ENERGY STAR® Program Requirements for Computers

Partner Commitments

Following are the terms of the ENERGY STAR Partnership Agreement as it pertains to the manufacture and labeling of ENERGY STAR certified products. The ENERGY STAR Partner must adhere to the following partner commitments:

Certified Products

1. **Comply with current ENERGY STAR Eligibility Criteria**, which define performance requirements and test procedures for Computers. A list of eligible products and their corresponding Eligibility Criteria can be found at www.energystar.gov/specifications.

2. **Prior to associating the ENERGY STAR name or mark with any product**, obtain written certification of ENERGY STAR qualification from a Certification Body recognized by EPA for Computers. As part of this certification process, products must be tested in a laboratory recognized by EPA to perform Computer testing. A list of EPA-recognized laboratories and certification bodies can be found at www.energystar.gov/testingandverification.

3. **Ensure that any model associated with the ENERGY STAR name or mark** meets the following standards:

   3.1. Product material requirements as defined in restriction of hazardous substances (RoHS) regulations, as generally accepted. This includes exemptions in force at the date of product manufacture, where the maximum concentration values tolerated by weight in homogeneous materials are: lead (0.1%), mercury (0.1%), cadmium (0.01%), hexavalent chromium (0.1%), polybrominated biphenyls (PBB) (0.1%), or polybrominated diphenyl ethers (PBDE) (0.1%). Batteries are exempt.

   3.2. The generally accepted attributes of a recyclable product at the date of product manufacture: where products shall be designed for ease of disassembly and recyclability where external enclosures, sub-enclosures, chassis and electronic subassemblies are easily removable with commonly available tools, by hand, or by a recycler's automated processes.

   Notes:

   - The explicit intention is to harmonize with EU RoHS.

   - For purposes of ENERGY STAR third-party certification, these requirements shall not be reviewed when products are initially certified nor during subsequent verification testing. Rather, EPA reserves the right to request supporting documentation at any time.

Using the ENERGY STAR Name and Marks

4. Comply with current ENERGY STAR Identity Guidelines, which define how the ENERGY STAR name and marks may be used. Partner is responsible for adhering to these guidelines and ensuring that its authorized representatives, such as advertising agencies, dealers, and distributors, are also in compliance. The ENERGY STAR Identity Guidelines are available at www.energystar.gov/logouse.

5. Use the ENERGY STAR name and marks only in association with certified products. Partner may not refer to itself as an ENERGY STAR Partner unless at least one product is certified and offered for sale in the U.S. and/or ENERGY STAR partner countries.

6. Provide clear and consistent labeling of ENERGY STAR certified Computers.

6.1. Partner shall adhere to the following product-specific commitments regarding use of the ENERGY STAR certification mark on certified products:

    6.1.1. Partner must use the ENERGY STAR mark in one of the following ways:

        1) Via permanent or temporary label,. All temporary labeling must be affixed to the product with an adhesive or cling-type application:

            a. The label shall be on the top or front of the product if the top or front of the product has a contiguous, coplanar surface area not used for touch input or display that is greater than or equal to 0.625 in square;

            b. Otherwise, the label shall be on the reverse side of the screen; or

        2) Via electronic labeling displayed on the screen such that the ENERGY STAR mark must be at least 4% of the screen by area; must be greater than or equal to 76 pixels x 78 pixels; must be legible; must be in cyan, black, or white; and either

            a. Must appear at system start-up, and must display for a minimum of 5 seconds; or

            b. Must appear within the system power settings dialog window. EPA will consider alternative proposals for electronic labeling on a case-by-case basis.

6.2. Partner must use the ENERGY STAR mark in product literature (i.e., user manuals, spec sheets, etc.).

6.3. Partner must use the ENERGY STAR mark on product packaging for products sold at retail.

6.4. Partner must use the ENERGY STAR mark on the manufacturer's Internet site where information about ENERGY STAR certified models is displayed.

    6.4.1. If additional information about the ENERGY STAR program or other products is provided by the Partner on its website, Partner must comply with the ENERGY STAR Web Linking Policy, which can be found at www.energystar.gov/partners;

Verifying Ongoing Product Qualification

7. Participate in third-party verification testing through a Certification Body recognized by EPA for Computers, providing full cooperation and timely responses, EPA/DOE may also, at its discretion, conduct tests on products that are referred to as ENERGY STAR certified. These products may be obtained on the open market, or voluntarily supplied by Partner at the government's request.

Providing Information to EPA

8. Provide unit shipment data or other market indicators to EPA annually to assist with creation of ENERGY STAR market penetration estimates, as follows:

8.1. Partner must submit the total number of ENERGY STAR certified Computers shipped in the calendar year or an equivalent measurement as agreed to in advance by EPA and Partner. Partner shall exclude shipments to organizations that rebrand and resell the shipments (unaffiliated private labelers).

8.2. Partner must provide unit shipment data segmented by meaningful product characteristics (e.g., type, capacity, presence of additional functions) as prescribed by EPA.

8.3. Partner must submit unit shipment data for each calendar year to EPA or an EPA-authorized third party, preferably in electronic format, no later than March 1 of the following year.

Submitted unit shipment data will be used by EPA only for program evaluation purposes and will be closely controlled. If requested under the Freedom of Information Act (FOIA), EPA will argue that the data is exempt. Any information used will be masked by EPA so as to protect the confidentiality of the Partner;

9. Report to EPA any attempts by recognized laboratories or Certification Bodies (CBs) to influence testing or certification results or to engage in discriminatory practices.

10. Notify EPA of a change in the designated responsible party or contacts within 30 days using the My ENERGY STAR Account tool (MESA) available at www.energystar.gov/mesa.

Training and Consumer Education

11. Partner shall agree to complete steps to educate users of their products about the benefits of power management by including the following information with each Computer (i.e., in the user manual or on a box insert):

    11.1. Energy saving potential;

    11.2. Financial saving potential;

    11.3. Environmental benefits;

    11.4. Information on ENERGY STAR and a link to www.energystar.gov; and

    11.5. ENERGY STAR logo (used in accordance with "The ENERGY STAR Identity Guidelines" available at www.energystar.gov/logos).

12. In addition, a link should be made available to www.energystar.gov/powermanagement from Computer product pages, product specifications, and related content pages.

13. At the manufacturer's request, EPA will supply suggested facts and figures related to the above criteria, template elements, or a complete template suitable for use in user guides or box inserts.

Performance for Special Distinction

In order to receive additional recognition and/or support from EPA for its efforts within the Partnership, the ENERGY STAR Partner may consider the following voluntary measures, and should keep EPA informed on the progress of these efforts:

- Provide quarterly, written updates to EPA as to the efforts undertaken by Partner to increase availability of ENERGY STAR certified products, and to promote awareness of ENERGY STAR and its message.

- Consider energy efficiency improvements in company facilities and pursue benchmarking buildings through the ENERGY STAR Buildings program.

- Purchase ENERGY STAR certified products. Revise the company purchasing or procurement specifications to include ENERGY STAR. Provide procurement officials' contact information to EPA for periodic updates and coordination. Circulate general ENERGY STAR certified product information to employees for use when purchasing products for their homes.

- Feature the ENERGY STAR mark(s) on Partner website and other promotional materials. If information concerning ENERGY STAR is provided on the Partner website as specified by the ENERGY STAR Web Linking Policy (available in the Partner Resources section of the ENERGY STAR website), EPA may provide links where appropriate to the Partner website.

- Ensure the power management feature is enabled on all ENERGY STAR certified displays and computers in use in company facilities, particularly upon installation and after service is performed.

- Provide general information about the ENERGY STAR program to employees whose jobs are relevant to the development, marketing, sales, and service of current ENERGY STAR certified products.

