Following is the Final Draft Version 8.0 ENERGY STAR product specification for Displays. A product shall meet all of the identified criteria if it is to earn the ENERGY STAR.

1 DEFINITIONS

A) Product Types:

1) **Electronic Display (Display):** A product with a display screen and associated electronics, often encased in a single housing, that as its primary function produces visual information from (1) a computer, workstation, or server via one or more inputs (e.g., VGA, DVI, HDMI, DisplayPort, IEEE 1394, USB), (2) external storage (e.g., USB flash drive, memory card), or (3) a network connection.

   a) **Monitor:** An Electronic Display intended for one person to view in a desk-based environment.

   b) **Signage Display:** An Electronic Display intended for multiple people to view in non-desk-based environments, such as retail or department stores, restaurants, museums, hotels, outdoor venues, airports, conference rooms or classrooms. For the purposes of this specification, a Display shall be classified as a Signage Display if it meets three or more criteria listed below:

      (1) Diagonal screen size is greater than 30 inches;
      (2) Maximum Reported Luminance is greater than 400 candelas per square meter;
      (3) Pixel density is less than or equal to 7,000 pixels per square inch;
      (4) Ships without a mounting stand designed to support the display on a desktop; or
      (5) Contains RJ45 or RS232 physical ports.

   Note: In response to the Draft 2 proposal that signage displays meet three instead of two of the above criteria, stakeholders suggested the pixel density maximum be increased from 5,000 to 7,000 pixels per square inch to accommodate the trend towards higher resolution signage displays. EPA agrees with the suggestion and has updated criterion (3) accordingly.

   Additionally, stakeholders requested clarification on criterion (5) regarding the capability of remote management or the presence of an external data controller. In response, EPA has specified that models shall contain RJ45 or RS232 physical ports to meet this criterion as these may commonly be used in remote management systems.

   c) **Tiled Display System:** A testable configuration of Signage Displays in which multiple Signage Displays are tiled together contiguously and supported by one or more modular external controllers and one or more modular external power supplies to produce a single larger image.

      (1) **Maximum Tiled Configuration:** A Tiled Display System configured with the maximum number of Signage Display panels supported by the same set of external support modules (e.g., power supplies, controllers, etc.) that are needed to support a configuration with two panels.
Note: In response to stakeholder requests for clarification, EPA is revising the proposed definitions of Tiled Display System and Maximum Tiled Configuration. Further below, EPA is also proposing to modify Section 4.2, Number of Units Required for Testing, to specify that Tiled Display Systems shall be tested in the Maximum Tiled Configuration.

B) Operational Modes:

2) **On Mode:** The mode in which the Display has been activated, and is providing the primary function.

3) **Sleep Mode:** A low-power mode in which the Display provides one or more non-primary protective functions or continuous functions.

   Note: Sleep Mode may serve the following functions: facilitate the activation of On Mode via remote switch, Touch Technology, internal sensor, or timer; provide information or status displays including clocks; support sensor-based functions; or maintain a network presence.

4) **Off Mode:** The mode where the Display is connected to a power source, produces no visual information, and cannot be switched into any other mode with the remote control unit, an internal signal, or an external signal.

   Note: The Display may only exit this mode by direct user actuation of an integrated power switch or control. Some products may not have an Off Mode.

C) Displays Settings and Menus

5) **Preset Picture Setting:** A preprogrammed factory setting obtained from the Display menu with pre-determined picture parameters such as brightness, contrast, color, sharpness, etc.

6) **Default Picture Setting:** The Preset Picture Setting tested and recognized according to the ENERGY STAR test method. The Default Picture Setting is typically the Preset Picture Setting in the model’s as-shipped default state. If the Display has a Forced Menu, the Default Picture Setting is the Preset Picture Setting identified according to the ENERGY STAR test method, usually the setting labeled “Standard” or “Home.”

7) **Forced Menu:** A series of menus which require the selection of initial settings before allowing the user to utilize primary functions. These menus may contain an option to select between the Default Picture Setting and other picture settings not tested in the ENERGY STAR test method.

   Note: In the case that no standard setting or equivalent exists, the default setting recommended by the manufacturer is considered the Default Picture Setting for the purposes of this specification.

Note: EPA has made minor clarification to the above note to reference the Default Picture Setting as defined above.

D) Visual Characteristics:

8) **Ambient Light Conditions:** The combination of light illuminances in the environment surrounding a Display, such as a living room or an office.

9) **Automatic Brightness Control (ABC):** The self-acting mechanism that controls the brightness of a Display as a function of Ambient Light Conditions.

   Note: ABC functionality must be enabled to control the brightness of a Display.

10) **Color Gamut:** The range of color supported within the CIE LUV 1976 \( L^* u^* v^* \) color space and calculated per Section 5.18 Gamut Area of the Information Display Measurements Standard Version 1.03.
Note: Any gamut support in non-visible/invisible color areas is not to be counted. The gamut must be expressed as a percentage from 1% to 100% to the nearest 0.1% of the area of the visible CIE LUV color space only.

11) **High Dynamic Range (HDR):** The ability to display images with greater range of contrast and color than what is considered standard dynamic range.

**Note:** EPA is adding the definition of High Dynamic Range (HDR) adapted from the well-accepted definition by the Video Electronics Standards Association (VESA).

