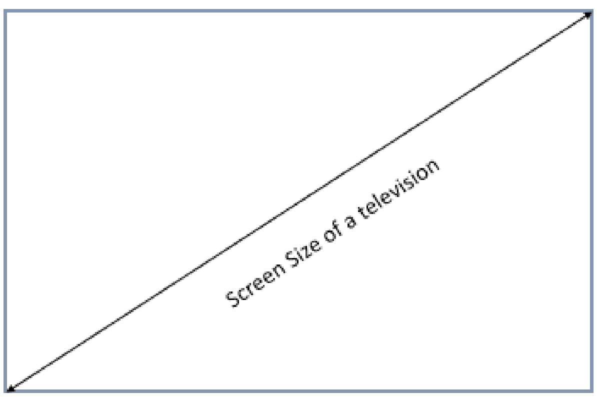


FIGURE 1 MEASUREMENT OF TV SCREEN SIZE

TABLE 1 CONVERSION TABLE FROM CENTIMETERS TO INCHES

Centimeters	Inches	Centimeters	Inches
100	39	180	71
105	41	185	73
110	43	190	75
115	45	195	77
120	47	200	79
125	49	205	81
130	51	210	83
135	53	215	85
140	55	220	87
145	57	225	89
150	59	230	91
155	61	235	93
160	63	240	94
165	65	245	96
170	67	250	98
175	69	255	100

CLASSIFICATION BY SCREEN RESOLUTION

In a television, pixels are arranged in a grid, and pixel count is determined by the number of vertical lines of pixels multiplied by the number of horizontal lines of pixels. An image on the television screen has thousands of pixels of different colors. In a digital image, the resolution of an image is determined by the pixel count, i.e., the resolution is the number of pixels used to make up an image. Higher resolution displays allow the viewer to see finer details on the TV screen. This is demonstrated in Figure 2 and Figure 3, where two images of the same size are shown with different number of pixels and it can be seen that the image with the high number of pixel count can show small details better whereas the image with the low pixel count is much more granulated. The screen resolution that a television offers is one of the most important aspects that defines its picture quality.

FIGURE 2 HIGH PIXEL COUNT IMAGE

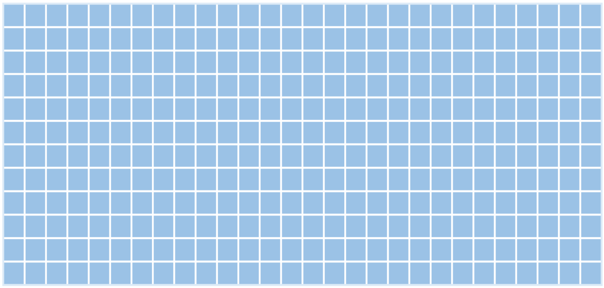


FIGURE 3 LOW PIXEL COUNT IMAGE

TABLE 2 VARIOUS SCREEN RESOLUTIONS AND THE ASSOCIATED NUMBER OF PIXELS

Display Screen Resolution	Horizontal Lines	Vertical Lines	Number of Pixels
High Definition (HD)	1,280	720	921,600
Full High Definition (FHD)	1,920	1,080	2,073,600
Quad High Definition (QHD)[9]	2,560	1,440	3,686,400
Ultra - High Definition 4K (UHD 4K)	3,840	2,160	8,294,400
Ultra - High Definition 8K (UHD 8K)	7,680	4,320	33,177,600

Table 2 lists the number of pixels available on the screens of various types of televisions available in the market. A UHD 4K television, or UHD as it is sometimes known, is made up of 3,840 x 2,160 pixels, which is over eight million pixels in total, giving four times the detail of an HD TV. Picture quality of 4K resolution is exceptionally sharp, with lots of detail and depth. At the top of the resolution scale is 8K, there aren't many televisions around currently that support 7,680 x 4,320 resolution, and those that can be found in the market are comparatively expensive.

Figure 4 further illustrates a comparison of the number of pixels available in each type of television. The image shows a comparison of the number of pixels each type of television has, and it can be seen that a UHD 8K television has 4 times the number of pixels available in an UHD 4K television. Similarly, UHD 4K televisions have 4 times the number of pixels in an FHD television.

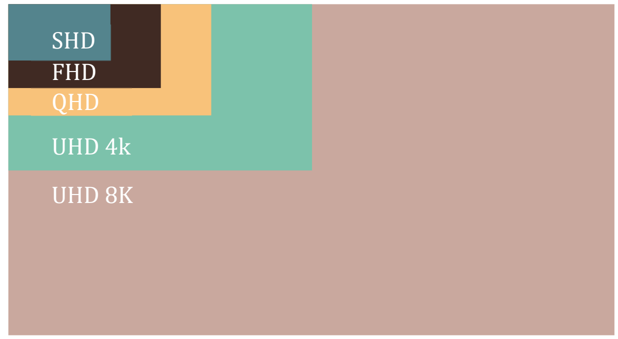


FIGURE 4 A COMPARISON OF THE NUMBER OF PIXELS AVAILABLE IN EACH TYPE OF TELEVISION

CLASSIFICATION BY TECHNOLOGY[10, 11]

UHD televisions have Flat Screen Display or Flat Panel Display (FPD) televisions and therefore can sustain high screen resolution. FPD televisions mainly use one of the following three technologies:

- Liquid Crystal Display (LCD) Technology, which are Liquid Crystal Display screens with cold cathode fluorescent lamp (CCFL) backlighting; or
- Liquid Crystal Display (LCD) Technology with Light Emitting Diode (LED) lights installed as backlighting; or
- Organic Light Emitting Diode (OLED) Technology, which is a self-illuminating technology and does not require additional backlighting.

Earlier, a third technology called "Plasma Technology" was also used, and more recently, some new technologies have been brought into the market, such as MicroLEDs, and QLEDs.

All these technologies use the RBG color technology described previously to form images on the screen but have different methods of lighting the pixels so that viewers can see them. The working principle of all these technologies are explained in **Annexure 1: Screen technologies.**

[9] This screen resolution is generally not available in the market. After Full HD televisions, the next screen resolution available in the market are UHD 4K, and UHD 8K televisions.
[10] Parts of LED TV And Their Functionality, https://specstalk.com/parts-of-led-tv/
[11] Understanding Today's LCD Screen Technology, https://pid.samsungdisplay.com/en/learning-center/blog/lcd-structure

Market Assessment

METHODOLOGY FOR DATA COLLECTION

Secondary and primary research methods were used to collect information about the UHD television market in India, including the information on energy performance, as well as the global best practices for UHD television standards and labeling. Some of the key steps undertaken to collate the desired information are as follows:

1. Secondary research: Intensive research involving review of various trade and business publications such as BARC publications; technology websites such as Specstalk, whathifi, pcmag, explainthatstuff, and digitaltrends, among others; newspapers and publications such as TV Veopar Journal, Times of India, the Hindu, the Indian Express, Mint, the Hindustan Times and others; academic journals; global standards and labeling regulations for televisions in a variety of countries such as Japan, China, Australia, New Zealand, Canada, USA, and the European Union, as well as in-depth assessment of web-portals of manufacturers/ brands that sell UHD televisions in India.

2. Primary research: Comprising of questionnaire-based surveys as well as in depth interviews. Separate questionnaires were developed and distributed to the stakeholders.

   a. Questionnaire based survey: Structured questionnaires were shared with all the major manufacturers, manufacturer association, and test facilities to collate the required information. The questionnaire included questions on the following key parameters:

      i. Market size: Volume of sales of UHD televisions and key players in the market.

      ii. Product specifications and characteristics: Information on screen resolution of the UHD TV product models (whether the television model is 4K or 8K resolution), and screen technology (whether the television model is equipped with LED screen, or an OLED screen, or any other technology), and information on screen sizes, etc.

      iii. Performance data: Information about the ON mode power consumption, the standby mode power consumption, and the annual energy consumption.

      iv. Testing capacity: The number of BEE empaneled National Accreditation Board for Testing and Calibration Laboratories (NABL) accredited labs which can conduct testing as per the relevant standards on UHD televisions and their monthly testing capacity.

   b. Intensive interviews and interaction with the industry experts and CEAMA[12] -the manufacturers' association for consumer electronics and electrical appliances. The discussions facilitated validation of the data coverage.

   c. Discussions with the BEE to gain insights on existing S&L program for color televisions.

MARKET CHARACTERISTICS IN INDIA

TOTAL SALES

A total of 10.5 million units of televisions (UHD and all other screen resolution types) were sold in India in 2018-19.[13] In 2018-19, approximately 1.31 million units of UHD televisions were sold, which is about 12% of the total Indian television market. Between 2016 and 2019, the UHD TV market grew at a CAGR of 33%.[14] These numbers indicate that UHD televisions

[12] Consumer Electronics and Appliances Manufacturers Association

[13] Source: Information on market of televisions upto FHD has been collected from the Bureau of Energy Efficiency. Further, the estimated sales of UHD TVs have been added to arrive at total TVs sales.

[14] Source: CAGR estimated based on data collected.

are becoming increasingly popular with Indian consumers. Sales of UHD televisions from 2016 to 2019 are shown in Figure 5.

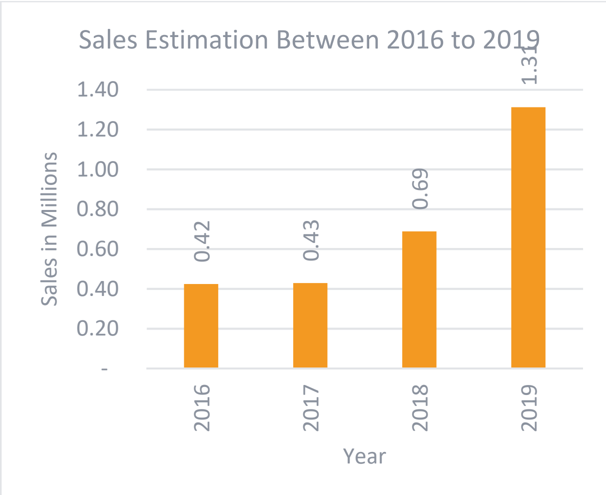


FIGURE 5 SALES ESTIMATION OF UHD TELEVISIONS FROM 2016 TO 2019[15]

INSTALLED STOCK

Taking into account annual sales and the average lifespan of UHD televisions, shared by the television manufacturers, it is estimated that there are about 2.9 million units of UHD televisions installed stock currently in India.

MARKET FORECAST UNTIL FY 2030

Market sales projection have been estimated in the following manner:

- Sales growth in 2020 is considered 1.5%[16], because of low demand due to the impact of the COVID-19 pandemic.
- Assumed at a growth rate of 9% year on year after 2030, based on information received from the industry.

FIGURE 8 SALES BY SCREEN TECHNOLOGY IN FY 2019

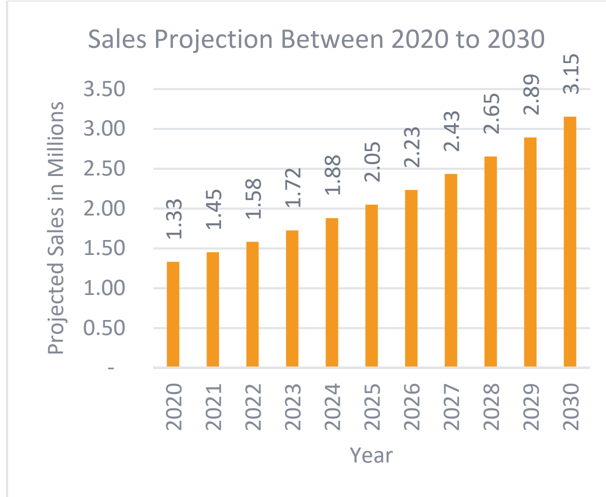


FIGURE 6 SALES PROJECTION BETWEEN 2020 TO 2030

It is estimated that the annual sales of UHD televisions may be more than 3 million units by 2030, as shown in Figure 6, this is more than two times the estimated annual sales of 2020. This growth may be fueled by the following factors:

- UHD TVs have not just more resolution or pixels compared to Standard Definition (SD) and HD televisions, but also have smarter pixels and better color rendition. The most important aspect is that it delivers images with a wider range of truly life-like natural colors, greatly expanded contrast range and faster motion having less motion blurs.
- Purchase patterns may be positively affected by the increasing disposable income of the consumers. Consumers now also have access to on demand video streaming services like Netflix, Amazon Prime, etc. on their televisions which provides high display quality.
- Competition between manufacturers as well as maturing technology, especially for OLED TVs, may lead to lower prices of UHD televisions. Lastly, consumer interest in UHD televisions may increase due to increased availability of UHD content as well as better internet access.