- Provide a simple plan to EPA outlining specific measures Partner plans to undertake beyond the program requirements listed above. By doing so, EPA may be able to coordinate, and communicate

Partner's activities, provide an EPA representative, or include news about the event in the ENERGY STAR newsletter, on the ENERGY STAR website, etc. The plan may be as simple as providing a list of planned activities or milestones of which Partner would like EPA to be aware. For example, activities may include: (1) increasing the availability of ENERGY STAR certified products by converting the entire product line within two years to meet ENERGY STAR guidelines; (2) demonstrating the economic and environmental benefits of energy efficiency through special in-store displays twice a year; (3) providing information to users (via the website and user's manual) about energy-saving features and operating characteristics of ENERGY STAR certified products; and (4) building awareness of the ENERGY STAR Partnership and brand identity by collaborating with EPA on one print advertorial and one live press event.

- Join EPA's SmartWay Transport Partnership to improve the environmental performance of the company's shipping operations. The SmartWay Transport Partnership works with freight carriers, shippers, and other stakeholders in the goods movement industry to reduce fuel consumption, greenhouse gases, and air pollution. For more information on SmartWay, visit www.epa.gov/smartway.

- Join EPA's Green Power Partnership. EPA's Green Power Partnership encourages organizations to buy green power as a way to reduce the environmental impacts associated with traditional fossil fuel-based electricity use. The partnership includes a diverse set of organizations including Fortune 500 companies, small and medium businesses, government institutions as well as a growing number of colleges and universities. For more information on Green Power, visit www.epa.gov/greenpower.

ENERGY STAR® Program Requirements
Product Specification for Computers

Eligibility Criteria
Version 7.0
Rev. Oct 2018

Following is the **Version 7.0** ENERGY STAR Product Specification for Computers. A product shall meet all of the identified criteria if it is to earn the ENERGY STAR.

1 DEFINITIONS

A) Product Types:

1) Computer: A device which performs logical operations and processes data. For the purposes of this specification, computers include both stationary and portable units, including Desktop Computers, Integrated Desktop Computers, Notebook Computers, Small-Scale Servers, Thin Clients, and Workstations. Although computers are capable of using input devices and displays, such devices are not required to be included with the computer upon shipment. Computers are composed of, at a minimum:

   a) A central processing unit (CPU) to perform operations. If no CPU is present, then the device must function as a client gateway to a server which acts as a computational CPU;

   b) User input devices such as a keyboard, mouse, or touchpad; and

   c) An Integrated Display screen and/or the ability to support an external display screen to output information.

2) Desktop Computer: A computer whose main unit is designed to be located in a permanent location, often on a desk or on the floor. Desktop computers are not designed for portability and are designed for use with an external display, keyboard, and mouse. Desktop computers are intended for a broad range of home and office applications, including point of sale applications.

   a) Integrated Desktop Computer: A Desktop Computer in which the computing hardware and display are integrated into a single housing, and which is connected to ac mains power through a single cable. Integrated Desktop Computers come in one of two possible forms: (1) a system where the display and computer are physically combined into a single unit; or (2) a system packaged as a single system where the display is separate but is connected to the main chassis by a dc power cord and both the computer and display are powered from a single power supply. As a subset of Desktop Computers, Integrated Desktop Computers are typically designed to provide similar functionality as Desktop systems.

3) Notebook Computer: A computer designed specifically for portability and to be operated for extended periods of time both with and without a direct connection to an ac mains power source. Notebook Computers include an Integrated Display, a non-detachable, mechanical keyboard (using physical, moveable keys), and pointing device.

   a) Mobile Thin Client: A computer meeting the definition of a Thin Client, designed specifically for portability, and also meeting the definition of a Notebook Computer. These products are considered to be Notebook Computers for the purposes of this specification.

   b) Two-In-One Notebook: A computer which resembles a traditional Notebook Computer with a clam shell form factor, but has a detachable display which can act as an independent Slate/Tablet when disconnected. The keyboard and display portions of the product must be shipped as an integrated unit. Two-In-One Notebooks are considered Notebooks in the remainder of this specification and are therefore not referenced explicitly.

4) <u>Slate/Tablet</u>: A computing device designed for portability that meets all of the following criteria:

   a) Includes an integrated display with a diagonal size greater than 6.5 inches and less than 17.4 inches;

   b) Lacking an integrated, physical attached keyboard in its as-shipped configuration;

   c) Includes and primarily relies on touchscreen input; (with optional keyboard);

   d) Includes and primarily relies on a wireless network connection (e.g., Wi-Fi, 3G, etc.); and

   e) Includes and is primarily powered by an internal battery (with connection to the mains for battery charging, not primary powering of the device).

5) <u>Portable All-In-One Computer:</u> A computing device designed for portability that meets all of the following criteria:

   a) Includes an integrated display with a diagonal size greater than or equal to 17.4 inches;

   b) Lacking keyboard integrated into the physical housing of the product in its as-shipped configuration;

   c) Includes and primarily relies on touchscreen input; (with optional keyboard);

   d) Includes wireless network connection (e.g. Wi-Fi, 3G, etc.); and

   e) Includes an internal battery

6) <u>E-Reader</u>: A device designed for display and consumption of static images. The display is characterized by a low refresh rate and a display made of bistable materials where no energy is needed to maintain a visible image, only to alter the image.

7) <u>Small-scale Server</u>: A computer that typically uses desktop components in a desktop form factor, but is designed primarily to be a storage host for other computers. Small-scale Servers are designed to perform functions such as providing network infrastructure services (e.g., archiving) and hosting data/media. These products are not designed to process information for other systems or run web servers as a primary function. A Small-scale Server has the following characteristics:

   a) Designed in a pedestal, tower, or other form factor similar to those of desktop computers such that all data processing, storage, and network interfacing is contained within one box/product;

   b) Designed to operate 24 hours/day, 7 days/week, with minimal unscheduled downtime (on the order of hours/year);

   c) Capable of operating in a simultaneous multi-user environment serving several users through networked client units; and

   d) Designed for an industry accepted operating system for home or low-end server applications (e.g., Windows Home Server, Mac OS X Server, Linux, UNIX, Solaris).

8) <u>Thin Client</u>: An independently-powered computer that relies on a connection to remote computing resources (e.g., computer server, remote workstation) to obtain primary functionality. Main computing functions (e.g., program execution, data storage, interaction with other Internet resources) are provided by the remote computing resources. Thin Clients covered by this specification are (1) limited to devices with no rotational storage media integral to the computer and (2) designed for use in a permanent location (e.g. on a desk) and not for portability.

      a)   <u>Integrated Thin Client</u>: A Thin Client in which computing hardware and display are connected to ac mains power through a single cable. Integrated Thin Client computers come in one of two possible forms: (1) a system where the display and computer are physically combined into a single unit; or (2) a system packaged as a single system where the display is separate but is connected to the main chassis by a dc power cord and both the computer and display are powered from a single power supply. As a subset of Thin Clients, Integrated Thin Clients are typically designed to provide similar functionality as Thin Client systems.

      b)   <u>Ultra-thin Client</u>: A computer with lesser local resources than a standard Thin Client that sends raw mouse and keyboard input to a remote computing resource and receives back raw video from the remote computing resource. Ultra-thin clients cannot interface with multiple devices simultaneously nor run windowed remote applications due to the lack of a user-discernible client operating system on the device (i.e., beneath firmware, user inaccessible).