12) **Luminance:** The photometric measure of the luminous intensity per unit area of light travelling in a given direction, expressed in candelas per square meter (cd/m²).
   
   a) **Maximum Reported Luminance:** The maximum luminance the Display may attain at an On Mode preset setting, and as specified by the manufacturer, for example, in the user manual.
   
   b) **Maximum Measured Luminance:** The maximum measured luminance the Display may attain by manually configuring its controls, such as brightness and contrast.
   
   c) **As-shipped Luminance:** The luminance of the Display at the factory default preset setting the manufacturer selects for normal home or applicable market use.

13) **Total Native Resolution:** Resolution expressed as total pixel count in megapixels calculated as the product of physical lines along the vertical and horizontal axes of the Display within the visible area of the Display.

   Note: A Display with a screen resolution of 1920 x 1080 (horizontal x vertical) would have a Total Native Resolution of 2.07 megapixels (MP).

14) **Screen Area:** The visible area of the Display that produces images.

   Note: Screen Area is calculated by multiplying the viewable image width by the viewable image height. For curved screens, measure the width and height along the arc of the Display.

E) **Additional Functions and Features:**

15) **Bridge Connection:** A physical connection between two hub controllers (e.g. USB, FireWire).

   Note: Bridge Connections allow for expansion of ports typically for the purpose of relocating the ports to a more convenient location or increasing the number of available ports.

16) **Full Network Connectivity:** The ability of the Display to maintain network presence while in Sleep Mode. Presence of the Display, its network services, and its applications, is maintained even if some components of the Display are powered down. The Display can elect to change power states based on receipt of network data from remote network devices, but should otherwise stay in Sleep Mode absent a demand for services from a remote network device.

   Note: Full Network Connectivity is not limited to a specific set of protocols. Also referred to as “network proxy” functionality and described in the Ecma-393 standard.

17) **Occupancy Sensor:** A device used to detect human presence in front of or in the area surrounding a Display.

   Note: An Occupancy Sensor is typically used to switch a Display between On Mode and Sleep Mode by detecting human presence or a combination of human presence and a signaling device such as Bluetooth device.

18) **Touch Technology:** Enables the user to interact with a product by touching areas on the Display screen.
19) **Plug-in Module**: A modular plugin device for Signage Displays with compute functionality that provides one or more of the following functions:

   a) Display remote content streamed to it, such as images or screen mirroring, or otherwise render content on the screen from local or remote sources; or

   b) Process touch signals.

   Note: Modules providing any other additional input options are not considered Plug-in Modules for the purposes of this specification. Modules typically meet the Open Pluggable Specification (OPS).

20) **Embedded Module**: A non-modular processor or computing system embedded in a Signage Display that provides one or more of the following functions:

   a) Display remote content streamed to it, such as images or screen mirroring, or otherwise render content on the screen from local or remote sources; or

   b) Process touch signals.

   **Note**: In response to the new proposed definition of Embedded Module for Signage Displays in Draft 2, one stakeholder recommended that the phrase "without the explicit purpose of providing general computing function" be omitted from the Embedded Module and Plug-in Module definitions because of the ambiguity regarding capabilities of compute cards present in these modules and interpreting the meaning of general computing function. EPA has removed the clause restricting these modules from having general computing function. To reduce overlap with Integrated Desktop Computers in the ENERGY STAR Computers specification, EPA has specified in the definition that the Embedded Module and Plug-in Modules are for Signage Displays (not Computer Monitors).

F) **Product Family**: A group of product models that (1) are made by the same manufacturer, (2) share the same Screen Area, Total Native Resolution, and Maximum Reported Luminance, and (3) are of a common basic screen design. Models within a Product Family may differ from each other according to one or more characteristics or features. For Displays, acceptable variations within a Product Family include:

   1) External housing;

   2) Number and types of interfaces;

   3) Number and types of data, network, or peripheral ports; and

   4) Processing and memory capability.

G) **Representative Model**: The product configuration that is tested for ENERGY STAR certification and is intended to be marketed and labeled as ENERGY STAR.

H) **Power Sources**:

   1) **External Power Supply (EPS)**: An external power supply circuit that is used to convert household electric current into dc current or lower-voltage ac current to operate a consumer product.

   2) **Standard dc**: A method for transmitting dc power defined by a well-known technology standard, enabling plug-and-play interoperability.

   **Note**: Common examples are USB and Power-over-Ethernet. Usually Standard dc includes both power and communications over the same cable, but as with the 380 V dc standard, that is not required.
2 SCOPE

2.1 Included Products

2.1.1 Products that meet the definition of a Display as specified herein and are powered directly from ac mains, an External Power Supply, or Standard dc are eligible for ENERGY STAR certification, with the exception of products listed in Section 2.2. Typical products that would be eligible for certification under this specification include:

i. Monitors;
ii. Signage Displays;
iii. Signage Displays with Plug-in Modules;
iv. Signage Displays with Embedded Modules; and
v. Signage Displays in a Tiled Display System configuration.