TYPE-WISE MARKET TREND

MARKET BY SCREEN TECHNOLOGY

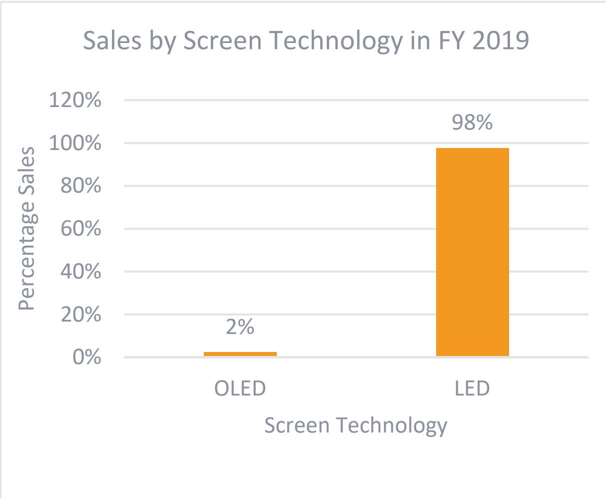
Indian UHD TV market is dominated by LED TVs with 98% sales attributable to the category.[17] It may also be noted that all

FIGURE 7 MARKET AVAILABILITY (NO. OF MODELS) BY SCREEN RESOLUTION

[15] Source: Information has been collected from the manufacturers of UHD TVs and discussions were held with some of these manufacturers to understand and validate the information on market sales.

[16] Source: 1.5% in 2020 has been assumed based on discussion with a few industry experts. This has been further discussed with stakeholders during the Technical Committee Meeting.
[17] Source: Information based on the data provided by manufacturers

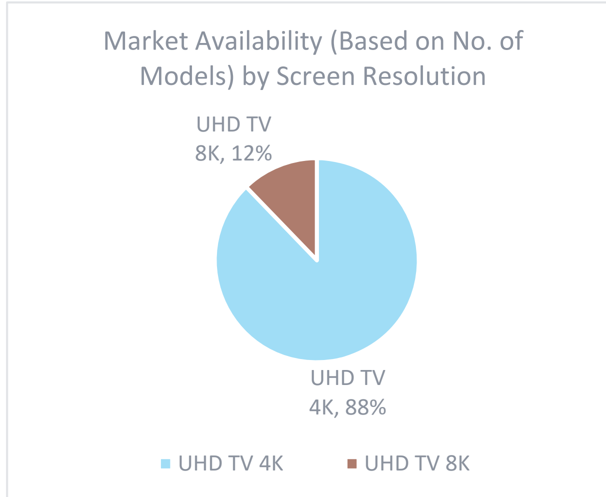
UHD OLED televisions in the market are UHD 4K TVs.



MARKET BY SCREEN RESOLUTION

In terms of availability in the market 88% of the UHD televisions available for sale are UHD 4K televisions.[17] The remaining 12%[17] of the UHD televisions available for sale are 8K televisions.

In terms of market sales, UHD TV market is dominated by UHD 4K televisions, which comprise 98-99% of the market, while UHD 8K televisions are only 1% to 2%. This may be due to a variety of reasons, such as:



- Unavailability of UHD 8K content- 8K content is not available as yet to any streaming, broadcast, or physical media.[18]
- UHD 8K televisions are more expensive than UHD 4K televisions of similar screen sizes.

MARKET BY SCREEN SIZE

In the year 2019, the estimated sales of all UHD televisions fell largely in the 102 to 152 cm screen size categories, with 94% sales, presented in Figure 9. This indicates that consumers have a distinct preference for the smaller UHD televisions available in the market. This preference may be due to the cost of larger television sizes as well as due to the average room size in which a television is installed since on average the distance between the viewer and the television should be 1.5 times the height of the television screen.

[18] Source: https://in.pcmag.com/dvd/118747/what-is-8k-should-you-buy-a-new-tv-or-wait

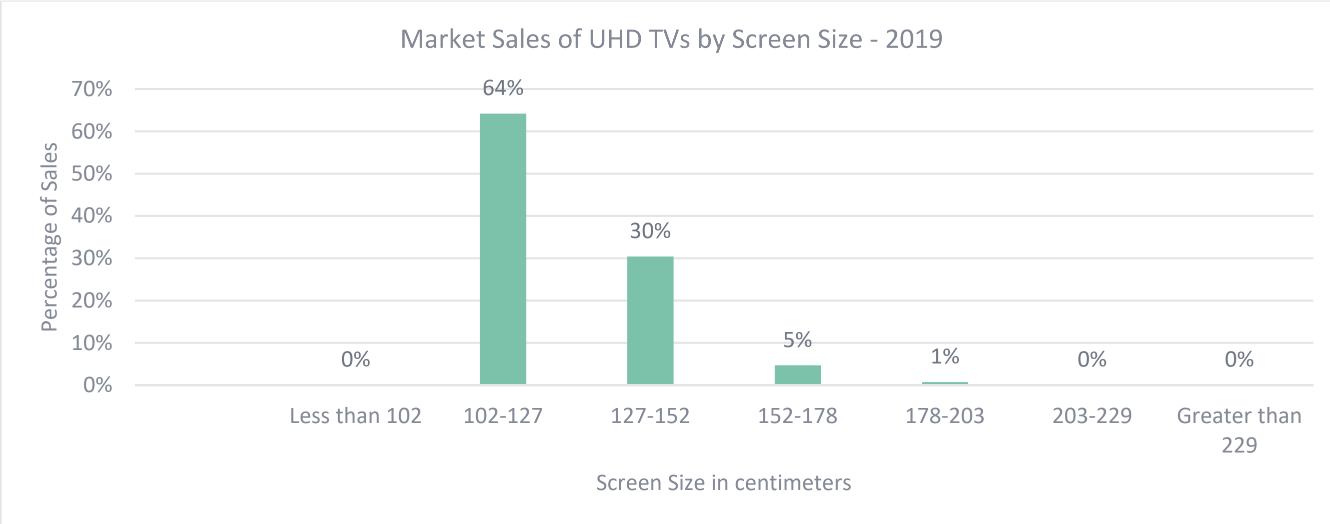


FIGURE 9 SALES OF UHD 4K AND 8K TELEVISIONS BY SCREEN SIZE

Figure 10 shows the market availability of UHD television models for sale in the market, segregated in respective screen size bands. According to the data collected from stakeholders for 123 UHD television models, it is observed that:

- 85% UHD 4K televisions are in the 102– 178 cm categories.
- 87% UHD 8K televisions are in the 152.4 - 229 cm size categories. 93% UHD 8K televisions available in the market are more than 152.4 cm in size.

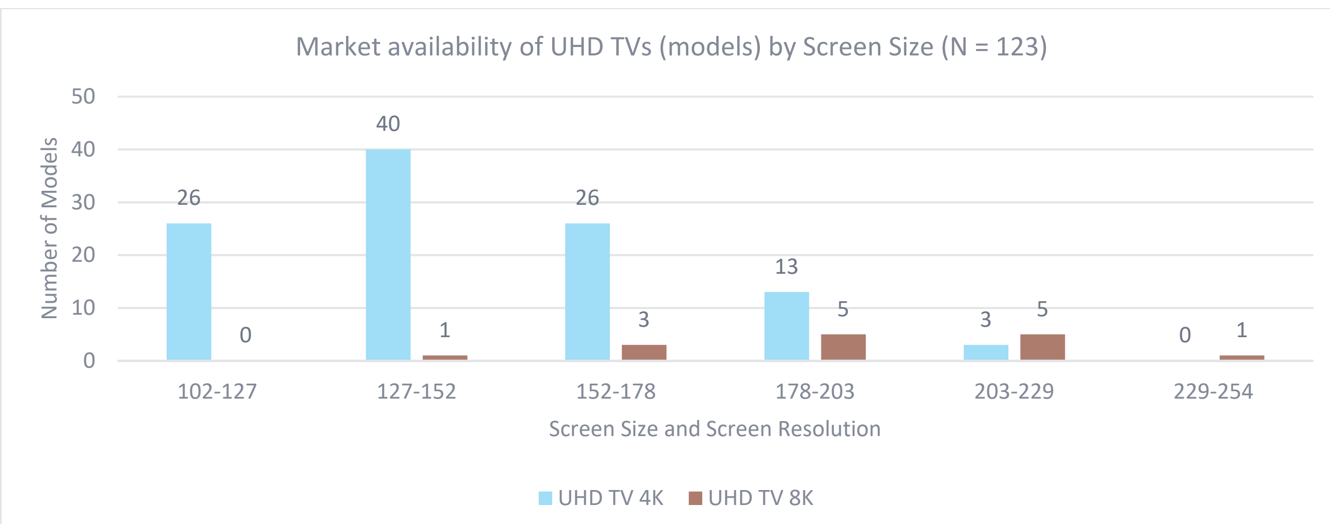


FIGURE 10 MARKET AVAILABILITY OF UHD TVS (MODELS) BY SCREEN SIZE AND SCREEN RESOLUTION

KEY PLAYERS

The Indian UHD TV market has some of the most prominent international and national brands. The UHD television market is dominated by four major players – Samsung, LG, Sony, and Panasonic. Together, these brands hold nearly 84% of the market by sales by volume. Among these, Samsung and LG are the market leaders and hold about 59% of UHD TV market sales, followed by Sony and Panasonic, which comprise 25% of UHD TV market sales.[19]

84% of the Indian UHD TV market:

[19] Source: Information for the year 2019 based on data collected from stakeholders

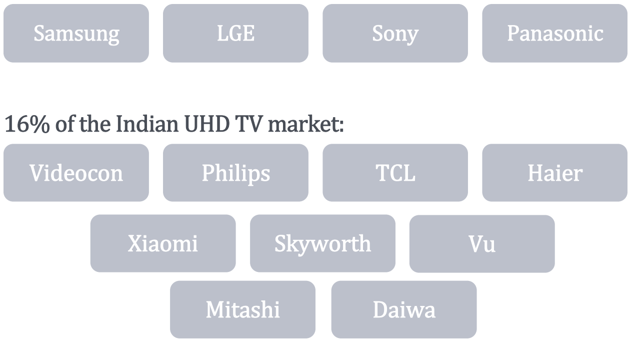


FIGURE 11 MAJOR PLAYERS IN THE INDIAN UHD TV MARKET

SUPPLY CHAIN ANALYSIS

IMPORT AND EXPORT

The imports and exports are classified as per HS (Harmonized System) codes. The relevant HS code for import of televisions is 85287217. This HS code covers televisions with all screen resolutions with screen size greater than 105 centimeters including UHD. Since the screen size of all UHD television models available in India is more than 105 cm[20], it can therefore be construed that all UHD televisions that are imported in India fall under this HS code.

The Department of Commerce, Ministry of Commerce and Industry, Government of India, maintains the record of annual import of televisions under the given HS code. Figure 12 presents the annual imports reported from 2015-16 to 2018-19. The total imports reported between April 2019 and March 2020 were 0.51 million[21].

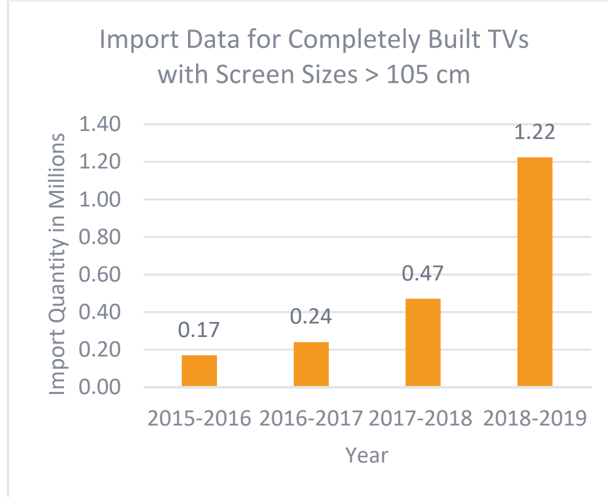


FIGURE 12 IMPORT DATA FOR ALL TVS (UHD AND NON-UHD) WITH SCREEN SIZES > 105 CM[21]

Of the total annual imports reported in Figure 12, the annual import of UHD TVs is estimated to be around 0.65 million[22] for 2018-19 (close to 50% of total UHD television sales estimated).