9)   <u>Workstation</u>: A high-performance, single-user computer typically used for graphics, CAD, software development, financial and scientific applications among other compute intensive tasks. Workstations covered by this specification (a) are marketed as a workstation; (b) do not support altering frequency or voltage beyond the CPU and GPU manufacturers' as shipped operating specifications; and (c) has system hardware that supports error-correcting code (ECC) that detects and corrects errors with dedicated circuitry on and across the CPU, interconnect, and system memory. In addition, a workstation meets two or more of the following criteria:

      a)   Supports one or more discrete GPU or discrete compute accelerators

      b)   Supports four or more slots of PCI-express, other than discrete GPU, connected to accessory expansion slots or ports where each lane has a bandwidth of 8 gigabits per second (Gb/s) or more.

      c)   Provide multi-processor support for two or more physically separate processor packages or sockets. (this requirement cannot be met with support for a single multi-core processor); and/or

      d)   Certification by 2 or more Independent Software Vendor (ISV) product certifications; these certifications can be in process, but shall be completed within 3 months of certification.

10)   <u>Rack-mounted Workstation</u>: A workstation that is designed to be natively rack mounted as described in IEC 60297-3-101:2004. The rack-mounted workstation may be accessed locally by direct connection to the workstation and display or accessed remotely across a network by one or more users.

B)   <u>Product Category</u>: A second-order classification or sub-type within a product type that is based on product features and installed components. Product categories are used in this specification to determine certification and test requirements.

C)   <u>Computer Components</u>:

1)   <u>Graphics Processing Unit (GPU)</u>: An integrated circuit, separate from the CPU, designed to accelerate the rendering of either 2D and/or 3D content to displays. A GPU may be mated with a CPU, on the system board of the computer or elsewhere to offload display capabilities from the CPU.

2)   <u>Discrete Graphics (dGfx)</u>: A graphics processor (GPU) which must contain a local memory controller interface and local graphics-specific memory.

3)   <u>Integrated Graphics (iGfx)</u>: A graphics solution that does not contain Discrete Graphics.

4) <u>Display</u>: A commercially-available product with a display screen and associated electronics, often encased in a single housing, that as its primary function displays 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) <u>Enhanced-performance Integrated Display</u>: An integrated Computer Display that has all of the following features and functionalities:

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

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

   (3) A color gamut of at least sRGB as defined by IEC 61966-2-1. Shifts in color space are allowable as long as 99% or more of defined sRGB colors are supported.

5) <u>External Power Supply (EPS)</u>: Also referred to as External Power Adapter. 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.

6) <u>Internal Power Supply (IPS)</u>: A component internal to the computer casing and designed to convert ac voltage from the mains to dc voltage(s) for the purpose of powering the computer components. For the purposes of this specification, an internal power supply shall be contained within the computer casing but be separate from the main computer board. The power supply shall connect to the mains through a single cable with no intermediate circuitry between the power supply and the mains power. In addition, all power connections from the power supply to the computer components, with the exception of a DC connection to a display in an Integrated Desktop Computer, shall be internal to the computer casing (i.e., no external cables running from the power supply to the computer or individual components). Internal dc-to-dc converters used to convert a single dc voltage from an external power supply into multiple voltages for use by the computer are not considered internal power supplies.

D) <u>Operational Modes</u>:

1) <u>Active State</u>: The power state in which the computer is carrying out useful work in response to a) prior or concurrent user input or b) prior or concurrent instruction over the network. Active State includes active processing, seeking data from storage, memory, or cache, including Idle State time while awaiting further user input and before entering low power modes.

2) <u>Idle State</u>: The power state in which the operating system and other software have completed loading, a user profile has been created, activity is limited to those basic applications that the system starts by default, and the computer is not in Sleep Mode. Idle State is composed of two sub-states: Short Idle and Long Idle.

   a) <u>Long Idle</u>: The mode where the Computer has reached an Idle condition (i.e., 15 minutes after OS boot or after completing an active workload or after resuming from Sleep Mode) and the main Computer Display has entered a low-power state where screen contents cannot be observed (i.e., backlight has been turned off) but remains in the working mode (ACPI G0/S0). If power management features are enabled as-shipped in the scenario described in this definition, such features shall engage prior to evaluation of Long Idle (e.g., display is in a low power state, HDD may have spun-down), but the Computer is prevented from entering Sleep Mode. P_{LONG_IDLE} represents the average power measured when in the Long Idle Mode.

   b) <u>Short Idle</u>: 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). P_{SHORT_IDLE} represents the average power measured when in the Short Idle mode.

3) <u>Off Mode</u>: The lowest power mode which cannot be switched off (influenced) by the user and that may persist for an indefinite time when the appliance is connected to the main electricity supply and used in accordance with the manufacturer's instructions. For systems where ACPI standards are applicable, Off Mode correlates to ACPI System Level S5 state.

4) <u>Sleep Mode</u>: A low power mode that the computer enters automatically after a period of inactivity or by manual selection. A computer with Sleep capability can quickly "wake" in response to network connections or user interface devices with a latency of less than or equal to 5 seconds from initiation of wake event to system becoming fully usable including rendering of display. For systems where ACPI standards are applicable, Sleep Mode most commonly correlates to ACPI System Level S3 (suspend to RAM) state.

E) <u>Networking and Additional Capabilities</u>:

1) <u>Additional Internal Storage</u>: Any and all internal hard disk drives (HDD) or solid state drives (SSD) installed beyond the largest capacity non-volatile storage device present in the system in its as shipped state. This definition does not include external drives.

2) <u>Energy Efficient Ethernet (EEE)</u>: A technology which enables reduced power consumption of Ethernet interfaces during times of low data throughput. Specified by IEEE 802.3az.

3) <u>Full Network Connectivity</u>: The ability of the computer to maintain network presence while in Sleep Mode or an alternative low power mode (LPM) with power demand of less than or equal to 10 watts and intelligently wake when further processing is required (including occasional processing required to maintain network presence). Presence of the computer, its network services and applications, is maintained even though the computer is in a LPM. From the vantage point of the network, a computer with full network connectivity that is in LPM is functionally equivalent to an idle computer with respect to common applications and usage models. Full network connectivity in LPM is not limited to a specific set of protocols but can cover applications installed after initial installation. Also referred to as "network proxy" functionality and as described in the *Ecma-393* standard.

   a) <u>Network Proxy - Base Capability</u>: To maintain addresses and presence on the network while in LPM, the system handles IPv4 ARP and IPv6 NS/ND.

   b) <u>Network Proxy - Full Capability</u>: While in LPM, the system supports Base Capability, Remote Wake, and Service Discovery/Name Services.

   c) <u>Network Proxy - Remote Wake</u>: While in LPM, the system is capable of remotely waking upon request from outside the local network. Includes Base Capability.

   d) <u>Network Proxy - Service Discovery/Name Services</u>: While in LPM, the system allows for advertising host services and network name. Includes Base Capability.

4) <u>Network Interface</u>: The components (hardware and software) whose primary function is to make the computer capable of communicating over one or more network technologies. Examples of Network Interfaces are IEEE 802.3 (Ethernet) and IEEE 802.11 (Wi-Fi).

5) <u>Wake Event</u>: A user, scheduled, or external event or stimulus that causes the computer to transition from Sleep Mode or Off Mode to an active state of operation. Examples of wake events include, but are not limited to: movement of the mouse, keyboard activity, controller input, real-time clock event, or a button press on the chassis, and in the case of external events, stimulus conveyed via a remote control, network, modem, etc.

6) <u>Wake On LAN (WOL)</u>: Functionality which allows a computer to transition from Sleep Mode or Off Mode to an Active State of operation when directed by a network Wake Event via Ethernet.

7) <u>Switchable Graphics</u>: Functionality that allows Discrete Graphics to be disabled when not required in favor of Integrated Graphics.

Note: This functionality allows lower power and lower capability integrated GPUs to render the display while on battery or when the output graphics are not overly complex while then allowing the more power consumptive but more capable discrete GPU to provide rendering capability when required.