**Note:** Per the requested refinements to the definition of Plug-in Module, Embedded Module, and Tiled Display System, EPA has amended the language here to explicitly include Signage Displays with Plug-in and Embedded Modules and Signage Displays in a Tiled Display System configuration in the scope of this specification. The inclusion of these products was proposed implicitly by defining criteria for their certification in Draft 2 in response to stakeholder requests. Only favorable responses were received regarding this expansion in scope, so EPA does not foresee any concern with explicitly including these products.

2.2 Excluded Products

2.2.1 Products that are covered under other ENERGY STAR product specifications are not eligible for certification under this specification including Televisions and Computers (Thin Clients, Slates/Tablets, Portable All-in-one Computers, and Integrated Desktops). The list of specifications currently in effect can be found at [www.energystar.gov/products](http://www.energystar.gov/products).

2.2.2 The following products are not eligible for certification under this specification:

i. Products with an integrated television tuner;

ii. Displays with integrated or replaceable batteries designed to support primary operation without ac mains or external dc power, or device mobility (e.g., electronic readers, battery-powered digital picture frames); and

iii. Products that must meet Food and Drug Administration specifications for medical devices that prohibit power management capabilities and/or do not have a power state meeting the definition of Sleep Mode.

vi. Monitors with keyboard, video, and mouse (KVM) switch functionality;

3 CERTIFICATION CRITERIA

3.1 Significant Digits and Rounding

3.1.1 All calculations shall be carried out with directly measured (unrounded) values.

3.1.2 Unless otherwise specified, compliance with specification requirements shall be evaluated using directly measured or calculated values without any benefit from rounding.
3.1.3 Directly measured or calculated values that are submitted for reporting on the ENERGY STAR website shall be rounded to the nearest significant digit as expressed in the corresponding specification requirements.

3.2 General Requirements for Monitors and Signage Displays

3.2.1 External Power Supplies (EPSs): Single- and Multiple-voltage EPSs shall meet the Level VI or higher performance requirements under the International Efficiency Marking Protocol when tested according to the Uniform Test Method for Measuring the Energy Consumption of External Power Supplies, Appendix Z to 10 CFR Part 430.

i. Single- and Multiple-voltage EPSs shall include the Level VI or higher marking.


3.2.2 General User Information: The product shall ship with consumer informational materials located in either (1) the hard copy or electronic user manual, or (2) a package or box insert. These materials shall include:

a) Information about the ENERGY STAR program,

b) Information on the energy consumption implications of changes to default as-shipped displays configuration and settings, and

c) Notification that enabling certain optional features and functionalities (e.g., instant-on), may increase energy consumption beyond the limits required for ENERGY STAR certification, as applicable.

3.2.3 Forced Menu: Any product that includes a Forced Menu upon initial start-up shall upon selection of any mode other than the Default Picture Setting as identified and tested by the ENERGY STAR test procedure either (1) display a second prompt requiring the user to confirm the choice of the other mode, or (2) display information either with the ENERGY STAR mark or copy on the start-up menu that the DefaultPicture Setting is the setting in which the product qualifies for ENERGY STAR.

Note: To clarify this section, EPA now refers to the defined term Default Picture Setting.

3.2.4 Preset Picture Setting Menu: For any product where consumers have the option of selecting different picture settings from a preset menu at any time:

a) The product shall identify on-screen the Default Picture Setting under which the product qualifies for the ENERGY STAR, if available. For example, the product may display an electronic ENERGY STAR mark alongside the name or description of that Default Picture Setting or display a message each time any setting other than the Default Picture Setting is selected.

b) The product shall return to the identified Default Picture Setting, including all energy saving features enabled by default, whenever the user selects that Preset Picture Setting.

Note: To clarify expectations for Preset Picture Setting, EPA has replaced 'should' with 'shall' in the above requirement and made minor language revisions to the requirement, 'the product shall return to the identified Default Picture Setting, including all energy saving features enabled by default, whenever the user selects that Preset Picture Setting.'

3.2.5 Sleep Mode Settings: If users can select and enable Sleep Mode functions from a display prompt in On Mode or a settings menu other than a Forced Menu, and if these functions may alter power draw (i.e. quick start) from the default as-shipped Sleep Mode in which the product qualifies for the ENERGY STAR:
a) The product shall display on-screen information identifying the settings under which the product qualifies for the ENERGY STAR. For example, such information may be indicated by including an electronic ENERGY STAR mark alongside the name or description of the default as-shipped settings or in the form of a message displayed each time any setting other than a default as-shipped setting is selected.

b) Products with a physical ENERGY STAR mark affixed to the front or top of the Display may alternatively display on-screen information that enabling settings other than those under which the product qualifies for the ENERGY STAR may change the energy consumption of the product.

3.2.6 Power Management:

i. Products shall offer at least one power management feature that is enabled by default, and that can be used to automatically transition from On Mode to Sleep Mode either by a connected host device or internally (e.g., support for VESA Display Power Management Signaling (DPMS), enabled by default).

ii. Products that generate content for display from one or more internal sources shall have a sensor or timer enabled by default to automatically engage Sleep or Off Mode.

iii. For products that have an internal default delay time after which the product transitions from On Mode to Sleep Mode or Off Mode, the delay time shall be reported.

iv. Monitors shall automatically enter Sleep Mode or Off Mode within 5 minutes of being disconnected from a host computer.