Market players in India import significant percentage of the UHD televisions from China, followed by Malaysia, Vietnam, Korea, Indonesia, and Thailand. Information on imports of televisions of screen sizes greater than 105 cm from key trade partners are shown in Table 3 and Table 4.

TABLE 3 IMPORTS UNDER HS CODE 85287217 FROM CHINA, INDONESIA, HONG KONG, AND KOREA RP FOR THE YEARS FY 2015 - 2020

Year	China	Indonesia	Hong Kong	Korea RP
2014-2015	570	10	-	320
2015-2016	7,800	2,650	10	350
2016-2017	110,440	-	-	280
2017-2018	212,510	-	1,650	860
2018-2019	1,073,440	-	6,590	370
2019-2020	483,980	-	2,840	760

[20] Source – Refer section on UHD TV classification in this report
[21] Source: EXPORT IMPORT DATA BANK Version 7.1 – TRADESTAT, https://commerce-app.gov.in/eidb/. The import numbers for 2019-20 might still get updated in next few months. The unprecedented Covid situation might have delayed in updating of the records.
[22] Source: Almost all market players (makes /brands) of UHD televisions in the Indian market import fully built UHD TV units (based on the information collected from stakeholders). Amongst these, there are few players which do not have local manufacturing or assembly facility and hence these players are fully reliant upon import of CBUs UHD TVs. The estimation of UHD TV annual import has been done by applying the annual sales of these players which are expected to import CBUs only and also discussions were held with some of the key brands which imports CBUs as well as assemble the UHD TVs in India. The import percentage of CBUs of UHD TVs is estimated to be around 50% of the market sales. This figure is likely to fall in 2020 as the imports under this HS code so far reported, are significantly lower in numbers.

TABLE 4 IMPORTS UNDER HS CODE 85287217 FROM MALAYSIA, SINGAPORE, THAILAND, VIETNAM FOR THE YEARS FY 2015 - 2020

Year	Malaysia	Singapore	Thailand	Vietnam
2014-2015	243,160	100	-	-
2015-2016	159,140	20	-	-
2016-2017	128,730	110	-	290
2017-2018	252,490	170	730	2,070
2018-2019	91,900	130	270	50,080
2019-2020	11,240	670	1,410	130

The Government of India launched “Make in India” initiative in 2014to encourage domestic manufacturing, and its impact can be seen in Table 3 and Table 4, where the imports reported from April 2019 until March 2020 are significantly less than the previous year (2018-19).

Furthermore, it is likely that imports have been impacted by the Government’s drive towards self-reliance in manufacturing through their “Atmanirbhar Bharat” program. The Directorate General of Foreign Trade has changed the import policy for color televisions from “Free” to “Restricted” via a notification dated 30 July 2020.[23] It states that a company that wishes to import these televisions will now need a special license to do so.[24]

Under the same HS code, Table 5 presents the reported numbers of television exports from India as per Ministry of Commerce’s Export Import Data Bank, which is very marginal.

TABLE 5 EXPORTS UNDER HS CODE 85287217

Year	Exported nos. of televisions with screen size greater than 105 cm
2014-2015	40
2015-2016	0
2016-2017	20
2017-2018	40
2018-2019	70
2019-2020	110

Since 2014-15, the most exports have been made to Malaysia and Bhutan, of 60 televisions each, 50 have been exported to Japan in the same time period, though none in 2019-20, 40 have been exported to Singapore. Smaller numbers have been exported to Bangladesh, Taiwan, Nepal, UAE, USA, and Yemen.

LOCAL MANUFACTURING

Among the four major players in the UHD TV market, LG and Sony have local in-house facilities for assembly of UHD TVs. Most parts that go into the making of UHD televisions are imported in India. According to the information collected through questionnaires, market players who import parts and assemble them in India, import between 60-70% of all parts used in their UHD TV product models. The key parts are mainly imported from China, Vietnam, Malaysia, Thailand and Indonesia. Only a few types of television screens and speakers are sourced locally in India. The break-up of the supply chain of the parts used to make /assemble UHD televisions are provided here:

TABLE 6 COMPONENTS IMPORTED FOR UHD TELEVISIONS AND RESPECTIVE COUNTRIES

Part	China	Indonesia	Malaysia
Housing (mechanical parts)	✓	✓	✓
Motherboards	✓	-	-
Complete modules	✓	-	✓
Television screens	✓	-	-
Optical film	✓	-	-
Light guide plates	✓	-	-
Ports (HDMI, USB, etc.)	✓	-	✓
Speakers	✓	✓	✓
Bluetooth and Wi-Fi parts	✓	✓	-
Remotes	✓	✓	✓
Power supply boards	✓	-	-
Power adaptors	✓	-	✓

TABLE 7 COMPONENTS FOR MANUFACTURING OF UHD TELEVISIONS FROM VIETNAM, THAILAND, AND INDIA

Part	Vietnam	Thailand	India
Housing (mechanical parts)	✓	✓	-
Motherboards	✓	✓	-
Complete modules	✓	✓	✓
Television screens	✓	✓	✓
Optical film	✓	✓	-

[23] Source: DGFT Notification 30.07.2020, https://content.dgft.gov.in/Website/dgftprod/b1b48bd4-bcda-4a71-b96c-5ea3c3306760/Notification%2022%20English.pdf

[24] Source: Here’s why getting an import licence for TV sets will not be easy now https://www.moneycontrol.com/news/business/economy/heres-why-getting-an-import-licence-for-tv-sets-will-not-be-easy-now-5703371.html

Light guide plates	✓	✓	-
Ports (HDMI, USB, etc.)	✓	✓	-
Speakers	✓	✓	✓
Bluetooth and Wi-Fi parts	✓	✓	-
Remotes	✓	✓	-
Power supply boards	✓	✓	-
Power adaptors	✓	✓	-

DISTRIBUTION CHANNELS

The distribution channels used by UHD television manufacturers are the same as those for other color televisions for the market as a whole. Well established brands leverage the distribution network they have already built over the years, while also taking advantage of relatively new channels such as e-commerce. On the other hand, newer brands which do not have the advantage of an established distribution network have been exploring newer forms of entering the Indian UHD television market place, such as their own websites or sales through partner e-commerce websites such as Flipkart or Amazon[25]. However, the UHD television segment is relatively new in the Indian market in terms of both the number of years of availability as well as market penetration, and there is no "set" way that all manufacturers have chosen.[26]

According to data received from the manufacturers, currently traditional brick and mortar distribution channels dominate the Indian market, making up approximately 80% - 90% of the UHD television market in India. The remaining 10% belongs to e-commerce stores, whether the company's own website or a third-party partner.

E-COMMERCE

Internet based web stores which may be single stores brand stores such as those belonging to the brands themselves or multi-brand markets such as Amazon or Flipkart are categorized under this distribution channel. These stores do not have an associated brick and mortar store as is the case with the e-commerce websites of Modern Retail Stores. Sales of up to 20% of total television sales in 2018 were estimated to be through online transactions[27]. It is estimated from data received that between 10% to 20%[28] sales of UHD televisions may happen through these stores.

[25] Nokia 43-inch 4K Ultra-HD Smart TV with Dolby Vision and JBL Audio launched in India for Rs 31,999, https://www.financialexpress.com/industry/technology/nokia-43-inch-4k-ultra-hd-smart-tv-with-dolby-vision-and-jbl-audio-launched-in-india-for-rs-31999/1980829/
[26] Narrow focused, short term strategy always fails: Kodak on the Indian TV market, https://www.deccanchronicle.com/technology/in-other-news/250618/narrow-focused-short-term-strategy-always-fails-kodak-on-the-indian.html
[27] Sales of televisions above 32-inch has grown by 10% in offline market January to April, https://economictimes.indiatimes.com/industry/cons-products/electronics/sales-of-televisions-above-32-inch-has-grown-by-10-in-offline-market-january-to-april/articleshow/69994440.cms?from=mdr
[28] Source: Information based on the data provided by manufacturers

Review of test standards and facilities

There are two relevant test standards applicable to the testing of televisions in India. These are:

- IS 616:2017 – Standard for safety requirements
- IEC 62087:2015 parts 1, 2, and 3 Edition 1.0 – Standard for measurement of power consumption

IS 616:2017

IS 616, which is identical with corresponding IEC 60065:2014, applies to electronic apparatus intended for reception, generation, recording or reproduction of audio, video and associated signals. This standard primarily concerns apparatus intended for household and similar general use concerning electrical, mechanical, radiation and fire safety. Some of the new tests are tests related to the new requirement of electric shock hazard under normal operating conditions for loudspeaker systems, tests related to the additional requirements for "Measurement of temperature rise", added requirements for provisions for protective earthing, added requirements for printing boards, and others.

IEC 62087:2015 Edition 1.0

IEC 62087:2015 states how the power consumption in different modes and illuminance and luminance shall be measured for televisions.

The general set up for power measurement includes conditions about main battery connection, external power supplies, mains power, power from other than the mains, power source, On mode power source, partial On and Off modes specified in clause 5.1.1 of IEC 62087 part 1.

The initial activities to be undertaken before measurement of power consumption are listed in clause 6.3 of IEC 62087 part 3, including cool down, main batteries, plug-in module, installation, application of input signals, luminance measuring device setup, light source setup, power on, and TV settings.

Information about signal generation equipment, interfaces and accuracy, as well as the video signal for on mode power consumption, peak luminance ration determination, and other information about video and audio signals are provided in IEC 62087-2. Luminance measurement is detailed in clause 6.5 of IEC 62087-3. The clause talks of Automatic Brightness Control, stabilization, normal measurement, quick measurement, and activities for peak luminance ratio and power factor determination.

The methods for the determination of power consumption in standby modes is specified in clause 6.6 of IEC 62087-3. Power consumption in the standby-passive mode may be determined according to clause 6.6.4, and power consumption in the Standby-active low mode may be tested as per clause 6.6.5. Determination of power consumption of the off mode can be done according to clause 6.7.

The method for calculating the on-mode power consumption is detailed in clause 6.4.5. Measurements using static video signals are in clause 6.4.5.2, measurements using the dynamic broadcast-content video signal are specified in clause 6.4.5.3, and the measurements using the Internet-content video signal are in clause 6.4.5.4.

LIST OF INDEPENDENT TEST FACILITIES

To determine the testing facilities available in the market, detailed discussions were carried out with testing facilities as well as Consumer Electronics and Appliances Manufacturers Association (CEAMA) and manufacturing companies. It was found that adequate testing facilities exist in the country to carry out tests for UHD televisions. Some of the third-party / independent facilities equipped with infrastructure to test televisions for performance and safety have been listed or are given Table 8.

TABLE 8 LIST OF INDEPENDENT TEST FACILITIES FOR PERFORMANCE AND SAFETY TESTING OF TELEVISIONS

Sr. no.	Independent Test facility (empaneled with BEE)	Location	Applicable test standards and NABL accreditation status	
			IS 616	IEC 62087:2015

1.	Bharat Test House Pvt. Ltd.	Sonipat, Haryana	Yes	Yes
2.	Classic Instrumentation Pvt. Ltd.	Noida, Uttar Pradesh	Yes	Yes
3.	EMC Testing and Compliance LLP	Bengaluru, Karnataka	Yes	Yes
4.	URS Testing Labs	Noida, Uttar Pradesh	Yes	Yes
5.	Nextron International Lab Pvt. Ltd.	Delhi	Yes	No

In addition, manufacturers also have their own testing facilities for safety and performance testing of UHD TVs.

Global Efficiency Policy Programs

Several global standards and labeling programs for televisions were reviewed for this project. Three of the major programs i.e., European Union Regulation, the US ENERGY STAR performance standard, and the Chinese Regulation for energy consumption of televisions are described in the chapter.

OVERVIEW OF THE EU PROGRAM

Currently the European Union (EU) television market is governed by the standards and labeling regulation which came into effect in 2010. However, a new regulation has already been passed, which will come into effect in 2021. The implementing body for this regulation will be the European Commission, and the regulation will apply to electronic displays, including televisions, monitors and digital signage displays. The test regulation is the Commission Delegated Regulation (EU) 2019/2013 of 11 March 2019, and it grades the Energy Efficiency Index (ratio of weighted energy consumption to the standard energy consumption) to understand how energy efficient a display system is.