F) Marketing and Shipment Channels:

    1) Enterprise Channels: Sales channels typically used by large and medium-sized business, government, educational, or other organizations to purchase computers for use in managed client/server environments.

    2) Model Name: A marketing name that includes reference to the computer model number, product description, or other branding references.

    3) Model Number: A unique marketing name or identification reference that applies to a specific hardware and software configuration (e.g., operating system, processor type, memory, GPU), and is either pre-defined or selected by a customer.

G) Product Family: A high-level description referring to a group of computers sharing one chassis/motherboard combination that often contains hundreds of possible hardware and software configurations. Product models within a family differ from each other according to one or more characteristics or features that either (1) have no impact on product performance with regard to ENERGY STAR certification criteria, or (2) are specified herein as acceptable variations within a product family. For Computers, acceptable variations within a product family include:

    1) Color;

    2) Housing; and

    3) Electronic components other than the chassis/motherboard, such as the processor, memory, GPU, etc.

2 SCOPE

2.1 Included Products

2.1.1   Products that meet the definition of a Computer <u>and</u> one of the following Product Type definitions, as specified herein, are eligible for ENERGY STAR certification, with the exception of products listed in Section 2.2:

    i.   Desktop Computers and Integrated Desktop Computers;

    ii.   Notebook Computers;

    iii.   Slates/Tablets;

    iv.   Portable All-In-One Computers;

    v.   Workstations; and

    vi.   Thin Clients.

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. The list of specifications currently in effect can be found at www.energystar.gov/products.

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

    i.   Docking Stations;

    ii.   Game Consoles;

iii.   E-Readers;

iv.   Handheld gaming devices, typically battery powered and intended for use with an integral display as the primary display;

v.   Mobile Thin Clients not meeting the definition of Notebook Computer;

vi.   Personal Digital Assistant devices (PDAs);

vii.   Point of Sale (POS) products that do not use internal components common to Notebook, Desktop, or Integrated Desktop Computers, including a processor, motherboard, and memory;

viii.   Slate/Tablet based POS products;

ix.   Handheld Computers which contain cellular voice capability;

x.   Ultra-thin Clients; and

xi.   Small-scale Servers.

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 in this specification, compliance with specification limits 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 limit.

3.2   General Requirements

3.2.1   Power supply test data and test reports from testing entities recognized by EPA to perform power supply testing shall be accepted for the purpose of certifying the ENERGY STAR product.

3.2.2   Internal Power Supply (IPS) Requirements: IPSs used in Computers eligible under this specification must meet the following requirements when tested using the *Generalized Internal Power Supply Efficiency Test Protocol, Rev. 6.6* (available at http://www.plugloadsolutions.com/docs/collatrl/print/Generalized_Internal_Power_Supply_Efficiency_Test_Protocol_R6.6.pdf).

i.   IPS with maximum rated output power less than 75 watts shall meet minimum efficiency requirements as specified in Table 1.

ii.   IPS with maximum rated output power greater than or equal to 75 watts shall meet both minimum efficiency requirements and minimum power factor requirements, as specified in Table 1 or Table 2 as applicable.

Table 1: Requirements for Internal Power Supplies with Rated Output of 500 Watts and Below

Loading Condition (Percentage of Nameplate Output Current)	Minimum Efficiency (115V)	Minimum Efficiency (230V)	Minimum Power Factor
20%	0.82	0.85	-
50%	0.85	0.88	0.90
100%	0.82	0.85	-

Table 2: Requirements for Internal Power Supplies with Rated Output Above 500 Watts

Loading Condition (Percentage of Nameplate Output Current)	Minimum Efficiency (115V)	Minimum Efficiency (230V)	Minimum Power Factor
20%	0.87	0.90	-
50%	0.90	0.92	0.90
100%	0.87	0.89	-

3.2.3 <u>External Power Supply (EPS) Requirements</u>: Single- and Multiple-voltage EPSs shall meet the Level V 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-voltage EPSs shall include the Level VI or higher marking.

    ii. Multiple-voltage EPSs meeting Level VI or higher shall include the Level VI or higher marking.

    iii. Additional information on the Marking Protocol is available at http://www.regulations.gov/#!documentDetail;D=EERE-2008-BT-STD-0005-0218

3.3 Power Management Requirements

3.3.1 Products shall include power management features in their "as-shipped" condition as specified in Table 3, subject to the following conditions:

    i. For Thin Clients, the Wake-on-LAN (WOL) requirement shall apply for products designed to receive software updates from a centrally managed network while in Sleep Mode or in Off Mode. Thin Clients whose standard software upgrade framework does not require off-hours scheduling are exempt from the WOL requirement.

    ii. For Notebooks, WOL may be automatically disabled when the product is disconnected from ac mains power.

    iii. For all products with WOL, directed packet filters shall be enabled and set to an industry standard default configuration.

    iv. Products that do not support Sleep Mode by default are only subject to the Display Sleep Mode requirement.

Table 3: Power Management Requirements

Mode or Mode Transition	Requirement	Desktops	Integrated Desktops	Portable All-In-Ones	Notebooks	Slates/Tablets	Thin Clients	Workstations
System Sleep Mode[i]	(1) Sleep Mode shall be set to activate after no more than 30 minutes of user inactivity. (2) The speed of any active 1 Gb/s or faster Ethernet network links shall be reduced when transitioning to Sleep Mode or Off Mode.	Yes	Yes	Yes	Yes	N/A	Yes	Yes
Display Sleep Mode	(1) Display Sleep Mode shall be set to activate after no more than 15 minutes of user inactivity.	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Wake on LAN (WOL)[i]	(1) Computers with Ethernet capability shall provide users with an option to enable and disable WOL for Sleep Mode.
	(2) Computers with Ethernet capability that are shipped through enterprise channels shall either:
	  (a) be shipped with WOL enabled by default for Sleep Mode, when the computer is operating on ac mains power; or
	  (b) provide users with the ability to enable WOL that is accessible from both the client operating system user interface and over the network.
		Yes	Yes	Yes	Yes	N/A	Yes	Yes

Wake Manage-ment[i]	(1) Computers with Ethernet capability that are shipped through enterprise channels shall:
	  (a) be capable of both remote (via network) and scheduled (via real-time clock) wake events from Sleep Mode, and
	  (b) provide clients with the ability to centrally manage (via vendor tools) any wake management settings that are configured through hardware settings if the manufacturer has control over such features.
		Yes	Yes	Yes	Yes	N/A	Yes	Yes

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i Where Sleep Mode is supported by the UUT by default and Sleep Mode power is used as part of the TEC equation for certification.

3.4 User Information Requirements

3.4.1   Products shall be shipped with informational materials to notify customers of the following:

    i.   A description of power management settings that have been enabled by default,

    ii.   A description of the timing settings for various power management features, and

    iii. Instructions for properly waking the product from Sleep Mode.

3.4.2   Products shall be shipped with one or more of the following:

    i.   A list of default power management settings.

    ii.   A note stating that default power management settings have been selected for compliance with ENERGY STAR (within 15 min of user inactivity for the display, within 30 min for the computer, if applicable per Table 3), and are recommended by the ENERGY STAR program for optimal energy savings.

    iii. Information about ENERGY STAR and the benefits of power management, to be located at or near the beginning of the hard copy or electronic user manual, or in a package or box insert.

3.4.3   Provisions 3.4.1 and 3.4.2 may be met through use of either electronic or printed product documentation, provided it adheres to <u>all</u> of the following:

    i.   Documentation is shipped with the product (e.g., in a printed manual or insert, on included optical media, in a file installed with the software load shipped to the customer) or available electronically on the manufacturer's website. In the latter case, instructions for accessing the information on the website shall be provided in the product package or on the Desktop or home screen; and

    ii.   Documentation is included either (a) only with ENERGY STAR certified Computers; or (b) as part of the standard documentation if and only if accompanied by EPA-approved customer guidance on how to identify if their computer configuration is ENERGY STAR certified.