3.2.7 Signage Displays shall have a true power factor in On Mode of 0.7 or greater per Section 5.2.F in the ENERGY STAR Test Method.

3.3 Energy Requirements for Computer Monitors

3.3.1 The Total Energy Consumption (TEC) in kWh shall be calculated per Equation 1 based on measured values.

\[
E_{TEC} = 8.76 \times (0.35 \times P_{ON} + 0.65 \times P_{SLEEP})
\]

Where:

- \(E_{TEC}\) is the Total Energy Consumption calculation in kWh;
- \(P_{ON}\) is Measured On Mode Power in watts
- \(P_{SLEEP}\) is Measured Sleep Mode Power in watts;
- The result shall be rounded to the nearest tenth of a kWh for reporting.

3.3.2 The Maximum TEC (\(E_{TEC_{MAX}}\)) in kWh for Monitors shall be calculated per Table 1.

Table 1: Calculation of Maximum TEC (\(E_{TEC_{MAX}}\)) for Monitors in kWh

<table>
<thead>
<tr>
<th>Area (in²)</th>
<th>(E_{TEC_{MAX}}) (kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A &lt; 190)</td>
<td>(4.00 \times r + (0.172 \times A) + 1.50)</td>
</tr>
<tr>
<td>(190 \leq A &lt; 210)</td>
<td>(4.00 \times r + (0.020 \times A) + 30.4)</td>
</tr>
<tr>
<td>(210 \leq A &lt; 315)</td>
<td>(4.00 \times r + (0.091 \times A) + 15.4)</td>
</tr>
<tr>
<td>(A \geq 315)</td>
<td>(4.00 \times r + (0.182 \times A) - 13.2)</td>
</tr>
</tbody>
</table>

Where:

- \(A\) = Viewable screen area in in²
- \(r\) = Screen resolution in megapixels (MP)
- The result shall be rounded to the nearest tenth of a kWh for reporting.
Note: In response to Draft 2, EPA received comments requesting less stringent criteria for models with screen areas over 300 square inches. The equation for ETEC MAX proposed in Draft 2 was a single linear function of area and resolution. Per closer review of the data, EPA recognizes that separate functions could better balance requirements for monitors of different sizes; at 13%, the pass rate for monitors with diagonal screen sizes over 30 inches was significantly lower than the overall pass rate of 27%. Based on stakeholder feedback, EPA is thus proposing revised ETEC MAX requirements for monitors with different ETEC MAX equations based on four size bins: Screen Area less than 190 square inches, 190 to 210 square inches, 210 to 315 square inches, and greater than or equal to 315 square inches. To avoid issues with models that straddle size bins, the ETEC MAX equation for each size bin is continuous with the next bin. The revised Final Draft requirements for monitors, including ETEC MAX and allowances, result in balanced dataset pass rates of 32%, 29%, 32%, and 33% for monitors with Screen Area less than 190 square inches, 190 to 210 square inches, 210 to 315 square inches, and greater than or equal to 315 square inches, respectively. To account for changes in the area coefficient, intercepts, and feature allowances, EPA has revised the resolution allowance of 4.2 kWh per megapixel to 4.0 kWh per megapixel.

Through two drafts, numerous stakeholder meetings, and careful consideration of all comments and data, this final draft specification balances recognizing energy savings while also supporting the features that consumers seek. Approximately 30% of monitors in a variety of size bins from a wide selection of brand owners meet the final draft levels. EPA did receive an additional request to ease the TEC requirements for monitors. EPA evaluated this request and found that accommodating it would result in more than 50% of available models meeting the eased levels. In the interest of recognizing leadership products, EPA has not made this requested change.

3.3.3 For all Monitors, Calculated TEC (ETEC) in kWh shall be less than or equal the calculation of Maximum TEC (ETEC_MAX) with the applicable allowances and adjustments (applied at most once) per Equation 2.

Equation 2: Total Energy Consumption Requirement for Monitors

\[ E_{TEC} \leq (E_{TEC\_MAX} + E_{EP} + E_{ABC} + E_{N} + E_{T} + E_{C} + E_{H600} + E_{H1000} + E_{USB}) \times \text{eff}_{AC\_DC} \]

Where:
- \( E_{TEC} \) is TEC in kWh calculated per Equation 1;
- \( E_{TEC\_MAX} \) is the Maximum TEC requirement in kWh calculated per Table 1;
- \( E_{EP} \) is the enhanced performance display allowance in kWh per Section 3.3.4;
- \( E_{ABC} \) is the Automatic Brightness Control allowance in kWh per Equation 5;
- \( E_{N} \) is the Full Network Connectivity allowance in kWh per Table 2;
- \( E_{T} \) is the Touch Technology allowance in kWh per Equation 6;
- \( E_{C} \) is the curved Display allowance in kWh per Equation 7;
- \( E_{H600} \) is the HDR 600 Display allowance in kWh per Table 3;
- \( E_{H1000} \) is the HDR 1000 Display allowance in kWh per Table 3;
- \( E_{USB} \) is the allowance for Displays with USB-C functionality per Table 4; and
- \( \text{eff}_{AC\_DC} \) is the standard adjustment for ac-dc power conversion losses that occur at the device powering the Display, and is 1.0 for Ac-powered Displays and 0.85 for Displays with Standard dc.