An Energy Efficiency Index (EEI) is more effective methodology to determine the on-mode power consumption as it takes into account one or more features in addition to the standby power consumption. Some of the most common features are as follows:

- Screen size of the television
- Whether it is playing HDR content
- The sound levels
- Whether ABC is enabled

Indices provide a baseline against which performances can be measured. The smaller the value of the Energy Efficiency Index, the more energy efficient the television is.

The energy efficiency class of an electronic display shall be determined on the basis of its Energy Efficiency Index (EEI_{label}) for labeling using the following equation.

$EEI_{label} = (P_{measured} + 1) / (3 \times (90 \times \tanh(0.025 + 0.0035 \times (A - 11) + 4)) + 3) + Corr_l$

Where:

- $P_{measured}$ is the measured power in on-mode in Watts in the normal configuration; This may be measured for Standard Dynamic Range (SDR) displays or High Dynamic Range (HDR) displays as per procedure.
    - Electronic displays with automatic brightness control (ABC) shall qualify for a 10% reduction in $P_{measured}$ if they meet certain conditions.
- A represents the viewing surface area in decimeter squared.
- $corr_l$ is a correction factor, which is 0.0 for televisions.

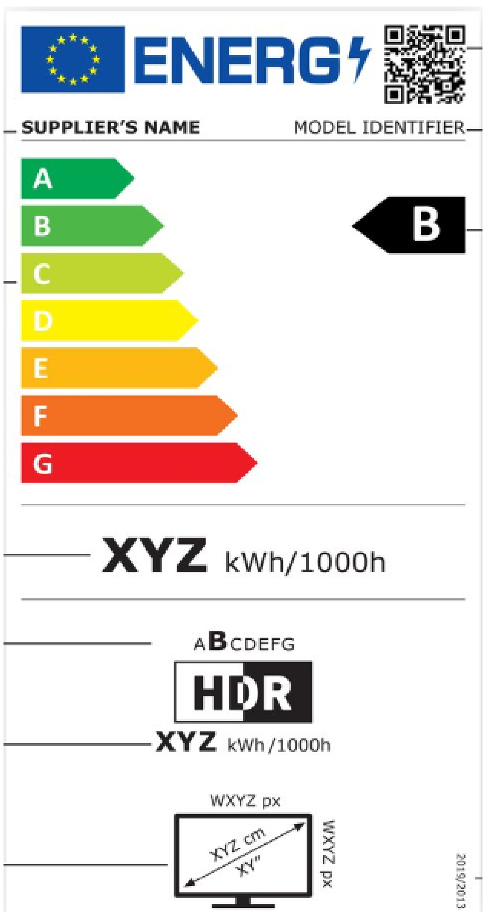


Figure 13 EU television energy efficiency label

Table 9 Star Label Table for the EU Display Screen MEPS Regulation

Efficiency class	Label bands
A	$EEI_{label} < 0.30$
B	$0.30 \leq EEI_{label} < 0.40$
C	$0.40 \leq EEI_{label} < 0.50$
D	$0.50 \leq EEI_{label} < 0.60$
E	$0.60 \leq EEI_{label} < 0.75$
F	$0.75 \leq EEI_{label} < 0.90$
G	$0.90 \leq EEI_{label}$

Measurement of Peak White Luminance shall be made:

- Using a luminance meter, detecting the portion of the screen which is displaying a 100% white image, which is part of a 'full screen test' pattern not exceeding the Average Picture Level (APL) where any power limiting or other irregularity occurs.
- Without disturbing the luminance meter's detection point on the electronic display whilst switching between the normal configuration and the brightest on mode configuration.

Measurements:

- For Standard Dynamic Range, measurements shall be made using a dynamic broadcast video signal test loops representing typical broadcast content for electronic displays in standard dynamic range (SDR).
- For High Dynamic Range measurement, the electronic display must automatically and correctly respond to the HDR metadata in the test loop.
- The measurement shall be the average power consumed over 10 consecutive minutes

How to make measurements:

- Put the television in off mode, or if off mode is unavailable, in standby mode, for a minimum of 1 hour.
- Immediately after d(i), put the television in On Mode for 1 hour continuously displaying the relevant video signal.
- All tests must be completed before a maximum of 3 hours in the On Mode.
- For electronic displays that are known to stabilize within 1 hour, these durations may be reduced if the resulting measurement can be shown to be within 2% of the results that would otherwise be achieved using the durations described here.

For televisions with ABC:

- Measurements should be made with ABC switched off.
- If ABC cannot be switched off, measurements should be performed in an ambient light condition of 100 lux measured at the ABC sensor.

OVERVIEW OF THE ENERGY STAR PROGRAM

The ENERGY STAR Program is active for televisions manufactured on or after January 1, 2013. The Version 8.0 ENERGY STAR TV specification took effect on March 1, 2019. This program is implemented by US EPA.

FIGURE 14 EXAMPLES OF THE ENERGY STAR LABEL

The program includes products that are:

- marketed to the consumer as a TV/ Home Theater Displays (HTD), TV/HTD is the primary function)
- meet one of the following product type definitions: TVs, HTDs, and Hospitality TV/HTDs

This program excludes the following products:

- Products that are covered under other ENERGY STAR product specifications
- Projectors
- TV/HTDs with a Main Battery that enables operation without connected mains power
- Products with a computer input port (e.g., VGA), that are marketed and sold primarily as computer monitors or other displays, and that do not contain an integrated TV tuner encased within the product housing.

To qualify for Energy Star, televisions must be able to qualify on the following parameters:

- $P_{ON} \leq P_{ON\_MAX} + P_{HR}$,
- $P_{ON\_MAX} = 78.5 \times \tanh(0.0005 \times (A - 140) + 0.038) + 14$
- $P_{HR} = 0.5 \times P_{ON\_MAX}$

where:

- P_{ON} is the on-mode power in watts
- P_{ON_MAX} is the Maximum On-Mode Power requirement in watts
- P_{HR} is a high-resolution allowance in watts (as applicable)
- A is the viewable screen area of the product in square inches
- tanh is the hyperbolic tangent function

OVERVIEW OF THE PROGRAM IN CHINA

The minimum energy performance standard in China for televisions has been active since 2013, and is applicable to flat screen televisions, which are defined in the standard as LCD televisions and plasma televisions. However, since most manufacturers do not make televisions with plasma technology anymore, the program at the moment is applicable only to LCD televisions. This standard uses Energy Efficiency Index to determine the energy performance of the television.

The minimum energy efficiency index required for the energy efficiency limit for flat-screen TVs is level 3 EEI, while meeting the passive standby power limit, which states that passive standby power of the flat-screen TVs should be less than or equal to 0.50 W.

TABLE 10 EFFICIENCY CLASS FOR LCD TELEVISIONS IN THE CHINESE STANDARD FOR ENERGY PERFORMANCE OF TELEVISIONS

Efficiency class	LCD TV Energy Efficiency Index (EEI_{LCD})
Level 1	2.7
Level 2	2.0
Level 3	1.3

The energy efficiency of flat-screen TVs is calculated according to formula: $Eff = (L \times S) / (P_k - P_s)$,

Where:

- Eff is flat-screen TV energy efficiency, in Candela per watt (cd/W)
- L is the average screen brightness, in Candela per square meter (cd/m^2)
- S is the effective glow area of the screen in square meters (m^2)
- P_k is power, in watts (W)

- P_s is signal processing power in watts (W).

It may be noted that when using the analog RF interface input, P_s is 4 W; When using the digital RF interface input, P_s is 8 W; If a different interface input is used, P_s is 0 W.

Calculation of Energy Efficiency Index of LCD TV: $EEI_{LCD} = Eff / Eff_{LCD,\ ref}$

Where:

- EEI_{LCD} is LCD TV Energy Efficiency Index, measured 1;
- Eff_{LCD}, ref is LCD TV energy efficiency benchmark value, equal to 1.1 cd/W.

Technical assessment and development of energy performance standards

This section provides an analysis of the data collected from market players to gain technical insights about power consumption in UHD televisions and the effect of screen size and screen resolution on power consumption. Further, energy performance values have been analyzed for development of energy performance thresholds UHD 4K and UHD 8K televisions.

The data has been provided by six manufacturers for 123 UHD television models, of which 108 are UHD 4K televisions, and the remaining 15 are UHD 8K televisions. These six manufacturers hold approximately 90% market share in sales for UHD televisions.

POWER CONSUMPTION IN THE STANDBY MODE

According to IEC 62087-3:2015, during standby mode, the television set is connected to an external power source and does not provide picture or sound. The television set can be switched into another mode. An analysis of the standby mode (off, standby passive, standby active low, and standby active high) data received from manufacturers is captured in Table 9.

The measures of central tendency are comparable for both UHD 4K and UHD 8K TVs, with the mean and mode being the same at 0.4 watts and 0.5 watts, respectively. The median for UHD 8K TVs is slightly smaller than that of standby power consumed by UHD 4K TVs.

The minimum standby power consumed by a UHD 4K TV is 0.13 watts, and the maximum is 0.5 watts, giving a range of 0.37 watts. These numbers are 0.12 watts and 0.5 watts for UHD 8K TVs, which gives a range of 0.38 watts.

These results indicate that standby power consumption in UHD televisions being sold in India is already very efficient, and there is negligible difference between the power consumed by UHD 4K and UHD 8K TVs in this operational mode.

TABLE 11 SUMMARY OF POWER CONSUMPTION IN STANDBY MODE

Central tendency	UHD TV 4K	UHD TV 8K
Mean	0.40	0.40
Median	0.50	0.49
Mode	0.50	0.50
Min	0.13	0.12
Max	0.50	0.50
Range	0.37	0.38

POWER CONSUMPTION IN THE ON MODE

IEC 62087-3:2015 states that a television is in on mode when the television set is connected to an external power source and provides picture and, if possible, sound. During on mode, a television consumes power because it is using all its components to receive television signals and reproduce them for viewers.

As the screen size of UHD television increases, their average on-mode power consumption also increases. This is true for both UHD 4K and UHD 8K televisions. This is illustrated in Figure 15 in which the on mode power consumption of UHD televisions are shown by screen size and screen resolution, and it can be seen that UHD 8K models consume much more power in the on-mode than comparably sized UHD 4K televisions.

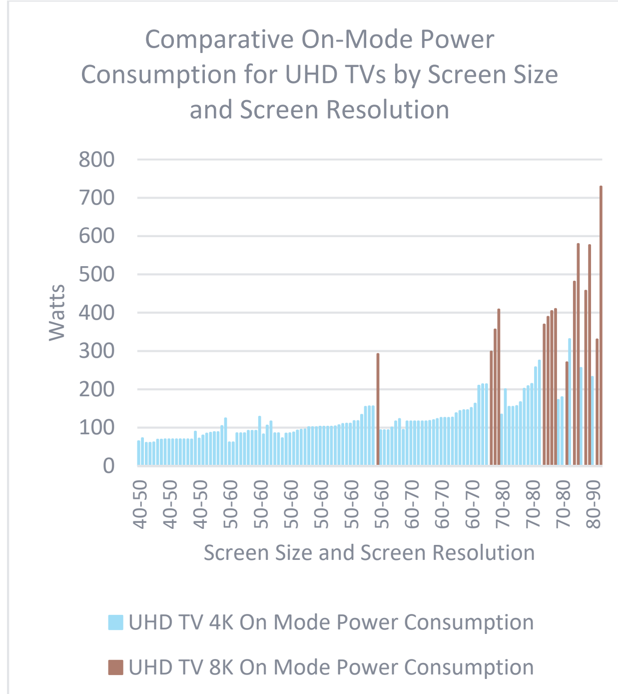


FIGURE 15 COMPARATIVE ON-MODE POWER CONSUMPTION FOR INDIVIDUAL UHD TVS BY SCREEN SIZE AND SCREEN RESOLUTION[29]

ANNUAL ENERGY CONSUMPTION OF UHD TELEVISIONS

According to the BEE's current notification on the labeling program for color televisions, the Annual Energy Consumption (AEC) is calculated in kWh/Year as follows:

AEC = (6 x On-Mode power Consumption + 12 x Standby mode power consumption) x 0.365

This formula considers a daily average of 6 hours of active television watching as well as 12 hours of the television being on standby mode. Based on the power consumption data both ON and OFF mode of 123 models shared by the manufacturers, average annual energy consumption was calculated using the above equation. The analysis of these results is presented in Figure 16 below. The number of hours for on mode and standby mode are in line with BEE's current labeling program of TVs of resolution up to and including 1,920 x 1,080 pixels.

