U.S. Environmental Protection Agency
November 2014

Proposed Total Energy Consumption (TEC) Approach for ENERGY STAR Version 7.0 Monitors

In recent years, computer monitors have significantly reduced On and Sleep Mode power consumption. Currently, the average power consumption of ENERGY STAR certified monitors is 19 watts, a 46% decrease from the average energy use of conventional models. Likewise in Sleep Mode, most products consume less than 0.5 watts. The current Displays specification uses modal power limits (On, Sleep, Off), but could shift to a Total Energy Consumption (TEC) approach as is used in the Imaging, Computers, and Set-Top Box ENERGY STAR specifications.

As new features and functionality, such as touch functionality, occupancy sensing, and network connectivity come into the market and are enabled during Sleep Mode, the energy allowance to qualify for ENERGY STAR needs to balance flexibility while still continuing to drive efficiency. ENERGY STAR recognizes those products that are able to implement such features at the lower power ranges and has proposed new allowances in Draft 1 of the Version 7.0 ENERGY STAR Displays specification. However, products with very low On Mode power may not be able to meet aggressive sleep limits if they include emerging features not accounted for in the specification, despite their very small increases in energy consumption. Therefore, EPA, while continuing to propose stringent Sleep Mode levels, is considering a Total Energy Consumption (TEC) approach under Version 7.0 to allow for some flexibility for products that have very low power consumption in On Mode but require slightly higher allowances than currently available in Sleep Mode.

Moving to a TEC limit reduces the need to have a large number of relatively small Sleep Mode allowances and lessens the criticality of the actual allowance values for the ones that are included. Rather, a few key adders under a TEC limit could encompass a range of functionality, thus still providing flexibility in implementing new features. Under such an approach, EPA would continue to require reporting of On, Sleep, and Off Modes power levels, but the requirement would be expressed in kWh per year. At this time EPA is only considering a TEC approach for Monitors, not Signage displays, given the lack of available data for typical duty cycles for signage displays.

Developing a TEC Approach from the Modal Approach for Computer Monitors

The current displays On Mode Power limit is a function of resolution, area, and allowances (e.g., ABC and Enhanced Performance). For the TEC calculation, EPA defines the proportion of time the Monitor spends in On and Sleep Modes. Off Mode is excluded from this duty cycle calculation as many products do not have an Off Mode and power levels are similar to Sleep Mode. If EPA applies a TEC approach to computer monitors, the Agency intends to maintain a separate modal power limit of 0.5 W for Off Mode in light of international standards for Off Mode.

EPA proposes referencing the established duty cycle in the Version 6.1 ENERGY STAR Computers Specification. Computers categorized as Conventional Desktops (no Full Network Capability) are assumed to spend 35% of time in Short Idle State per Table 3 of the Computer Specification below. Short Idle State is defined as follows:

> **Short Idle**: The mode where the Computer has reached an Idle condition (i.e., 5 minutes after OS boot or after completing an active workload or after resuming from Sleep Mode), the screen is on, and Long Idle power management features have not engaged (e.g. HDD is spinning and the Computer is prevented from entering sleep mode).

Table 3: Mode Weightings for Desktop, Thin Clients, and Integrated Desktop Computers

Mode Weighting	Conventional	Full Network Connectivity			
		Base Capability	Remote Wake	Service Discovery/ Name Services	Full Capability
T_{OFF}	45%	40%	30%	25%	20%
T_{SLEEP}	5%	15%	28%	36%	45%
T_{LONG_IDLE}	15%	12%	10%	8%	5%
T_{SHORT_IDLE}	35%	33%	32%	31%	30%

Short Idle State corresponds to the period in which the Monitor is most likely to be in On Mode providing its primary function. For the remaining 65% of the time, the Monitor is assumed to be in Sleep Mode.

EPA converted the proposed ENERGY STAR Version 7.0 specification modal power limits to a Total Energy Consumption requirement by multiplying the applicable On Mode and Sleep Mode requirements as follows:

- On Mode: 35% x 365 days x 24 hours/day = 3,066 hours
- Sleep Mode: 65% x 365 days x 24 hours/day = 5,694 hours

To simplify the presentation of an overall single Total Energy Consumption requirement, EPA combined the original modal Sleep Mode 0.5 W base value with the On Mode Limit equation in the Version 7.0 Draft 1.0 document for an addition of 2.85 kWh to the 0.92 kWh constant (from the On Mode power equation intercept multiplied by a 3.066 factor). The resulting total is 3.77 kWh in Table 1 below.

Additionally, EPA has applied a single ac-dc conversion factor of 85% for Standard dc products.

TEC applied to Draft 1 Version 7.0 Requirements

3.3 Energy Requirements

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

Equation 1: Total Energy Consumption Calculation

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

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;*

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

Table 1: Calculation of Monitors Maximum TEC (E_{TEC_MAX}) in kWh

E_{TEC_MAX} (kWh)
Where: A = Viewable screen area in in^2 r = Screen resolution in megapixels The result shall be rounded to the nearest tenth of a kWh for reporting
$(6.13 \times r) + 52.4 \times tanh(0.004 \times (A - 63) + 0.22) + 3.77$

3.3.3 For all Monitors, Calculated TEC (E_{TEC}) in kWh shall be less than or equal to the calculation of Maximum TEC (E_{TEC_MAX}) with the applicable allowances and adjustments per Equation 1.