3.3.4 For Monitors meeting the enhanced performance display (EPD) requirements below, the energy allowance in Equation 3 shall be applied to the Total Energy Consumption requirement in Equation 2:

i. Contrast ratio of at least 60:1 measured at a horizontal viewing angle of at least 85° from the perpendicular on a flat screen and at least 83° from the perpendicular on a curved screen, with or without a screen cover glass;

ii. A native resolution greater than or equal to 2.3 megapixels (MP); and

iii. Color Gamut greater than or equal to 32.9% of CIE LUV.
Equation 3: Calculation of Energy Allowance for Enhanced Performance Displays

\[ E_{EP} = ((1.70 \times \frac{G}{100\%}) - 0.52) \times E_{TEC, MAX} \]

Where:
- \( E_{EP} \) is the enhanced performance display energy allowance in kWh
- \( G \) is Color Gamut expressed as a percentage of CIE LUV from 1.0% to 100.0%, reported to the nearest 0.1%
- \( E_{TEC, MAX} \) is the Maximum TEC requirement in kWh calculated per Equation 2

Note: A model supporting greater than 99% of the sRGB color space translates to 32.9% of CIE LUV and a model supporting greater than 99% of Adobe RGB translates to 38.4% of CIE LUV.

Note: In response to Draft 2, stakeholders suggested that the EPD allowance, in addition to being a continuous function of Color Gamut, should be implemented as a percentage of the Maximum TEC requirement so as to also account for the impact of screen size on power demand. EPA agreed with this recommendation and has included an EPD allowance that computes a percentage of Maximum TEC by a linear function of the Color Gamut.

EPA received a number of suggestions regarding the equivalent allowances for models supporting sRGB and Adobe RGB color coverage, respectively. Ultimately, EPA based the Final Draft EPD allowance equation on balancing pass rates among models meeting the two performance levels. The ENERGY STAR dataset pass rate for eligible enhanced performance displays is 32% for both Color Gamut between 32.9% and 38.4% and Color Gamut 38.4% or higher, which is comparable to the overall pass rate for monitors of 31%. The Final Draft equation results in an allowance of 4% of \( E_{TEC, MAX} \) for models covering 32.9% of CIE LUV and 13% of \( E_{TEC, MAX} \) for models covering 38.4% of CIE LUV.

Models in the market covering the highest percentage of the CIE LUV color space receive an allowance of approximately 33% of \( E_{TEC, MAX} \).

Per closer review of the data, EPA agrees that WUXGA (MP=2.3) resolution is still a premium segment of the market and indicates need for the EPD allowance. Therefore, EPA has reverted to the original resolution requirement that models have a minimum of 2.3 MP down from 3.6 MP proposed in Draft 2 to be eligible for the EPD allowance.

3.3.5 For monitors with Automatic Brightness Control (ABC) enabled by default, an energy allowance (\( E_{ABC} \)), as calculated per Equation 5, shall be added to \( E_{TEC, MAX} \) in Equation 2, if the On Mode power reduction (\( R_{ABC} \)), as calculated per Equation 4, is greater than or equal to 20%.

Equation 4: Calculation of On Mode Reduction with ABC Enabled by Default

\[ R_{ABC} = 100\% \times \left( \frac{P_{300} - P_{12}}{P_{300}} \right) \]

Where:
- \( R_{ABC} \) is the On Mode percent power reduction due to ABC;
- \( P_{300} \) is the On Mode power in watts, as measured at an ambient light level of 300 lux in Section 6.4 of the Test Method; and
- \( P_{12} \) is the On Mode power in watts, as measured at an ambient light level of 12 lux in Section 6.4 of the Test Method.

Equation 5: ABC Energy Allowance (\( E_{ABC} \)) for Monitors

\[ E_{ABC} = 0.05 \times E_{TEC, MAX} \]

Where:
- \( E_{ABC} \) is the energy allowance for Automatic Brightness Control in kWh; and
- \( E_{TEC, MAX} \) is the Maximum TEC in kWh, per Table 1.
3.3.6 Products with Full Network Connectivity confirmed in Section 6.7 of the ENERGY STAR Test Method shall apply the allowance specified in Table 2.

<table>
<thead>
<tr>
<th>EN (kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.9</td>
</tr>
</tbody>
</table>

Table 2: Full Network Connectivity Energy Allowance (EN) for Monitors

3.3.7 Products tested with Touch Technology active in On Mode shall apply the allowance specified in Equation 6.

Equation 6: Energy Allowance for Touch Technology (ET) for Monitors

\[ E_T = 0.17 \times E_{TEC,MAX} \]

Where:
- \( E_T \) is the energy allowance for Touch Technology in kWh; and
- \( E_{TEC,MAX} \) is the Maximum TEC in kWh, per Table 1.

Note: Per review of the data and stakeholder comments, EPA has included a Touch Technology allowance of 17% of TEC, up from 15% of TEC in Draft 2, which results in 7 of the 21 models with Touch Technology meeting the Final Draft criteria.

3.3.8 Products tested with curved Displays shall apply the allowance specified in Equation 7.

Equation 7: Monitors Curved Display Energy Allowance (EC) for Monitors

\[ E_C = 0.15 \times E_{TEC,MAX} \]

Where:
- \( E_C \) is the energy allowance for curved Displays in kWh; and
- \( E_{TEC,MAX} \) is the Maximum TEC in kWh, per Table 1.