[29] On mode power consumption data was shared by manufacturers for all 123 models

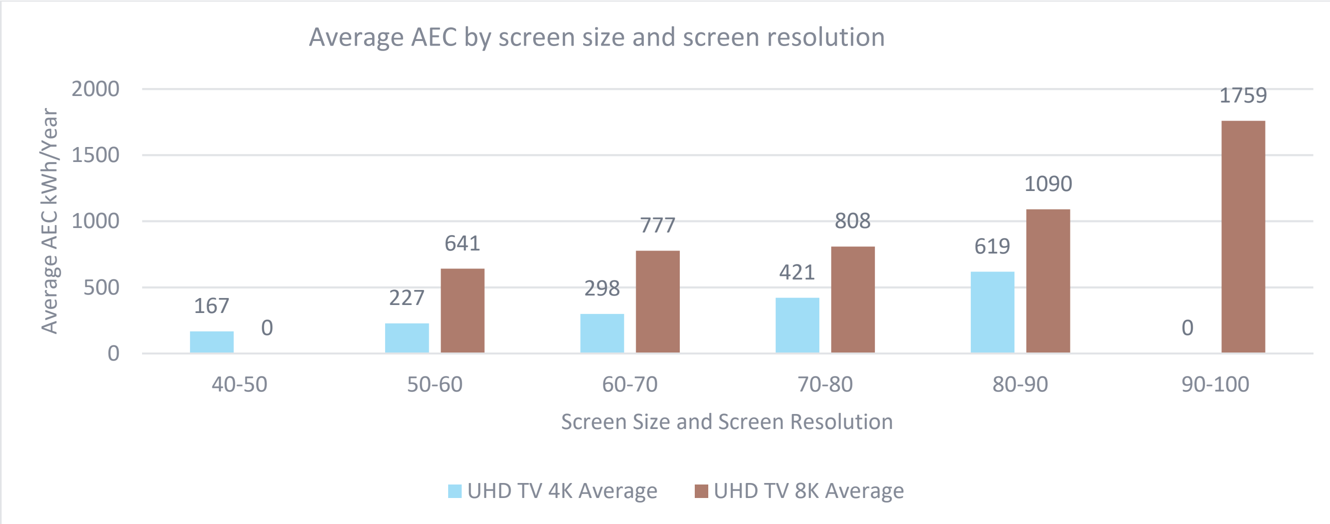


FIGURE 16 AVERAGE AEC BY SCREEN SIZE AND SCREEN RESOLUTION

The average AEC increases with increase in screen size, as shown in Figure 16. Since AEC is a function of the on mode and standby mode power consumption, the information collected from manufacturers of UHD televisions was used to calculate annual energy consumption using the above equation.

DEVELOPMENT OF STAR RATING BANDS FOR UHD TELEVISIONS

This sub-section discusses the methodology adopted for proposing star rating bands for UHD televisions. A comprehensive assessment of BEE's current labeling program for color television of screen resolution up to and including 1,920 x 1.080 pixels was conducted. The AEC information was analyzed and compared with BEE's current labeling program for TVs which does not cover UHD televisions to understand whether the current program can also be applied to UHD televisions.

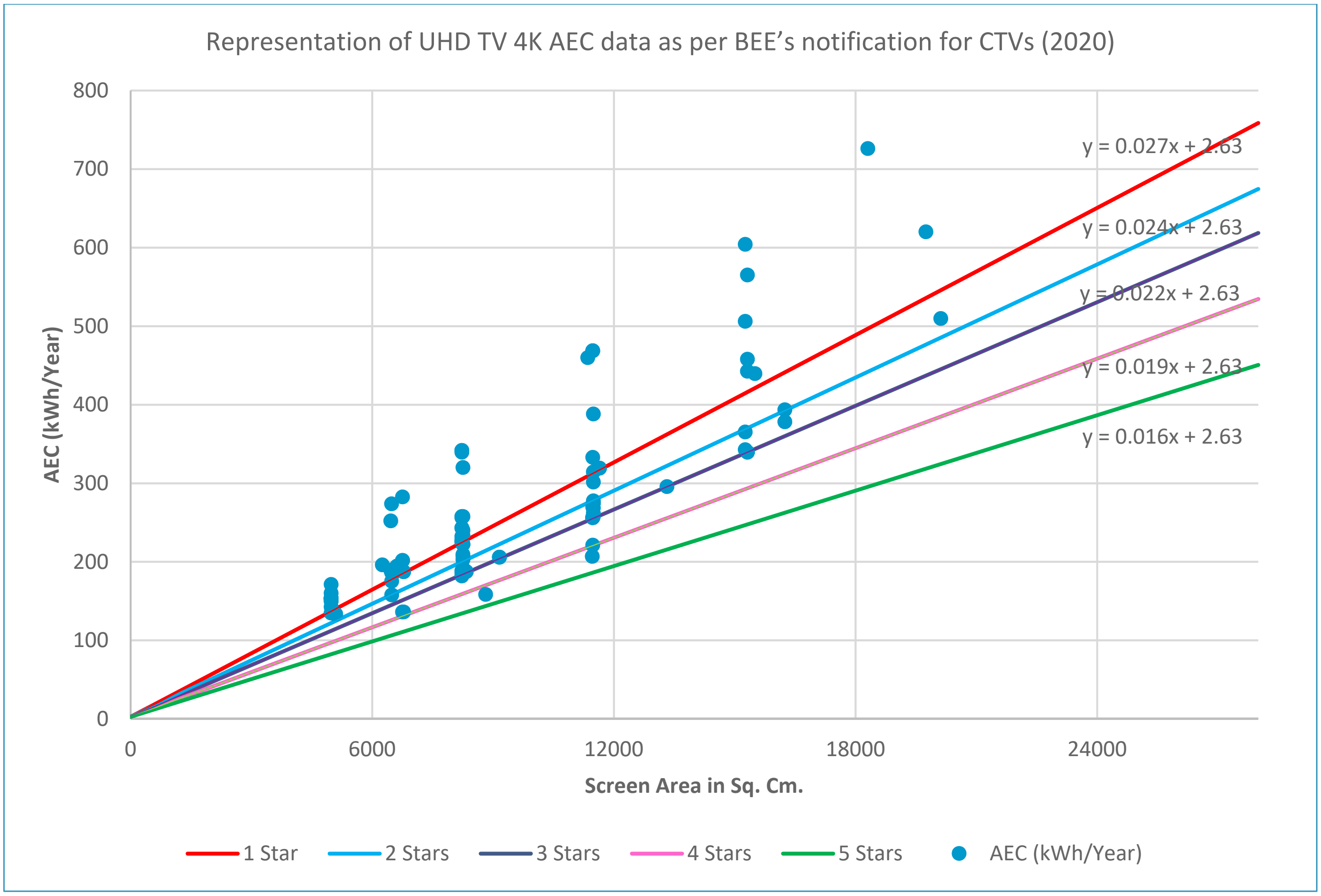


FIGURE 17 REPRESENTATION OF UHD TV 4K AEC DATA AS PER BEE’S NOTIFICATION FOR CTVS (2020)

As can be seen in Figure 17, the AEC of the 4K UHD television models are much higher than the star band AEC equations of BEE’s current labeling program for televisions of screen resolution up to 1,920 x 1,080. No UHD 4K television is able to achieve 5-star rating as per BEE’s current program for televisions and 60 of the 108 television models are unrated, or even below the one-star level as per this star rating table. Hence, it provided a strong basis to come-up with a different star rating band for UHD TVs. Similarly, Figure 18 shows that none of the UHD 8K television model qualifies for a rating under BEE’s current star labeling table.

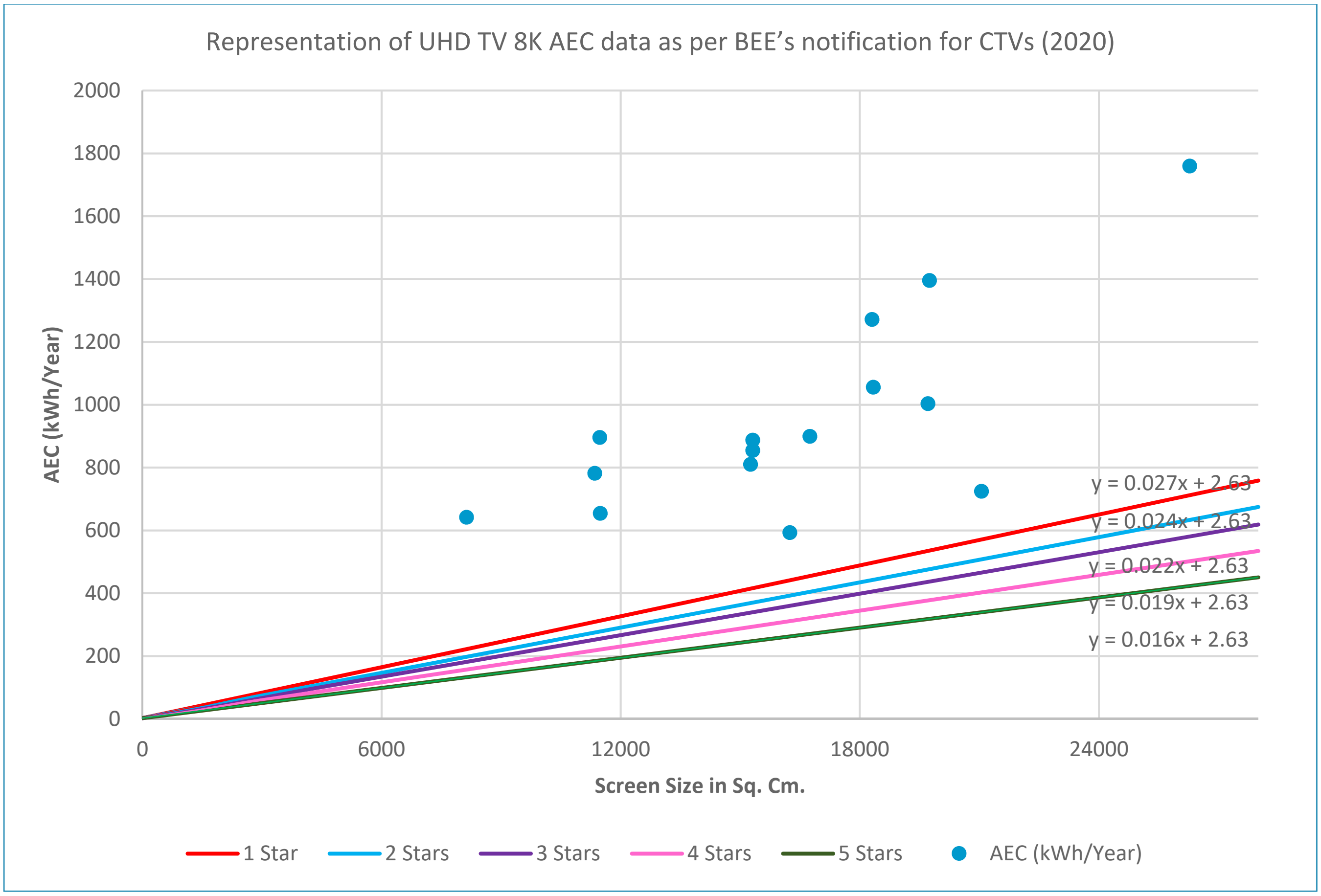


FIGURE 18 REPRESENTATION OF UHD TV 8K AEC DATA AS PER BEE'S NOTIFICATION FOR CTVS (2020)

Also, an important observation noted is, UHD 8K TVs consume significantly more energy than UHD 4K TVs. This observation was confirmed through linear regression analysis of both the data sets. Therefore, separate energy performance thresholds were proposed for UHD 4K and 8K televisions.

Linear regression analysis was applied to derive the relationship between the screen size of UHD televisions and their AEC, and the following equations were derived:

- UHD 4K TVs: AEC = 0.0271*A + 6.22
- UHD 8K TVs: AEC = 0.051*A + 122.16

Where "A" is the screen area of the television in square centimeters.

The correlation factor for UHD 4K televisions was 70.95%, and for UHD 8K was 53.98%, implying good fitness for the UHD 4K models, while indicating the wide range in the data for UHD 8K televisions- i.e., there is a large variation in the AECs of UHD 8K televisions which range from 592 kWh/annum to 1759 kWh/annum.