3.5 Requirements for Desktop, Integrated Desktop, and Notebook Computers

3.5.1   Calculated Typical Energy Consumption (E_{TEC}) for Desktop, Integrated Desktop, and Notebook Computers per Equation 1 shall be less than or equal to the maximum TEC requirement (E_{TEC_MAX}) per Equation 2, subject to the following requirements:

    i.   The Additional Internal Storage adder allowance ($TEC_{STORAGE}$) shall be applied if there are more than one internal storage devices present in the product, in which case it shall only be applied once.

    ii.   The Integrated Display adder allowance ($TEC_{INT\_DISPLAY}$) applies only for Integrated Desktops and Notebooks and may be applied for each display. For Enhanced-performance Integrated Displays, the adder is calculated as presented in Table 9 and Equation 3.

    iii. For a product to certify for the Full Network Connectivity mode weighting, one of the following sets of criteria shall be satisfied:

        • Option 1:

           - Products shall meet a non-proprietary Full Network Connectivity standard such as ECMA 393 or another standard that has been approved by EPA as meeting the goals of ENERGY STAR.

           - Products shall have the applied level of functionality enabled and configured by default upon shipment.

- Option 2:
  - Products shall be capable of Sleep Mode or an alternative low power mode which maintains constant network connectivity with energy consumption less than or equal to 2 watts.

Note: If a product does not comply with Option 1 or 2 above, the product shall be tested and reported with Conventional mode weightings shown in Table 4 and Table 5. Full Network Connectivity is a manufacturer-reported parameter. On Mac computers, "Wake for network access" enabled within the Energy Saver/Power Adapter Preferences signifies Base Capability or better. On Windows computers, "ARP Offload" or "NS Offload" or similar enabled within the Advanced Properties of the Network Interface Card (accessed through the Device Manager) signifies Base Capability or better. For systems with a dual Network Interface Card (NIC) configuration, only one NIC configuration needs to comply. The manufacturer can provide further guidance on how to confirm Proxy Support.

iv. For Notebooks, Desktops, and Integrated Desktops that use an alternative low power mode in place of System Sleep Mode, power in Long Idle (P_{LONG_IDLE}) may be used in place of power in Sleep (P_{SLEEP}) in Equation 1 if the alternative low power mode is less than or equal to 10 watts. In such instances, $(P_{SLEEP} \times T_{SLEEP})$, is replaced by $(P_{LONG\_IDLE} \times T_{SLEEP})$; Equation 1 remains otherwise unchanged.

v. Notebooks, Desktops, and Integrated Desktops with switchable graphics may not apply the Discrete Graphics allowance, TEC$_{GRAPHICS}$, from Table 9 in Equation 2. However, for Desktop and Integrated Desktop systems providing Switchable Graphics and enabling it by default, an allowance equal to 50% of the G1 graphics allowance for the platform type (Desktop or Integrated Desktop) may be applied. The switchable graphics incentive only applies to automated switching that is enabled by default. This capability is manufacturer-declared.

Equation 1: TEC Calculation (E$_{TEC}$) for Desktop, Integrated Desktop, Thin Client and Notebook Computers

$$E_{TEC} = \frac{8760}{1000} \times (P_{OFF} \times T_{OFF} + P_{SLEEP} \times T_{SLEEP} + P_{LONG\_IDLE} \times T_{LONG\_IDLE} + P_{SHORT\_IDLE} \times T_{SHORT\_IDLE})$$

Where:
- *P_{OFF} = Measured power consumption in Off Mode (W);*
- *P_{SLEEP} = Measured power consumption in Sleep Mode (W);*
- *P_{LONG_IDLE} = Measured power consumption in Long Idle Mode (W);*
- *P_{SHORT_IDLE} = Measured power consumption in Short Idle Mode (W); and*
- *T_{OFF}, T_{SLEEP}, T_{LONG_IDLE}, and T_{SHORT_IDLE} are mode weightings as specified in Table 4 (for Desktops, Integrated Desktops, and Thin Clients) or Table 5 (for Notebooks).*

Table 4: Mode Weightings for Desktop, Thin Clients, and Integrated Desktop Computers

Mode Weighting	Conventional	Network Proxy - Full Capability
T_{OFF}	45%	20%
T_{SLEEP}	5%	45%
T_{LONG_IDLE}	15%	5%
T_{SHORT_IDLE}	35%	30%

Table 5: Mode Weightings for Notebook Computers

Mode Weighting	Conventional	Network Proxy - Full Capability
T_{OFF}	25%	25%
T_{SLEEP}	35%	45%
T_{LONG_IDLE}	10%	5%
T_{SHORT_IDLE}	30%	25%

Equation 2: E_{TEC_MAX} Calculation for Desktop, Integrated Desktop, and Notebook Computers

$$E_{TEC\_MAX} = (1+ALLOWANCE_{PSU}) \times (TEC_{BASE} + TEC_{MEMORY} + TEC_{GRAPHICS} + TEC_{STORAGE} + TEC_{INT\_DISPLAY} + TEC_{SWITCHABLE} + TEC_{EEE})$$

Where:
- *$ALLOWANCE_{PSU}$ is an allowance provided to power supplies that meet the optional more stringent efficiency levels specified in Table 6; power supplies that do not meet the requirements receive an allowance of 0;*
- *TEC_{BASE} is the Base allowance specified in Table 7 or Table 8; and,*
- *$TEC_{GRAPHICS}$ is the discrete graphics allowance as specified in Table 9, with the exception of systems with integrated graphics, which do not receive an allowance, or Desktops and Integrated Desktops with switchable graphics enabled by default, which receive an allowance through $TEC_{SWITCHABLE}$; and*
- *TEC_{MEMORY}, $TEC_{STORAGE}$, $TEC_{INT\_DISPLAY}$, $TEC_{SWITCHABLE}$, and TEC_{EEE} are adder allowances as specified in Table 9.*

Table 6: Internal Power Supply Efficiency Allowance

Power Supply Type	Computer Type	Minimum Efficiency at Specified Proportion of Rated Output Current[ii]				Minimum Average Efficiency[iii]	Allowance$_{PSU}$
		10%	20%	50%	100%		
IPS	Desktop	0.86	0.90	0.92	0.89	-	0.015
		0.90	0.92	0.94	0.90	-	0.03
	Integrated Desktop	0.86	0.90	0.92	0.89	-	0.015
		0.90	0.92	0.94	0.90	-	0.04

Table 7: Base TEC (TEC$_{BASE}$) Allowances for Desktops and Integrated Desktops

Category Name	Graphics Capability[iv]	Desktop or Integrated Desktop	
		Performance Score, P^v	Base Allowance
0	Any Graphics dGfx ≤ G7	$P ≤ 3$	69.0
I1	Integrated or Switchable Graphics	$3 < P ≤ 6$	112.0
I2		$6 < P ≤ 7$	120.0
I3		$P > 7$	135.0
D1	Discrete Graphics dGfx ≤ G7	$3 < P ≤ 9$	115.0
D2		$P > 9$	135.0

Table 8: Base TEC (TEC$_{BASE}$) Allowances for Notebooks

Category Name	Notebook	
	Performance Score, P^v	Base Allowance
0	$P ≤ 2$	6.5
1	$2 < P < 8$	8.0
2	$P ≥ 8$	14.0

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ii   EPSs shall meet the specified requirements when tested using the *Uniform Test Method for Measuring the Energy Consumption of External Power Supplies, Appendix Z to 10 CFR Part 430.* IPSs shall meet the specified requirements when tested using the *EPRI 306 Generalized Internal Power Supply Efficiency Test Protocol, Rev. 6.6.*

iii Average efficiency is the arithmetic mean of efficiencies tested at 25%, 50%, 75%, and 100% of rated output current. EPSs shall meet the specified requirements when tested using the *Uniform Test Method for Measuring the Energy Consumption of External Power Supplies, Appendix Z to 10 CFR Part 430.*

iv   Discrete Graphics capability is categorized based on frame buffer bandwidth, as shown in Table 9.

v   P = [# of CPU cores] × [CPU clock speed (GHz)] , where # of cores represents the number of physical CPU cores and CPU clock speed represents the Max TDP core frequency, not the turbo boost frequency.