Note: EPA has considered stakeholder feedback and revised the curved display allowance from 5% in Draft 2 to 15% in the Final Draft to account for increased on mode power requirements inherent to curved screen technology while encouraging the most energy efficient implementations of this technology.

3.3.9 Monitors that meet either the following DisplayHDR 600 or DisplayHDR 1000 White Luminance Criteria specified in Table 2-1: DisplayHDR Performance Tier Summary of the Video Electronics Standards Association (VESA) High-performance Monitor and Display Compliance Test Specification (DisplayHDR CTS) Version 1.0 shall apply the allowance specified in Table 3.

a) 10% Center Patch Minimum Requirement (cd/m²);

b) Full-screen Flash Minimum Requirement (cd/m²); and

c) Full-screen Long-duration Minimum Requirement (cd/m²).

Table 3: HDR 600 and HDR 1000 Energy Allowances for Monitors

<table>
<thead>
<tr>
<th>VESA DisplayHDR Certification</th>
<th>Allowance (kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HDR 600 (EH600)</td>
<td>0.05*E_{TEC,MAX}</td>
</tr>
<tr>
<td>HDR 1000 (EH1000)</td>
<td>0.10*E_{TEC,MAX}</td>
</tr>
</tbody>
</table>

Where:
- \( EH600 \) and \( EH1000 \) are the allowances for models meeting the DisplayHDR CTS tiers 600 and 1000 respectively; and
- \( E_{TEC,MAX} \) is the Maximum TEC per Table 1.
Note: In response to stakeholder requests for an allowance for monitors with High Dynamic Range (HDR) capability, the final draft includes allowances for models that meet white luminance tier requirements for DisplayHDR 600 and DisplayHDR 1000 outlined in VESA’s DisplayHDR CTS v1.0 specification. These allowances are intended to account for increased power needed to support the capability to display higher peak brightness of models supporting HDR as opposed to standard dynamic range. EPA proposes that these allowances be applied regardless of whether HDR upscaling is enabled in the default, as-shipped settings to account for modest systematic increases attributable to a display supporting HDR. By setting modest 5% and 10% allowances, EPA seeks to only recognize HDR monitors that scale down power, peak brightness and processing functions in a content-based manner such that the monitor is saving power when displaying images for applications such as web browsing and word processing, which are the uses best accounted for by the ENERGY STAR Test Method.

EPA found that four out of ten models in the dataset either certified to VESA DisplayHDR 400 or marketed as HDR but not certified to the VESA specification met the proposed criteria without an allowance. Thus, models not meeting DisplayHDR 600 or higher performance are not eligible for the HDR allowance. EPA identified three HDR 600 models with diagonal screen size of 31 to 32 inches from two different brands, none of which were able to meet the proposed ENERGY STAR Final Draft criteria without an allowance. EPA also identified a 27-inch HDR 600 model that was able to meet the proposed Final Draft criteria without an allowance. Given the limited number of models with HDR 600, EPA has added a modest 5% of ETEC MAX allowance for HDR 600 and scaling that allowance up to 10% for higher performing HDR 1000 models. There is one HDR 1000 model in the ENERGY STAR dataset with diagonal screen size of 43 inches that meets the Final Draft criteria without the allowance and EPA is aware of two other non-ENERGY STAR certified models that meet HDR 1000.

The existing ENERGY STAR displays test method does not have a procedure in place to assess displaying native or upscaled HDR content and would require a substantial revision and review process to incorporate such procedures. Prior to the launch of the Version 9 specification development, EPA and DOE will continue to monitor the current development of HDR test procedures led by other organizations including CLASP and consider a possible future revision to the ENERGY STAR test method. Until such a change is made, EPA encourages energy-efficient implementation of HDR as tested per the existing methods.

3.3.10 Products with USB Type C interface compatibility shall apply the allowance specified in Table 4.

Table 4: Allowance for Monitors with USB Type C Compatibility

<table>
<thead>
<tr>
<th>E_USB (kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.7</td>
</tr>
</tbody>
</table>

Where:
- $E_{USB}$ is the allowance for models with USB Type C compatibility.

Note: In response to stakeholder feedback, EPA reviewed the latest ENERGY STAR certified model data and identified 56 monitors with USB-C ports. Without an allowance the pass rate for models with USB-C is 23%. Therefore, EPA added a modest allowance of 0.7 kWh to TEC Max for models with USB-C to account for additional background power demand of USB-C yet encourage energy-efficient implementations of USB-C when the port is not fully being utilized.
3.4 Signage Displays Tested in a Tiled Display System Configuration

3.4.1 Signage Displays marketed, shipped, and tested in a Tiled Display System configuration shall meet the Signage Display On Mode and Sleep Mode criteria as calculated per Equation 9 and Equation 11, in which the Screen Area used for all such calculations shall be the total screen area of the Maximum Tiled Configuration.

Note: The total Screen Area of a Tiled Display System with a Maximum Tiled Configuration of 2x2 individual 47.6-inch diagonal Signage Displays (height 23.3 inches and length 41.5 inches) is calculated as \((2 \times 23.3\text{''}) \times (2 \times 41.5\text{''})\) equal to 3867.8 square inches. The Tiled Display System shall meet the On Mode criteria for a 3,867.8 square inch Signage Display.