Star label tables were derived for both types of UHD televisions based on the above equations. It was assumed that the AEC calculated by using these equations would be the two star limit for both UHD 4K and UHD 8K televisions- i.e., televisions which have AEC less than the AEC calculated by these equations would be awarded two stars or more, and those that fell above this AEC would be awarded one star, or no stars.

The star label bands for UHD 4K televisions are shown in Table 12. On analyses, it was found that only 16 of 108 UHD 4K televisions were not qualified under this rating scale. 30% achieved 1-star rating, 50% achieved 2-star rating, 5% achieved 3-star rating, and 1 model (0.93% of the sample) was rated 4 stars.

TABLE 12 STAR RATING BAND – UHD 4K TELEVISIONS

Star Rating Band – UHD 4K Televisions (Valid from 01 January 2021 to 31 December 2021)			
1 Star	0.0271*A + 6.226	< AEC ≤	0.0325*A + 6.226
2 Star	0.0217*A + 6.226	< AEC ≤	0.0271*A + 6.226
3 Star	0.0174*A + 6.226	< AEC ≤	0.0217*A + 6.226
4 Star	0.0139*A + 6.226	< AEC ≤	0.0174*A + 6.226
5 Star		AEC ≤	0.0139*A + 6.226

The star rating bands derived from the regression analysis is shown in Table 13 below. Of the 15 models whose data is available, 1 (6.66%) UHD television was rated 1 star under this table, 7 (47%) achieved 2-star rating, 2 (13%) were rated 4 stars.

TABLE 13 STAR RATING BAND – UHD 8K TELEVISIONS

Star Rating Band – UHD 4K Televisions (Valid from 01 January 2021 to 31 December 2021)			
1 Star	0.0271*A + 6.226	< AEC ≤	0.0325*A + 6.226
2 Star	0.0217*A + 6.226	< AEC ≤	0.0271*A + 6.226
3 Star	0.0174*A + 6.226	< AEC ≤	0.0217*A + 6.226
4 Star	0.0139*A + 6.226	< AEC ≤	0.0174*A + 6.226
5 Star		AEC ≤	0.0139*A + 6.226

Estimation of energy savings and GHG reduction potential

The energy savings calculation methodology and results are discussed in detail in this chapter.

ASSUMPTIONS

List of key assumptions considered:

1. The assessment period is 10 years, 2021 – 2030. 2020 is the baseline rear.

2. As per the current market, UHD 4K televisions hold 98% of the market and UHD 8K have 2% market by sales volume. This is taken as the uniform distribution of sales until 2030. The overall market for UHD televisions in 2020 is calculated to be 1.33 million units.

3. Energy consumption for the entire UHD television market has been arrived by calculating the energy consumption for each television size available in the market currently. It has been assumed that the same range of television screen sizes will be available throughout the 10 years of the assessment period. This has been assumed because the size of a television screen has an impact on its AEC, and therefore on the overall energy consumed by all UHD televisions sold in this assessment period. For example, if screen sizes of 140 cm, 150 cm, 160 cm, 170 cm and 180 cm are sold now, it is assumed that these are the only screen sizes which will continue to be sold throughout the assessment period.

4. An assumption for distribution of sales of UHD televisions between various screen sizes (separately for 4K and 8K TVs). In the previous sections of this report it can be seen that there is a preference for smaller UHD televisions over larger ones in the market (both by availability and annual sales). Therefore, the sales projected for each year of the assessment period in 4K and 8K segment has been distributed between various sizes of the UHD televisions. The exact assumption on percentage distribution considered for each year of the assessment period has been provided in the calculation sheet.

5. With inputs from market players and given the impact of COVID-19 on the market, a modest growth of 1.5% was assumed for 2020. Based on growth rate, the market size for 2020 was calculated to be 1.33 million units. Sales from 2021 – 2030 is estimated to grow at a rate of 9% per annum, and based on this growth rate, the overall market size for UHD televisions in 2030 was calculated to be 3.09 million units.

6. The program is assumed to be voluntary for one year, and mandatory from 2022 onwards.

    a. It is assumed that the Star label bands arrived at in Section 4 of chapter 6 are used for the first three years of the program- i.e., the voluntary year, and the subsequent two years in which the program is mandatory (2021 – 2023).

    b. The program is revised in Year 4 by one star band, and the revised table is assumed to continue for 3 years (2024 – 2026).

    c. The program is revised one more time in year 7 by one-star band, and this revised table continues till the end of our calculation period (2027 – 2030).

    The program is explained diagrammatically in Table 14.

TABLE 14 AN ILLUSTRATION OF THE ABOVE ASSUMPTIONS ABOUT THE ASSESSMENT PERIOD

<table>
<tr><td>Baseline</td><td>2020</td><td colspan="2"></td></tr>
<tr><td>Voluntary Phase</td><td>2021</td><td>Y1</td><td rowspan="3">Original Star Label Bands</td></tr>
<tr><td rowspan="2">Mandatory Phase I</td><td>2022</td><td>Y2</td></tr>
<tr><td>2023</td><td>Y3</td></tr>
<tr><td rowspan="3">Mandatory Phase II</td><td>2024</td><td>Y4</td><td rowspan="3">Revision 1 of Star Label Bands</td></tr>
<tr><td>2025</td><td>Y5</td></tr>
<tr><td>2026</td><td>Y6</td></tr>
<tr><td>Mandatory Phase III</td><td>2027</td><td>Y7</td><td></td></tr>
</table>

	2028	Y8	**Revision 2 of Star Label Bands**
	2029	Y9	
	2030	Y10	

7. Different years will have different sales distribution for each of the star label bands. Therefore, the percentage of total sales of a given year that will fall in each band was assumed for each year of the assessment period. For the baseline year, this distribution was calculated from the information shared by the market players.

METHODOLOGY

1. Calculate the star bands applicable to each screen size. Since star bands for televisions are calculated based on the area of the screen in centimeter square, each size of television has different bands for 1-star, 2-star, 3-star, 4-star, and 5-star labels.

2. Calculate the total Annual Energy Consumption for one screen size for any star band. It is the annual sales for that screen size multiplied by the Annual Energy Consumption for the respective star band for which the numbers are being calculated for the given year.

For example, to calculate the Annual Energy Consumption for screen size 160 cm in 2025 which were rated 3 stars, multiply the number of televisions sold of that size in 2025 with the band limit of AEC consumed by 3 star rated televisions of 160 cm.

3. Calculate the total Annual Energy Consumption for all screen sizes. For any particular star band, it is the total annual energy consumption for the chosen star band found through Step TWO for all screen sizes for that year.

   The calculation in Step TWO was done for one screen size and one-star band for a given year. To find the AEC for the entire market in that year, the same calculation must be done for all screen sizes and every star band label. In the example in Step TWO, the calculation was made for 3-star televisions of the size 160 cm. Now the calculations must be made for 1, 2, 3, 4, and 5-star televisions of all the screen sizes sold in the year 2025, and for every other year of the assessment period.

4. Calculate the total Annual Energy Consumption. It is the energy consumptions found in Step THREE for a chosen year summed together.

5. Calculate the weighted average baseline energy consumption. This is the total Annual Energy Consumption found using Step FOUR for the baseline year and divided by the total sales of the baseline Year. This division provides the weighted average energy consumption of all UHD televisions sold in the baseline year.

6. Calculate the weighted Average Energy Consumption for the assessment period. This is the total Annual Energy Consumption found using Step FOUR for each year divided by the total sales of that respective year.

   Sales of UHD televisions are estimated to increase annually. Implementation of BEE's program for UHD television will improve the average energy consumption of the UHD televisions in the market, however due to the increasing annual sales, it will not be clear how much energy is being saved every year. This is explained through an example below.

   For example,

   - Sales in the baseline year = 100
   - Average energy consumption by UHD televisions in the baseline year = 150 kWh
   - Total energy consumed in the baseline year = 15,000 kWh
   - Sales in Year 1 = 110
   - Average energy consumption by UHD televisions in Y1 = 140 kWh
   - Total energy consumed in Y1 = 15,400 kWh

- Even though the average energy consumed by UHD televisions has reduced in Y1, however due to increase in sales, the total energy consumed by UHD televisions has also increased. When the weighted average energy consumption is taken, a more accurate picture emerges:

   - Weighted average energy consumption of UHD televisions for BASELINE year = 150/100 = 1.5 kWh
   - Weighted average energy consumption of UHD televisions for year 1= 140/110 = 1.23 kWh

7. To calculate the energy savings for any year, weighted Average Energy Consumption for that year found in Step FIVE is subtracted from the weighted average baseline energy consumption found in Step FOUR. This calculation must be done for each year, and in the calculation the baseline weighted average energy consumption will remain the same. These are the savings made by the UHD televisions sold in that particular year of the assessment period.

Taking the example mentioned in Step SIX, the savings made in Year 1 are = 1.50 kWh – 1.23 kWh = 0.27 kWh

8. Each UHD television is estimated to have an average lifetime of 7 years.[30] The energy savings made in any one year, as calculated in Step SEVEN, must be multiplied by the life of the UHD televisions sold in that year in comparison to the assessment period.

   The assessment period is between 2021 and 2030. Therefore, in the years 2021 – 2024 the life of the UHD television will be 7 years each since their entire lives will be finished before the end of the assessment period in 2030.

   From 2025, the life of a UHD television bought in these years will be more than the years remaining in the assessment period- i.e., the life of a UHD television bought in 2025 will be 7 years, but there are only 6 years remaining till the end of the assessment period. Therefore, energy will be saved by televisions bought in 2025 for 6 years and not for 7 years. Similarly, for all televisions bought in the years after 2024 until 2030.

Taking the example used in Step FIVE and Step SEVEN forward, the savings made for all UHD televisions sold in Year 1 of the assessment period = 0.27 kWh x 7 years of life = 1.89 kWh.

9. The total energy saved by the implementation of this program between 2021-2030 is the savings made for UHD TV Sales in a given year as calculated in Step SEVEN multiplied by the Life of the UHD televisions bought in that year as calculated in Step EIGHT.

The sum of the savings for each year of the assessment period is the total energy saved by the program in the assessment period.

CALCULATION OF AVERAGE ANNUAL ENERGY CONSUMPTION

In Step ONE above, sales of a screen size for that star band are multiplied by the Annual Energy Consumption for that screen size to arrive at the Total Annual Energy Consumption for the respective screen size and star band. However, the program prescribes bands of annual energy consumption, and any television that consumes energy within this entire band is considered to be part of this band.

Each of the bands has an upper limit and a lower limit, and therefore a television may consume energy above this lower limit but below the upper limit to be part of this band, and the actual energy consumption of the television can be any number in this band.

For uniformity, it was decided that for each of the star bands, the upper band limit of energy consumption will be taken as the AEC for all televisions that fall within the given star band for the calculations of energy savings.

There are some UHD televisions in the market in the baseline year which consume so much energy that they are disqualified from having a star rating. It is assumed that some televisions in the market will continue to be disqualified in Year 1 of the program, when the program is voluntary. To assign a numerical value to the AECs for the disqualified UHD televisions, the following calculations were made:

1. All the unrated televisions from the dataset provided by the manufacturers were identified.
2. The difference between their current AEC and the maximum possible AEC allowed for their screen size was calculated. The difference was the extra energy consumption that was more than the maximum 1-star level due to which these televisions were disqualified.
3. An arithmetic mean of all the differences found in step two was taken.
4. To find the AEC for the unrated televisions in the baseline year and Year 1 of the program, the average found in Step 3 was added to the maximum AEC allowed for achieving 1 star for each screen size.

FINAL RESULTS

[30] Source: Data from market players

Using the assumptions and calculations of the previous sections in this chapter, the total energy and greenhouse gas emissions saved by this program between the years 2021 and 2030 were determined. The results are shown below graphically in Figure 19 and Figure 20, and summarized in Table 15.