Table 9: Functional Adder Allowances for Desktop, Integrated Desktop, Thin Client, and Notebook Computers

Function			Desktop	Integrated Desktop	Notebook
TEC_MEMORY (kWh) [vi]			0.8		2.4 + (0.294 × GB)
TEC_GRAPHICS (kWh) [vii]	Graphics Category [viii]	**G1** (FB_BW ≤ 16)	36		29.3 × tanh(0.0038 × FB_BW – 0.137) + 13.4
		G2 (16< FB_BW ≤ 32)	51		
		G3 (32 < FB_BW ≤ 64)	64		
		G4 (64 < FB_BW ≤ 96)	83		
		G5 (96 < FB_BW ≤ 128)	105		
		G6 (FB_BW > 128; Frame Buffer Data Width < 192 bits)	115		
		G7 (FB_BW > 128; Frame Buffer Data Width ≥ 192 bits	130		
TEC_SWITCHABLE (kWh) [ix]			0.5 × G1		N/A
TEC_EEE (kWh) [x]			8.76 × 0.2 × (0.15 + 0.35)		N/A
TEC_STORAGE (kWh) [xi]			26		2.6
TEC_INT_DISPLAY (kWh) [xii]			N/A	8.76 × 0.35 × (1+EP) × (4×r + 0.05×A)	8.76 × 0.30 × (1+EP) × (0.43×r + 0.0263×A)

Equation 3: Calculation of Allowance for Enhanced-performance Integrated Displays

$$EP = \begin{cases} 0, & No\ Enhanced\ Performance\ Display \\ 0.3, & Enhanced\ Performance\ Display, d < 27 \\ 0.75, & Enhanced\ Performance\ Display, d \geq 27 \end{cases}$$

Where:
- *d is the diagonal of the screen, in inches;*

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vi TEC_MEMORY Adder: *GB* applies per GB installed in the system.

vii TEC_GRAPHICS Adder: Applies to only the first dGfx installed in the system, but not Switchable Graphics.

viii FB_BW: Is the display frame buffer bandwidth in gigabytes per second (GB/s). This is a manufacturer declared parameter and should be calculated as follows: (Data Rate [Mhz] × Frame Buffer Data Width [bits]) / (8 × 1000)

ix TEC_SWITCHABLE Incentive: Applies to automated switching that is enabled by default in Desktops and Integrated Desktops.

x TEC_EEE: Applies per IEEE 802.3az-compliant (Energy Efficient Ethernet) Gigabit Ethernet port enabled as shipped.

xi TEC_STORAGE Adder: Applies once if system has more than one Additional Internal Storage element.

xii TEC_INT_DISPLAY Adder: EP is the Enhanced Performance Display allowance calculated per Equation 3; r is the Screen resolution in megapixels; and A is viewable screen area in square inches.

3.6 Requirements for Slates/Tablets and Portable All-In-One Computers

3.6.1 Slates/Tablets and Portable All-In-One Computers shall follow **all** of the requirements for Notebook Computers in Section 3.5 above, including calculations of the following:

   i. Calculated Typical Energy Consumption (E_{TEC}), using Equation 1 with the Notebook Computer Mode Weightings from Table 5.

   ii. Calculated Maximum Allowed Typical Energy Consumption (E_{TEC_MAX}), using Equation 2 with the appropriate base Notebook Computer allowance from Table 8, and applicable Notebook Computer functional adder allowances from Table 9.

3.7 Requirements for Workstations

3.7.1 Weighted power consumption (P_{TEC}) as calculated per Equation 4 shall be less than or equal to the maximum weighted power consumption requirement (P_{TEC_MAX}) as calculated per Equation 5.

Equation 4: P_{TEC} Calculation for Workstations

$$P_{TEC} = P_{OFF} \times T_{OFF} + P_{SLEEP} \times T_{SLEEP} + P_{LONG\_IDLE} \times T_{LONG\_IDLE} + P_{SHORT\_IDLE} \times T_{SHORT\_IDLE}$$

Where:
- *P_{OFF} = Measured power consumption in Off Mode (W);*
- *P_{SLEEP} = Measured power consumption in Sleep Mode (W);*
- *P_{LONG_IDLE} = Measured power consumption in Long Idle Mode (W);*
- *P_{SHORT_IDLE} = Measured power consumption in Short Idle Mode (W); and*
- *T_{OFF}, T_{SLEEP}, T_{LONG_IDLE}, and T_{SHORT_IDLE} are mode weightings as specified in Table 10.*

Table 10: Mode Weightings for Workstations

T_{OFF}	T_{SLEEP}	T_{LONG_IDLE}	T_{SHORT_IDLE}
35%	10%	15%	40%

Equation 5: P_{TEC_MAX} Calculation for Workstations

$$P_{TEC\_MAX} = 0.28 \times (P_{MAX} + N_{HDD} \times 5) + 8.76 \times P_{EEE} \times (T_{SLEEP} + T_{LONG\_IDLE} + T_{SHORT\_IDLE})$$

Where:
- *P_{MAX} = Measured maximum power consumption (W)*
- *N_{HDD} = Number of installed hard disk drives (HDD) or solid state drives (SSD)*
- *P_{EEE} is an EEE allowance of 0.2 W per IEEE 802.3az-compliant (Energy Efficient Ethernet) Gigabit Ethernet port.*
- *T_{OFF}, T_{SLEEP}, T_{LONG_IDLE}, and T_{SHORT_IDLE} are mode weightings as specified in Table 10.*

3.7.2 <u>Active State Benchmark</u>: To be ENERGY STAR certified, a Workstation must be submitted for certification with the following information disclosed in full:

   i. Linpack benchmark test results, compiler optimizations, and total energy consumed over the duration of the test; and

   ii. SPECviewperf benchmark test results, configuration options, total duration of the test, and total energy consumed over the duration of the test.

3.7.3 <u>Desktop Workstations</u>: Products marketed as workstations may be ENERGY STAR certified under the Desktop requirements in Section 3.5 instead of the Workstation requirements in Section 3.6, at the Partner's option. EPA will identify Workstations certified as Desktops as "Desktops" in all ENERGY STAR marketing materials, on certified product lists, etc.

3.8 Requirements for Thin Clients

3.8.1 Calculated Typical Energy Consumption (E_{TEC}) per Equation 1 shall be less than or equal to the Maximum TEC Requirement (E_{TEC_MAX}), as calculated per Equation 6, subject to the following requirements.

   i. Allowances can only be applied if the corresponding adders are enabled by default.

   ii. Thin Clients can utilize the proxy weightings in Table 4 when calculating E_{TEC}.

   iii. For Thin Clients that lack a discrete System Sleep Mode, Long Idle State power (P_{LONG_IDLE}) may be used in place of Sleep Mode Power (P_{SLEEP}) in Equation 1 so long as the system meets the Thin Client TEC allowance. In such instances, ($P_{SLEEP} \times T_{SLEEP}$), is replaced by ($P_{LONG\_IDLE} \times T_{SLEEP}$); Equation 1 remains otherwise unchanged.