Equation 1: Total Energy Consumption Requirement for Monitors

$$E_{TEC} \leq (E_{TEC\_MAX} + E_{EP} + E_{ABC} + E_N + E_T + E_{OS}) \times eff_{AC\_DC}$$

Where:

- *E_{TEC} is Calculated TEC in kWh;*
- *E_{TEC_MAX} is the Maximum TEC requirement in kWh;*
- *E_{EP} is the enhanced performance display allowance in kWh per Equation 2;*
- *E_N is the Full Network Connectivity allowance in kWh specified in Table 2;*
- *E_T is the Touch Functionality allowance in kWh specified in Table 3;*
- *E_{OS} is the Occupancy Sensor allowance in kWh specified in Table 3;*
- *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; and The result shall be rounded to the nearest tenth of a kWh for reporting.*

3.3.4 For Monitors meeting the following enhanced performance criteria, an energy allowance (E_{EP}), as calculated per Equation 2, shall be added to E_{TEC_MAX}, as calculated per Equation 1:

i. A contrast ratio of at least 60:1 measured at a horizontal viewing angle of at least 85°, with or without a screen cover glass;

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

iii. A color gamut size of at least sRGB as defined by IEC 61966 2-1. Alternate color spaces are allowable as long as 99% or more of defined sRGB colors are supported.

Note: Only the 2-dimensional gamut of *x* and *y* coordinates for red, green, and blue are needed to form an eligible color space on the CIE 1931 *xy* chromaticity diagram.

Equation 2: Calculation of Energy Allowance for Enhanced Performance Displays

$$E_{EP} = 0.30 \times E_{TEC\_MAX}$$

Where:

- *E_{EP} is the energy allowance in kWh for an enhanced performance display; and*
- *E_{TEC_MAX} is the Maximum TEC requirement in kWh.*

3.3.5 For Monitors with Automatic Brightness Control (ABC) enabled by default, an energy allowance (E_{ABC}), as calculated per Equation 4, shall be added to E_{TEC_MAX}, as calculated per Equation 1, if the On Mode power reduction (R_{ABC}), as calculated per Equation 3, is greater than or equal to 20%.

Equation 3: Calculation of On Mode Reduction for Monitors 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 measured On Mode power in watts when tested with an ambient light level of 300 lux; and*
- *P_{10} is the measured On Mode power in watts when tested with an ambient light level of 12 lux.*

Equation 4: Monitors ABC Energy Allowance (E_{ABC})

$$E_{ABC} = 0.05 \times E_{TEC\_MAX}$$

Where:

- *E_{ABC} is the energy allowance for Automatic Brightness Control in kWh; and*
- *E_{TEC_MAX} is the Maximum TEC in kWh.*

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 2: Full Network Connectivity Energy Allowance (E_N)

E_N (kWh)
2.85

3.3.7 Products tested with Touch Functionality or an occupancy sensor active shall apply the allowance specified in Table 3.

Table 3: Additional Functions Energy Allowances (E_T, E_{OS})

Type	Allowance (kWh)
Touch Functionality E_T	1.71
Occupancy Sensor E_{OS}	1.71

3.3.8 ~~For products that offer more than one Sleep Mode (e.g., "Sleep" and "Deep Sleep"), measured Sleep Mode power (P_{SLEEP}) in any Sleep Mode shall not exceed P_{SLEEP_MAX} in the case of products without bridging or network connection capabilities, or P_{SLEEP_AP} in the case of products tested with additional power-consuming capabilities, such as bridging connections or network connections. If the product has a variety of Sleep Modes that may be manually selected, or if the product can enter Sleep Mode via different methods (e.g., remote control or putting the host PC to sleep), the measured Sleep Mode power (P_{SLEEP}) of the Sleep Mode with the highest P_{SLEEP}, as measured per Section 6.5 of the Test Method, shall be the P_{SLEEP} reported for certification. If the product automatically transitions through its various Sleep Modes, the average P_{SLEEP} of all Sleep Modes as measured in Section 6.5 of the Test Method shall be the P_{SLEEP} reported for certification~~

Note: EPA proposes removing the above requirement given that Sleep Mode is incorporated into the maximum TEC requirement. The Monitor is tested in only one Sleep Mode as specified by the ENERGY STAR Test Method. This single measurement is then the only power value applied in Equation 1. EPA proposes that the requirement remain for signage products that would still be subject to modal requirements, rather than TEC requirements.

3.4 Off Mode Requirements

3.4.1 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 5.

Table 2: Maximum Off Mode Power Requirement (P_{OFF_MAX})

P_{OFF_MAX} (watts)
0.5

Examples of Calculating TEC values from Proposed Requirements in Draft 1 Version 7.0 Displays Specification:

Model	Diagonal Screen Size (in)	Aspect Ratio	Viewable Screen Size, w x l (in)	Screen Area, A (sq. in)	Total Resolution, r (MP)	Measured On Mode, P_{ON} (W)	Measured Sleep Mode, P_{SLEEP} (W)	TEC Calc, E_{TEC} (kWh)	Max TEC , E_{TEC_MAX} (kWh)	Applicable Allowances (kWh)	TEC Req. (kWh)
A	14.0	1.8	6.8 x 12.2	83.0	1.0	5.8	0.4	20.1	25.5	*None*	20.1 ≤ 25.5
B	17.0	1.3	10.6 x 13.3	141.6	1.3	10.9	0.2	34.3	37.4	*None*	34.3 ≤ 37.4
C	23.8	1.8	11.7 x 20.7	242.2	2.1	16.7	0.2	52.3	55.0	*None*	52.3 ≤ 55.0
D	23.8	1.8	11.7 x 20.7	242.0	3.7	21.1	0.3	66.1	64.8	$E_{EP=}$ 0.3*64.8	66.1 ≤ (64.4+19.5)
E	32.0	1.8	15.7 x 27.9	437.6	8.3	38.4	0.4	120.0	103.8	$E_{EP=}$ 0.3*103.8	120.0 ≤ (103.8+31.1)