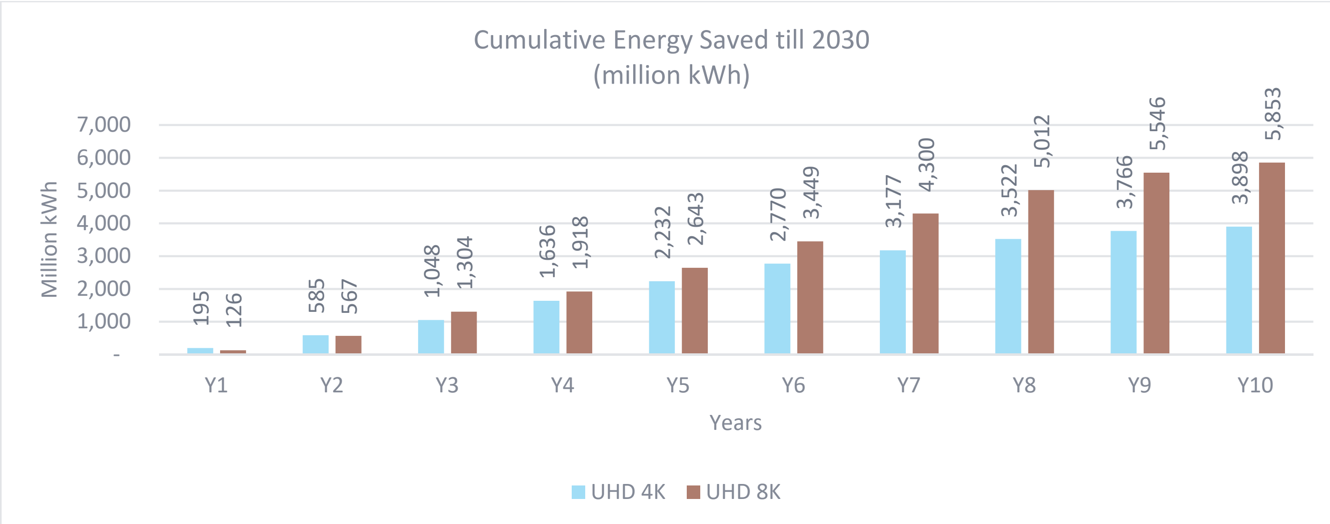


FIGURE 19 CUMULATIVE ENERGY SAVED IN MILLION KWH OVER THE ASSESSMENT PERIOD 2021 - 2030

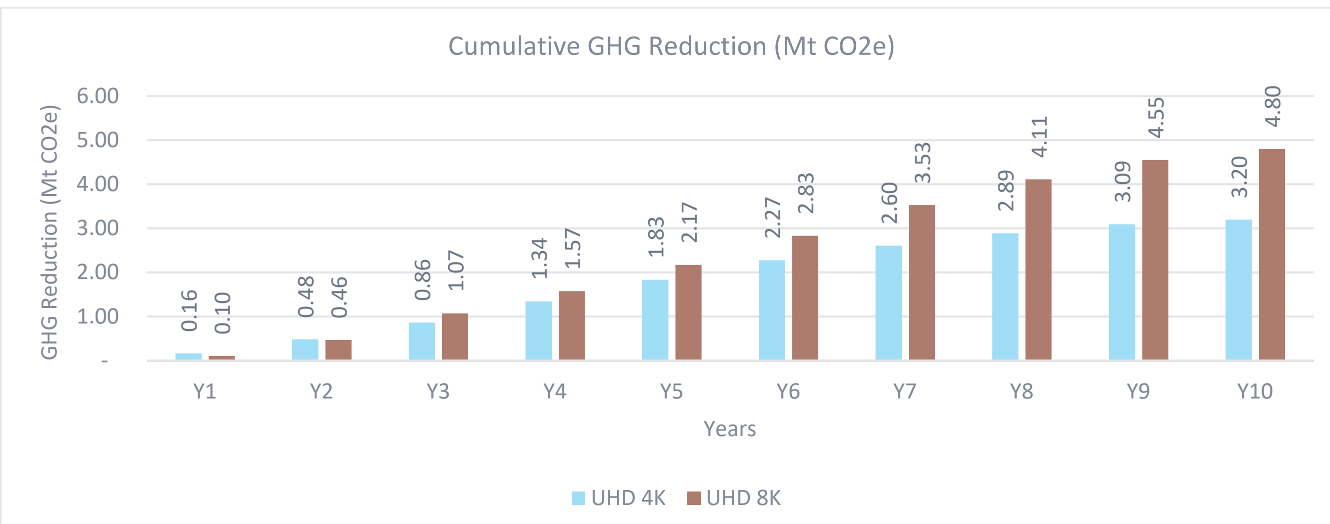


FIGURE 20 CUMULATIVE GHG REDUCTION (MT $CO2_E$) OVER THE ASSESSMENT PERIOD 2021 - 2030

TABLE 15 TOTAL ENERGY SAVINGS AND GHG EMISSION REDUCTION DURING THE ASSESSMENT PERIOD 2021 - 2030

Energy savings during assessment period		
4K UHD TVs	Million kWh	3,897.80
8K UHD TVs	million kWh	5,852.98
Total energy savings	**Million kWh**	**9,750.78**
	MWh	9,750,777
	TWh (billion Units)	9.75

GHG emission reduction		
Grid emission factor	tCO_2/MWh	0.82
GHG emission reduction	tCO_2	7,995,637
GHG emission reduction	Mt CO_2e	8

Annex 1: Screen Technologies

All televisions in the market are based on the RGB Color Model. This is an additive model based on the principle of adding the colors Red, Green and Blue (RGB) in various ways to produce different colors.

Every cell, or pixel, of a Flat Panel Display television has a potential to produce three light beams- one red, one green, and the third blue. These three colors are activated with different intensities so that their beams add together (additive) to form a fourth color. Different combinations of these three colors make all the images that are seen by viewers on their television screens.

LIQUID CRYSTAL DISPLAYS (LCD)

Liquid Crystal Display Televisions use a combination of polarization and phase changes in liquid crystal cells to create color in each pixel. The technology is explained here.

LIGHT POLARIZATION FILTERS

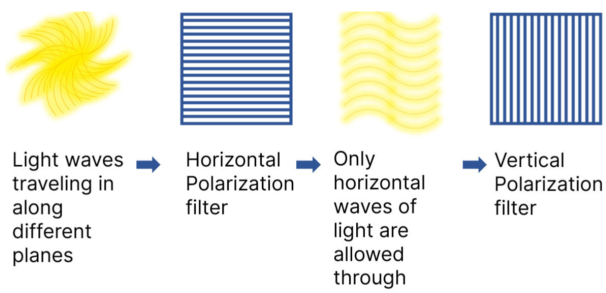


FIGURE 21 HOW LIGHT IS POLARIZED

Light travels in waves along different planes. Any beam of light has waves traveling in multiple planes. Polarization filters act as 'sieves' which allow light waves traveling only on a certain plane to pass through them. For example, a horizontal polarization filter will only allow light waves traveling on a horizontal plane to pass through.

LIQUID CRYSTALS[31,32]

Liquid Crystals are substances, which are in a state of matter where they have some properties of liquids and other properties of solid crystals. In LCD televisions, these substances are used to change the plane along which light waves are traveling.

LCD DISPLAY SCREENS

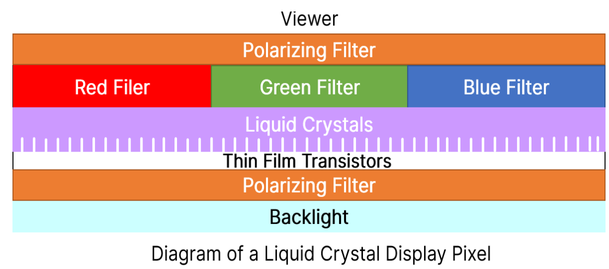


FIGURE 22 DIAGRAM OF A PIXEL IN AN LCD DISPLAY SCREEN

In LCD display screens, light from the backlight is passed through horizontal polarizing filters, which allow only waves traveling along the horizontal plane. The polarizing filters at the front of the pixels are vertical, and the light that has passed through the back polarizing filters will only be able to pass through them in case something turns them by 90° and makes them vertical. To do this, while the light is passing through the liquid crystals, an electronic transistor switches off the electricity flowing through the pixel. This twists the horizontal light wave coming through the liquid crystals by 90°, making them vertical. As light passes through the RGB filters, a combination of the RGB colors are used to change the color of the light passing through the pixel. A combination of all the pixels in the display system are used to form the image. Since the light is now traveling in the vertical plane due to the action of the electronic transistor and the liquid crystals, it can now pass through the front polarizing filters which only light waves traveling along the vertical plane, which makes the particular pixel bright so that the viewer can see it.

If the transistor switches the electricity flowing through the pixel on, the effect is that the light traveling on the horizontal plane cannot pass through the vertical polarizing filter, and the pixel is dark. The transistors can turn the pixels on and off several times a second.

[31] LCDs (liquid crystal displays), https://www.explainthatstuff.com/lcdtv.html

[32] Liquid Crystal Display, https://www.pcmag.com/encyclopedia/term/lcd

OLED DISPLAY SCREENS[33]

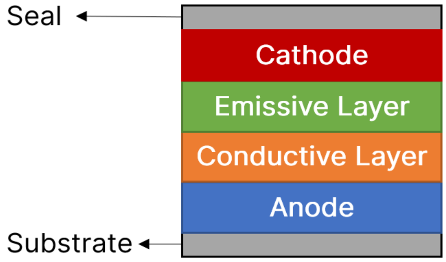


FIGURE 23 DIAGRAM OF A PIXEL IN AN OLED DISPLAY SCREEN

An OLED pixel consists of a Seal, a Substrate, a Cathode, an Emissive Layer, a Conductive Layer, and an Anode.

- The seal and substrate are protective layers made of glass and plastic.
- The Cathode is the negative terminal.
- The Anode is the positive terminal.
- The Emissive and Conductive layers are organic (carbon based). Light is produced in the Emissive Layer

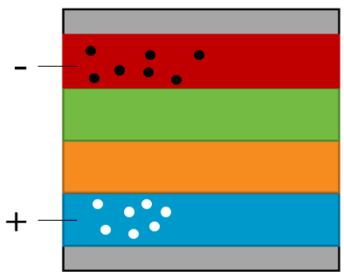


FIGURE 24 OLED PIXEL STEP 1

Step 1:
When electricity is passed through the cell, the cathode receives negative particles called electrons from the power source and the anode loses them to the power source (these can be thought of as holes, or positive particles).

PLASMA DISPLAY SCREENS[34,35]

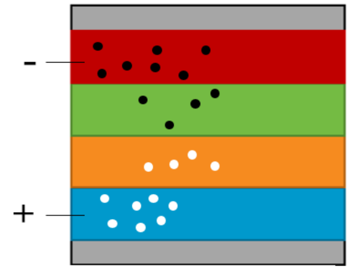


FIGURE 25 OLED PIXEL STEP 2

Step 2:
The electrons travel to the Emissive Layer, making it negatively charged, and the positive particles travel to the Conductive Layer, making is positively charged.

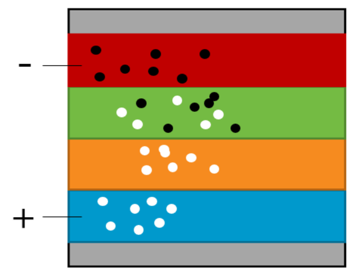


FIGURE 26 OLED PIXEL STEP 3

Step 3:
The positive particles are much more mobile and move into the negatively charged Emissive Layer.

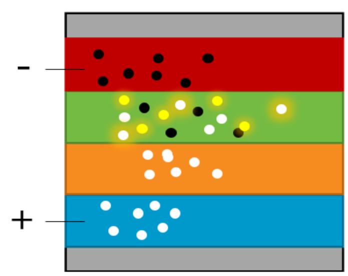


FIGURE 27 OLED PIXEL STEP 4

Step 4:
When the positive and negative particles meet, the cancel each other out, and release energy in the form of a photon, or a particle of light. Photons are produced many times every second, producing constant light
Adding colored filters before the seal and substrate will produce colored light.