Equation 6: Calculation of E_{TEC_MAX} for Thin Clients

$$E_{TEC\_MAX} = TEC_{BASE} + TEC_{GRAPHICS} + TEC_{WOL} + TEC_{INT\_DISPLAY} + TEC_{EEE}$$

  Where:

- *TEC_{BASE} is the Base Allowance specified in Table 11;*
- *$TEC_{GRAPHICS}$ is the Discrete Graphics allowance specified in Table 11 if applicable;*
- *TEC_{WOL} is the Wake-on-LAN allowance specified in Table 11 if applicable;*
- *$TEC_{INT\_DISPLAY}$ is the Integrated Display allowance for Integrated Desktops specified in Table 9 if applicable; and*
- *TEC_{EEE} is the Energy Efficiency Ethernet incentive for Desktops specified in*

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- Table *9 if applicable, per IEEE 802.3az-compliant (Energy Efficient Ethernet) Gigabit Ethernet port.*

Table 11: Adder Allowances for Thin Clients

Adder	Allowance (kWh)
TEC_{BASE}	31
$TEC_{GRAPHICS}$	36
TEC_{WOL}	2

Note: Products intended for sale in the US market are subject to minimum toxicity and recyclability requirements. Please see ENERGY STAR® Program Requirements for Computers: Partner Commitments for details.

4 TESTING

4.1 Test Methods

4.1.1   When testing Computer products, the test methods identified in Table 12 shall be used to determine ENERGY STAR certification.

Table 12: Test Methods for ENERGY STAR Certification

Product Type or Component	Test Method
All	ENERGY STAR Test Method for Computers, Rev. March-2016 OR ENERGY STAR Final Method for Computers, Rev. Oct-2018

4.2 Number of Units Required for Testing

4.2.1   Representative Models shall be selected for testing per the following requirements:

   i.   For certification of an individual product configuration, the unique configuration that is intended to be marketed and labeled as ENERGY STAR is considered the Representative Model.

   ii.   For certification of a Product Family of all product types, with the exception of Workstations, product configurations that represent the worst-case power consumption for each product category within the family are considered Representative Models. When submitting Product Families, manufacturers continue to be held accountable for any efficiency claims made about their products, including those not tested or for which data were not reported. This includes ensuring that all models shipped as ENERGY STAR certified within the product family maintain the same power management settings when testing the Representative Model(s).

   iii. For systems that meet the definition for multiple categories (as defined in Section 1.B) depending on the specific configuration, manufacturers will have to submit the highest power configuration for each category under which they would like the system to be ENERGY STAR certified. For example, a system that could be configured as either a Category 0 or 1 Desktop, as defined in Table 7 would require submittal of the highest power configuration for both categories in order to be ENERGY STAR certified. If a product could be configured to meet all categories, it would then have to submit data for the highest power configuration in all categories.

iv. For certification of a Product Family of Workstations under the Workstation or Desktop product type, the product configuration that represents the worst-case power consumption with a single GPU within the family is considered the Representative Model.

Note: Workstations that meet ENERGY STAR requirements with a single graphics device may also have a configuration with more than one graphics device be ENERGY STAR certified, provided the additional hardware configuration is identical with the exception of the additional graphics device(s). The use of multiple graphics includes, but is not limited to, driving multiple displays and ganging for high performance, multi-GPU configurations (e.g. ATI Crossfire, NVIDIA SLI). In such cases, and until such time as SPECviewperf® supports multiple graphics threads, manufacturers may submit the test data for the workstation with the single graphics device for both configurations without retesting the system.

4.2.2 A single unit of each Representative Model shall be selected for testing.

4.2.3 All units/configurations for which a Partner is seeking ENERGY STAR certification, must meet the ENERGY STAR requirements. However, if a Partner wishes to certify configurations of a model for which non-ENERGY STAR certified alternative configurations exist, the Partner must assign the certified configurations an identifier in the model name/number that is unique to ENERGY STAR certified configurations. This identifier must be used consistently in association with the certified configurations in marketing/sales materials and on the ENERGY STAR list of certified products (e.g. model A1234 for baseline configurations and A1234-ES for ENERGY STAR certified configurations).

Note: There may be cases—as described in the paragraph above—where not all units/configurations will meet ENERGY STAR requirements. If so, the worst-case configuration for test will be the worst-case certified configuration, and not one of the presumably even higher-energy consuming non-certified configurations.

4.3 International Market Certification

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

4.4 Customer Software and Management Service Pre-Provisioning

4.4.1 If a manufacturing Partner is hired by a customer to load a custom image on an ENERGY STAR certified computer, the Partner shall take the following steps:

i. Inform the customer that their product may not meet ENERGY STAR with the custom image. A sample notification letter is available on the ENERGY STAR Web site.

ii. Encourage the customer to test the product for ENERGY STAR compliance.

iii. Encourage the customer, should the product no longer meet ENERGY STAR, to make use of EPA's free technical assistance that can assist with Power Management performance, which can be found at www.energystar.gov/fedofficeenergy.

5   USER INTERFACE

5.1.1 Manufacturers are encouraged to design products in accordance with the user interface standard IEEE 1621: Standard for User Interface Elements in Power Control of Electronic Devices Employed in Office/Consumer Environments. For details, see http://eetd.LBL.gov/Controls.

6 EFFECTIVE DATE

6.1.1 <u>Effective Date</u>: The Version 7.0 ENERGY STAR Computers specification shall take effect **November 16, 2018**. To be ENERGY STAR certified, 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 <u>Future Specification Revisions</u>: 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 that the ENERGY STAR certification is not automatically granted for the life of a product model.

7 CONSIDERATIONS FOR FUTURE REVISIONS

7.1.1 **Desktop and Workstation Requirements**: EPA intends revise the desktop and workstation energy requirements in Version 8.0, including a possible recategorization of desktops to more effectively highlight the most efficient products in the market.

7.1.2 **Mode Weightings:** EPA will continue to accept any large scale data sets that help inform updates to the existing mode weighting values which have become dated.

7.1.3 **Low Load IPS Requirements:** EPA would like to work with stakeholders to investigate revising future IPS requirements to focus on lower power supply load levels which are more representative of the low power modes computers persist in when not performing work.

7.1.4 **Active Mode:** EPA will continue to monitor developments in test methodology that addresses active mode, where the computer is actively performing tasks, and assess whether these measurements warrant inclusion into the ENERGY STAR Computers specification.

APPENDIX A:
Sample Calculations

I. **Desktop, Integrated Desktop, Notebook Computers:** Below is a sample TEC calculation intended to show how levels for compliance are determined based on functional adders and operational mode measurements.

Following is a sample E_{TEC} evaluation for a 2.0 GHz, dual core Notebook with Switchable Graphics, 8 GB Memory, Energy Efficient Ethernet (EEE), and 1 hard disk drive (HDD).

A) Measure values using the ENERGY STAR Computers Test Method:

   1) Off Mode = 0.5 W

   2) Sleep Mode = 1.0 W

   3) Long Idle State = 6.0 W

   4) Short Idle State = 10.0 W

B) Determine the proxy support provided by the operating system and network card. This is a manufacturer-reported parameter.

   1) On Mac computers, "Wake for network access" enabled within the Energy Saver/Power Adapter Preferences signifies Base Capability or better.