3.5 On Mode Requirements for Signage Displays

3.5.1 The Maximum On Mode Power \(P_{ON_{MAX}}\) in watts shall be calculated per Equation 8.

**Equation 8: Calculation of Maximum On Mode Power \(P_{ON_{MAX}}\) in Watts for Signage Displays**

\[
P_{ON_{MAX}} = (4.0 \times 10^{-5} \times \ell \times A) + 120 \times \tanh(0.0005 \times (A - 140.0) + 0.03) + 20
\]

Where:
- \(P_{ON_{MAX}}\) is the Maximum on Mode Power, in watts;
- \(A\) is the Screen Area in square inches;
- \(\ell\) is the Maximum Measured Luminance of the Display in candelas per square meter, as measured in Section 6.2 of the test method; and
- The result shall be rounded to the nearest tenth of a watt for reporting.

**Equation 9: On Mode Power Requirement for Signage Displays**

\[
P_{ON} \leq P_{ON_{MAX}} + P_{ABC} + P_{Module}
\]

Where:
- \(P_{ON}\) is On Mode Power in watts, as measured in Section 6.3 or 6.4 of the Test Method;
- \(P_{ON_{MAX}}\) is the Maximum On Mode Power in watts, per Equation 8; and
- \(P_{ABC}\) is the On Mode power allowance for ABC in watts, per Equation 10; and
- \(P_{Module}\) is the On Mode power allowance for Signage Displays with Embedded or Plug-In Modules as specified in Table 5.

3.5.2 For Signage Displays with ABC enabled by default, a power allowance \(P_{ABC}\), as calculated per Equation 10, shall be added to \(P_{ON_{MAX}}\), as calculated per Equation 9, if the On Mode power reduction \(R_{ABC}\), as calculated per Equation 4, is greater than or equal to 20 percent.

**Equation 10: Calculation of On Mode Power Allowance for Signage Displays with ABC Enabled by Default**

\[
P_{ABC} = 0.05 \times P_{ON_{MAX}}
\]

Where:
- \(P_{ABC}\) is the Measured On Mode Power allowance for ABC in watts; and
- \(P_{ON_{MAX}}\) is the Maximum On Mode Power requirement in watts.

3.5.3 For Signage Displays with an Embedded Module, a power allowance \(P_{Module}\) determined by Table 5 shall be added to \(P_{ON_{MAX}}\), as calculated per Equation 9.
Table 5: On Mode Power Allowance for Signage Displays with an Embedded Module

| PModule (W) | 2.5 |

Where:

- \( P_{\text{Module}} \) is the Measured On Mode Power allowance for Embedded Modules in Watts.

Note: In response to Draft 2, one stakeholder requested EPA to provide an allowance for compute power if the signage display has a Plug-in Module or Embedded Module though no specific allowance amount was suggested given these types of models have either not yet entered the market or have not been tested per the ENERGY STAR test method. EPA analyzed the ENERGY STAR televisions dataset for televisions with Thin Client Capability, the ability of the TV to receive, decrypt, and display encrypted content provided by a Multichannel Video Programming Distributor (MVPD) over the Local Area Network. These "Smart TVs" are the most similar product to signage displays with embedded processors and computation capability. On average, UHD TVs with a thin client draw 2.7 W more in On Mode than UHD TVs without Thin Client controlling for screen area.

Based on these data, EPA included an adder of 2.5 W in On Mode for signage displays manufactured with Embedded Modules to encourage the adoption of the most energy-efficient designs and hardware.

EPA is not proposing to apply this allowance to Signage Displays shipped and tested with Plug-In Modules as these types of signage displays have been eligible for ENERGY STAR Version 7 and there is thus far no data or examples of models demanding higher power.

3.6 Sleep Mode Requirements for Signage Displays

3.6.1 Measured Sleep Mode Power (\( P_{\text{SLEEP}} \)) in watts shall be less than or equal the sum of the Maximum Sleep Mode Power Requirement (\( P_{\text{SLEEP_MAX}} \)) and any allowances (applied at most once) per Equation 11.

\[
P_{\text{SLEEP}} \leq P_{\text{SLEEP_MAX}} + P_N + P_{\text{OS}} + P_T
\]

Where:

- \( P_{\text{SLEEP}} \) is Measured Sleep Mode Power in watts;
- \( P_{\text{SLEEP_MAX}} \) is the Maximum Sleep Mode Power requirement in watts per Table 6;
- \( P_N \) is the Full Network Connectivity allowance in watts per Table 7;
- \( P_{\text{OS}} \) is the Occupancy Sensor allowance in watts per Table 8; and
- \( P_T \) is the Touch allowance in watts per Table 8.

Table 6: Maximum Sleep Mode Power Requirement (\( P_{\text{SLEEP_MAX}} \)) for Signage Displays

| \( P_{\text{SLEEP_MAX}} \) (watts) | 0.5 |
3.6.2 Products with Full Network Connectivity confirmed in Section 6.7 of the ENERGY STAR Test Method shall apply the allowance specified in Table 7.