[33] OLEDs (Organic LEDs) and LEPs (light-emitting polymers), https://www.explainthatstuff.com/how-oleds-and-leps-work.html

[34] Plasma Displays, https://www.pcmag.com/encyclopedia/term/plasma-display
[35] Plasma TV, https://www.explainthatstuff.com/plasmatv.html

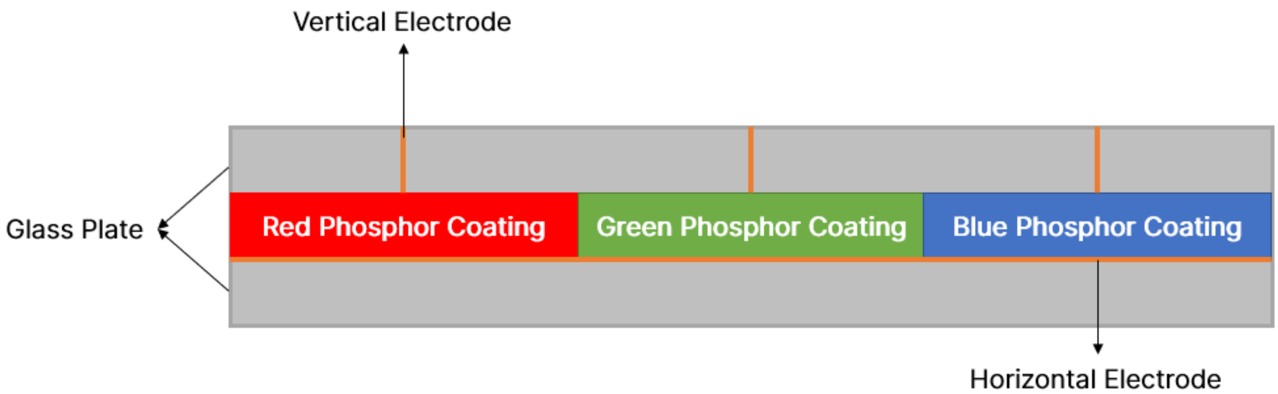


FIGURE 28 DIAGRAM OF A PIXEL IN A PLASMA DISPLAY SCREEN

Plasma is the state of matter a gas reaches when it is very hot. This state of matter is highly conductive for electricity. In a plasma display screen, each pixel cell has neon or xenon gas and is coated on the inside with phosphor chemicals that are red, blue, or green. Each pixel may be switched on or off by electrodes that are mounted horizontally and vertically along the pixels. The electrodes put a high voltage charge on the pixel that should be switched on and cause the gas inside to ionize and emit ultraviolet light. Ultraviolet light is invisible to human eyes, however the colored phosphor coating on the inside of the pixels makes the invisible light visible in the same color as the coating- i.e., red phosphor coating would lead to red color light being emitted. **This technology is not used to make TVs anymore.**

QUANTUM LIGHT-EMITTING DIODE (QLED) SCREENS[36]

QLEDs have tiny phosphorescent nanoparticles that release color when they react to light. LEDs are used to produce "white" looking light as the backlighting. However, LEDs don't naturally produce "white" colored light. They produce blue color light and are coated with a yellow phosphor, which helps the blue light look close to white. This sort of white light tends to look blue, and when this blue-tending backlight mixes with RGB color palette of the pixels, it skews the colors to look blueish, rather than true Red, or True Green. It changes the color composition of the final image from what was intended, to what the TV can produce.

Quantum dots can glow in a variety of colors. The color they glow depends on their size, and now these nanoparticles can be produced in very precise sizes, which means that the exact color desired can be manufactured, and since quantum dots are very stable, they will glow the same shade for a long time.

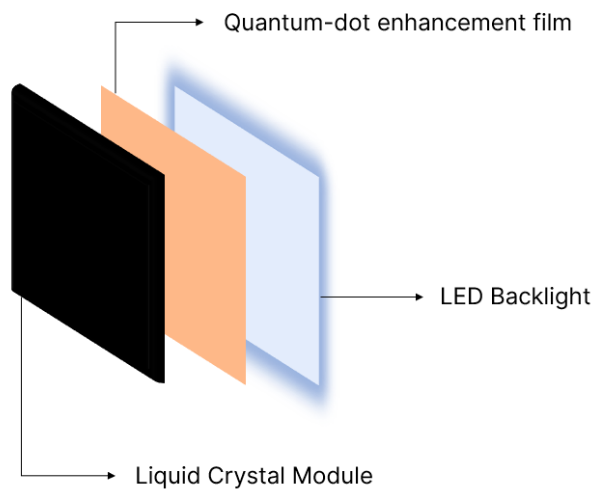


FIGURE 29 A TYPICAL QLED TV SET UP

With the advent of modern QLED technology, manufacturers now do not need to use yellow phosphor covered LED lamps as backlight to approximate a white light. They use a Quantum dot enhancement film, which has been covered in nanoparticles which produce green and red light when they are exposed to light. The setup is as shown in Figure 29, and use blue led light as the backlight. Now whenever the backlight is on, it produces blue light, and the Quantum Dot Film produces red and green light. Together all three-produce pure white light, and

[36] What the hell are quantum dots, and why do you want them in your next TV?, https://www.digitaltrends.com/home-theater/how-quantum-dot-lcd-tvs-work/

therefore the colors produced on screen by the liquid crystal module are not skewed towards blue.

A QLED TV is an LED TV with much better color production and works in the same way that LED TVs do.

MicroLED SCREENS[37]

MicroLEDs use three tiny non-organic LEDs per pixel. This means that each pixel can be turned on or off individually, ensuring true black color production as well as the giving each pixel the ability to display a completely different color than that displayed by its neighboring pixels.

A technology that uses self-lighting pixels like OLED televisions, but the pixels are not made of organic material, unlike OLEDs. OLED screens are expensive, suffer burn in, and are not as bright as LED screens. MicroLED screen technology may take advantage of these failings and bring an OLED-like viewing experience to viewers at lower prices, and since they are not made of organic compounds, they are unlikely to suffer burn in.

MicroLEDs are comparable to OLEDs because they are self-emissive, the images seen on these screens does not falter at off-angles, and MicroLEDs can produce true blacks. However, they are considered better than OLEDs because they are much brighter than OLED televisions, and since they are not based on organic compounds they are expected to last much longer than OLEDs which are based on organic compounds which suffer burn in. It is also difficult to make very large OLED screens, but since small MicroLED panels can be combined to make larger screens, there may be no such problem with MicroLEDs.

The technology requires each pixel to have three miniscule LED lamps in the perfect alignment and with the same level of brightness. This is a challenging task at the moment, as a UHD 4K television set with more than 8 million pixels would require close to 25 million such LEDs. Therefore, for the moment this technology may be priced out of the consumer segment due to the prohibitive costs associated with solving these challenges. Once the technology is successfully commercialized, it is likely to offer a credible replacement alternative for LED, QLED, and OLED televisions discussed previously.

DESIGN AND COMPONENTS[38,39]

Most Flat panel FHD and UHD display televisions are LCD screens with LED backlighting. These televisions may look similar to Figure 30. The basic design of such televisions is explained here.

- Non-Screen Components
    - The Top and Bottom Chassis are the front and back covers which contain all the other parts of the television. They protect the other components of the television.
    - The Power Adapter adjusts the voltage coming from the power source to the device, protecting it from voltage fluctuations.
    - The Supply of SMPS Board is the component to which the power cable is connected. LED TVs run on DC power, but power is supplied as an AC current, so this component converts the AC power to DC power for LED TVs.
    - The Mother Board decodes all the television signals received and is also the component to which the HDMI ports and the RAM are connected. Once the Mother Board interprets the signals, it produces the audio and video outputs.
    - The Infrared Receiver receives the commands from the television remote and conveys them to the Mother Board.
    - The Speakers put out the audio output that goes along with the videos being displayed on the screen.

- Screen Components
    - A Reflector Sheet, also called a Dual Brightness Enhancement Film (DBEF), increases the amount of light available to be transmitted through the LCD, i.e., it increases the brightness of the lights generated by the light source.
    - The Light Guide Plate (LGP) is a transparent and water-resistant sheet of acrylic plastic, which has bumps printed on it. This component helps it exit from the front no matter which direction it enters the LGP from.
    - The LED Strip is the backlight, which may either be of the Edge-lit variety, or the Direct-lit variety. The backlight provides the light, which allows viewers to see images on the screen. For Edge-lit backlighting, the LED strip is placed only on the side of the display. For Direct Lit backlighting, LED strips are placed evenly throughout the display.

[37] MicroLED TV: everything you need to know, https://www.whathifi.com/features/what-is-micro-led-tv-and-is-it-any-good
[38] Parts Of LED TV And Their Functionality, https://specstalk.com/parts-of-led-tv/
[39] Understanding Today's LCD Screen Technology, https://pid.samsungdisplay.com/en/learning-center/blog/lcd-structure

- A diffuser sheet is the component that breaks up and distributes the light produced by the backlighting. This allows all areas of the display screen to be equally bright and prevents dark spots and LED hotspots.
- A prism sheet is placed on the top of the LGP and has angled ridges that keep reflecting the light until it is at the brightest angle to the viewer.
- The bottom and Top polarizers only allow light traveling along a certain direction to pass through them.
- The bottom and top Glass Substrates are special glass components between which the polarizers, electrodes and the color components are sandwiched.
- Liquid Crystals are substances whose molecules change their orientations based on whether power is applied to them or not. They are used to twist the incoming backlight by 90°.
- The Common Electrode is used to maintain a common pixel voltage across the LCD screen. It is used to turn the power applied to the Liquid Crystals on or off.
- The RGB colors are sub-pixels and are present on every pixel. They are used to form images on the screen that viewers can enjoy.

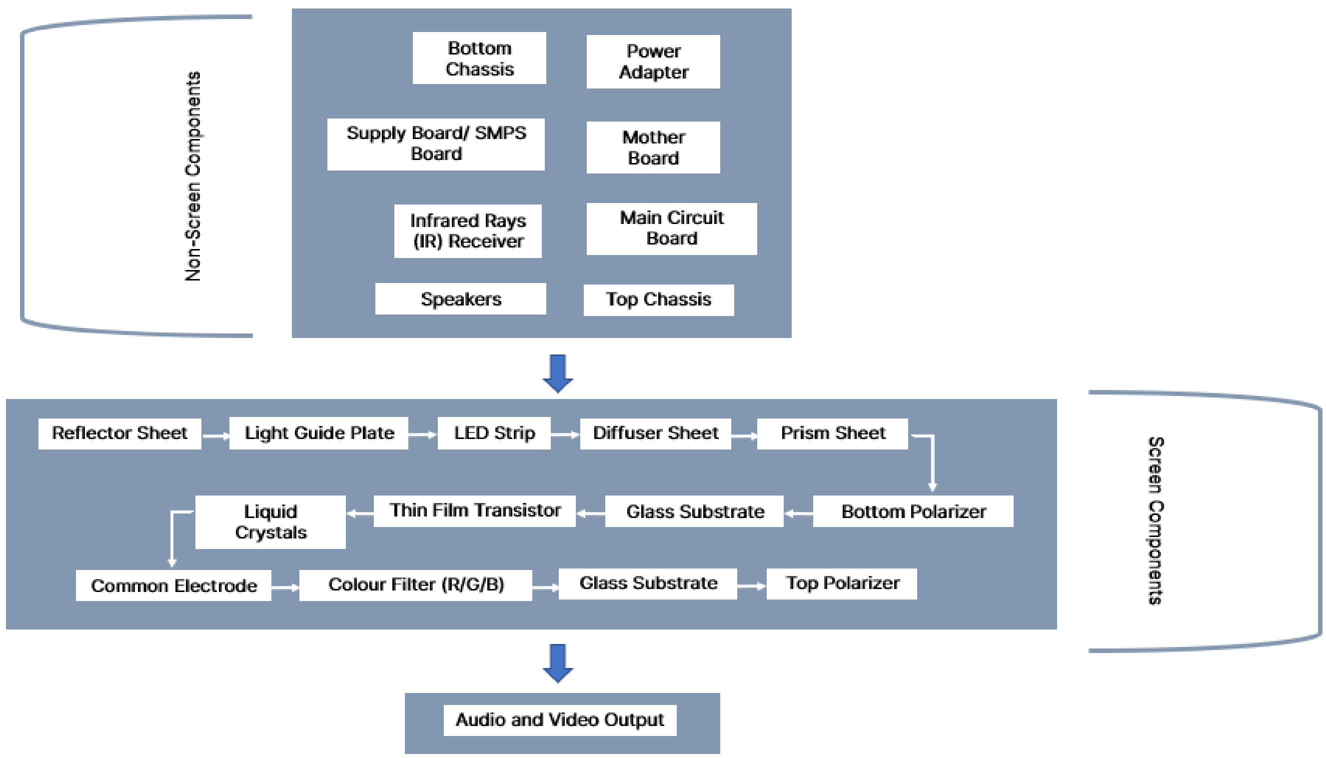


FIGURE 30 SCHEMATIC OF AN LED-LCD FLAT PANEL DISPLAY TV