**Table 7: Full Network Connectivity Allowance for Signage Displays**

<table>
<thead>
<tr>
<th>PN (watts)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.0</td>
</tr>
</tbody>
</table>

3.6.3 Products tested with an Occupancy Sensor or Touch Technology active in Sleep Mode shall apply the allowances specified in Table 8.

**Table 8: Additional Functions Sleep Mode Power Allowance for Signage Displays**

<table>
<thead>
<tr>
<th>Type</th>
<th>Screen Size (in)</th>
<th>Allowance (watts)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occupancy Sensor POS</td>
<td>All</td>
<td>0.3</td>
</tr>
<tr>
<td>Touch Functionality PT (applicable only to Signage Displays where screen size is greater than 30 inches)</td>
<td>≤ 30</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>&gt; 30</td>
<td>1.5</td>
</tr>
</tbody>
</table>

3.7 Off Mode Requirements for all Displays

3.7.1 A product need not have an Off Mode to be eligible for certification. For products that do offer Off Mode, measured Off Mode power (P_{OFF}) shall be less than or equal to the Maximum Off Mode Power Requirement (P_{OFF_MAX}) in Table 9.

**Table 9: Maximum Off Mode Power Requirement (P_{OFF_MAX})**

<table>
<thead>
<tr>
<th>P_{OFF_MAX} (watts)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5</td>
</tr>
</tbody>
</table>

3.8 Luminance and Total Native Resolution Reporting Requirements

3.8.1 Maximum Reported, Maximum Measured Luminance, and Total Native Resolution shall be reported for all products; As-Shipped Luminance shall be reported for all products except those with ABC enabled by default.

a) Testing for the above measurements shall be conducted for the individual Signage Display of a Tiled Display System.

Note: EPA has clarified testing procedures that apply to the individual Signage Display model for the Tiled Displays Systems.
Note: Products intended for sale in the US market are subject to minimum toxicity and recyclability requirements. Please see ENERGY STAR Program Requirements for Displays: Partner Commitments for details.

4 TEST REQUIREMENTS

4.1 Test Methods

4.1.1 Test methods identified in Table 10 shall be used to determine certification for ENERGY STAR.

Table 10: Test Methods for ENERGY STAR Certification

<table>
<thead>
<tr>
<th>Product Type</th>
<th>Test Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enhanced Performance Displays</td>
<td>International Committee for Display Metrology (ICDM) Information Display Measurements Standard – Version 1.03</td>
</tr>
<tr>
<td>Displays Claiming Full Network Connectivity</td>
<td>CEA-2037-A, Determination of Television Set Power Consumption</td>
</tr>
<tr>
<td>Displays Claiming High Dynamic Range (HDR)</td>
<td>VESA High-performance Monitor and Display Compliance Test Specification (DisplayHDR CTS) Version 1.0</td>
</tr>
</tbody>
</table>

4.2 Number of Units Required for Testing

4.2.1 One unit of a Representative Model, as defined in Section 1, shall be selected for testing.

i. For Tiled Display Systems, the Maximum Tiled Configuration, as defined in Section 1, shall be used for testing.

Note: EPA is clarifying the number of Signage Displays and support components to be used for the testing of Tiled Display Systems by referencing the Maximum Tiled Configuration, as defined in Section 1.

4.3 International Market Qualification

4.3.1 Products shall be tested for qualification at the relevant input voltage/frequency combination for each market in which they will be sold and promoted as ENERGY STAR.

5 USER INTERFACE

5.1.1 Manufacturers are encouraged to design products in accordance with the user interface standard, IEEE P1621: Standard for User Interface Elements in Power Control of Electronic Devices Employed in Office/Consumer Environments. For details, see http://energy.lbl.gov/controls/.

6 EFFECTIVE DATE

6.1.1 Effective Date: The Version 8 ENERGY STAR Display specification shall take effect on January 28, 2020. To qualify for ENERGY STAR, a product model shall meet the ENERGY STAR specification in effect on its date of manufacture. The date of manufacture is specific to each unit and is the date on which a unit is considered to be completely assembled.
6.1.2 Future Specification Revisions: EPA reserves the right to change this specification should technological and/or market changes affect its usefulness to consumers, industry, or the environment. In keeping with current policy, revisions to the specification are arrived at through stakeholder discussions. In the event of a specification revision, please note ENERGY STAR certification is not automatically granted for the life of a model.

7 CONSIDERATIONS FOR FUTURE REVISIONS

7.1.1 Standby-Active, High Mode: Similar to future revisions of the ENERGY STAR Televisions specification, EPA and the U.S. Department of Energy (DOE) are interested in learning more about Standby-Active, High Mode or Displays with Sleep Modes that demand higher power draw because they are actively running components to reduce latency from Sleep to On Mode, download software updates, or process sensor data. This issue is particularly pertinent with interactive displays that either have a remote or touch screen where the user expects the Display to display content without delay. EPA anticipates exploring this issue and potential power limits and duty cycle requirements in the next specification revision.

7.1.2 Revisions to Test Content: As displays technologies continue to evolve, DOE and EPA support external stakeholder efforts to revise test content (i.e. test clips) to better account for how products perform under more realistic consumer viewing conditions, especially with regard to UHD (4K) content and native HDR content.