   2) On Windows computers, "ARP Offload" or "NS Offload" or similar enabled within the Advanced Properties of the Network Interface Card (accessed through the Device Manager) signifies Base Capability or better. OEM can provide further guidance on how to confirm Proxy Support

C) Calculate E_{TEC} from power measurements and mode weightings—this example assumes no Proxy Support/Conventional Weightings:

T_{OFF}	25%
T_{SLEEP}	35%
T_{LONG_IDLE}	10%
T_{SHORT_IDLE}	30%

   1) $E_{TEC} = \frac{8760}{1000} \times (P_{OFF} \times T_{OFF} + P_{SLEEP} \times T_{SLEEP} + P_{LONG\_IDLE} \times T_{LONG\_IDLE} + P_{SHORT\_IDLE} \times T_{SHORT\_IDLE})$

   2) $E_{TEC} = \frac{8760}{1000} \times (0.5 \text{ W} \times 25\% + 1.0 \text{ W} \times 35\% + 6.0 \text{ W} \times 10\% + 10.0 \text{ W} \times 30\%)$

   3) E_{TEC} = 35.7 kWh / year

D) Determine which Base TEC allowance applies based on graphics capability and performance score: *P = [# of CPU cores] × [CPU clock speed (GHz)] = 2×2 GHz = 4.*

Table 8: Base TEC (TEC$_{BASE}$) Allowances for Notebooks

Category Name	Notebook	
	Performance Score, P^v	Base Allowance
1	2 < *P* < 8	8.0

E) Determine which Functional Adder Allowances apply:

1) Memory: *8 GB installed, so a TEC$_{MEMORY}$ allowance of* $2.4 + (0.294 \times 8) = 4.75 \text{ kWh}$ *applies*

2) Discrete Graphics? *No, therefore TEC$_{GRAPHICS}$ allowance does not apply.*

3) Switchable Graphics? *Yes, but TEC$_{SWITCHABLE}$ allowance does not apply to Notebooks.*

4) Energy Efficient Ethernet (EEE)? *Yes, but TEC$_{EEE}$ allowance does not apply to Notebooks.*

5) Storage? *No, the notebook has only one hard disk drive, so no storage allowance applies.*

6) Integrated Display? *Yes, and assuming a non-enhanced performance, 14 inch display with an area of 83.4 square inches and a resolution of 1.05 megapixels, a TEC$_{INT\_DISPLAY}$ allowance of* 8.76 ×*0.30* × (1+*EP)* × (0.43×*r* + 0.0263×*A*) = 8.76 ×*0.30* × (0.43×*1.05* MP+ 0.0263×83.4 in^2) = 6.95 kWh *applies.*

F) Calculate E$_{TEC\_MAX}$:

1) E$_{TEC\_MAX}$ = 8.0 kWh + 4.75 kWh + 6.95 kWh

2) E$_{TEC\_MAX}$ = 19.7 kWh/yr

G) Compare E$_{TEC}$ to the E$_{TEC\_MAX}$ to determine if the model qualifies:

35.7 kWh/yr > 19.7 kWh/yr

Therefore, the Notebook does not meet ENERGY STAR requirements.

II. **Workstations:** Below is a sample P$_{TEC}$ calculation for a Workstation with 2 hard drives and no Energy Efficient Ethernet capability.

A) Measure values using the ENERGY STAR Computers Test Method:

1) Off Mode = 2 W

2) Sleep Mode = 4 W

3) Long Idle State = 50 W

4) Short Idle State = 80 W

5) Max Power = 180 W

A) Note number of Hard Drives installed: Two hard drives installed during test.

B) Calculate P$_{TEC}$ from power measurements and mode weightings using Equation 4:

T$_{OFF}$	T$_{SLEEP}$	T$_{LONG\_IDLE}$	T$_{SHORT\_IDLE}$
35%	10%	15%	40%

1) *P$_{TEC}$* = (35% × *P$_{OFF}$* + 10% × *P$_{SLEEP}$* + 15% × *P$_{LONG\_IDLE}$* + 40% × *P$_{SHORT\_IDLE}$*)

2) *P$_{TEC}$* = (35% × 2 W + 10% × 4 W + 15% × 50 W + 40% × 80 W)

3) P_{TEC} = 40.6 W

C) Calculate the P_{TEC_MAX} requirement using Equation 5:

1) $P_{TEC\_MAX} = 0.28 \times (P_{MAX} + N_{HDD} \times 5) + 8.76 \times P_{EEE} \times (T_{SLEEP} + T_{LONG\_IDLE} + T_{SHORT\_IDLE})$

2) $P_{TEC\_MAX} = 0.28 \times (180 + 2 \times 5) + 8.76 \times 0 \times (T_{SLEEP} + T_{LONG\_IDLE} + T_{SHORT\_IDLE})$

3) $P_{TEC\_MAX} = 53.2 + 0$

D) Compare P_{TEC} to the ENERGY STAR levels to determine if the model qualifies:

40.6 W ≤ 53.2 W

Therefore, the Workstation meets ENERGY STAR requirements.

**ENERGY STAR® Program Requirements
Product Specification for
Computers**

**Final Test Method
Rev. Oct-2018**

1 OVERVIEW

The following test method shall be used for determining product compliance with requirements in the ENERGY STAR Specification for Computers.

2 APPLICABILITY

ENERGY STAR test requirements are dependent upon the feature set of the product under evaluation. The following guidelines shall be used to determine the applicability of each section of this document:

- The procedure in Section 6 shall be conducted on all eligible products that are covered under the scope as defined in Section 2 of the ENERGY STAR Final Draft Eligibility Criteria for Computers.

- The procedure in Section 7 shall be conducted only on eligible Workstation Computer products.

3 DEFINITIONS

Unless otherwise specified, all terms used in this document are consistent with the definitions in the ENERGY STAR Specification for Computers.

4 TEST SETUP

4.1 Test Setup and Instrumentation

Test setup and instrumentation for all portions of this procedure shall be in accordance with the requirements of International Electrotechnical Commission (IEC) standard, IEC 62301, "Household Electrical Appliances – Measurement of Standby Power" Edition 2.0, 2011-01, Section 4, "General Conditions for Measurements", unless otherwise noted in this document. In the event of conflicting requirements, the ENERGY STAR test method shall take precedence.

A) <u>Input Power:</u> Products intended to be powered from alternating current (ac) mains shall be connected to a voltage source appropriate for the intended market, as specified in Table 1 and Table 2.

**Table 1: Input Power Requirements for Products with
Nameplate Rated Power Less Than or Equal to 1500 watts (W)**

Market	Voltage	Voltage Tolerance	Maximum Total Harmonic Distortion	Frequency	Frequency Tolerance
North America, Taiwan	115 volts (V) ac	+/- 1.0 %	2.0 %	60 hertz (Hz)	+/- 1.0 %
Europe, Australia, New Zealand	230 V ac	+/- 1.0 %	2.0 %	50 Hz	+/- 1.0 %
Japan	100 V ac	+/- 1.0 %	2.0 %	50 Hz or 60 Hz	+/- 1.0 %

**Table 2: Input Power Requirements for Products with
Nameplate Rated Power Greater Than 1500 W**

Market	Voltage	Voltage Tolerance	Maximum Total Harmonic Distortion	Frequency	Frequency Tolerance
North America, Taiwan	115 V ac	+/- 4.0 %	5.0 %	60 Hz	+/- 1.0 %
Europe, Australia, New Zealand	230 V ac	+/- 4.0 %	5.0 %	50 Hz	+/- 1.0 %
Japan	100 V ac	+/- 4.0 %	5.0 %	50 Hz or 60 Hz	+/- 1.0 %

B) Ambient Temperature: Ambient temperature shall remain between 18 °C and 28 °C, inclusive, for the duration of the test.

C) Relative Humidity: Relative humidity shall remain between 10% and 80%, inclusive, for the duration of the test.

D) Light Measuring Device (LMD): All LMDs shall meet the following specifications:

1) Accuracy: ± 2% (± 2 digits) of the digitally displayed value; and

2) Acceptance Angle: 3 degrees or less.

The overall tolerance of LMDs is found by taking the absolute sum of 2%of the targeted screen luminance and a 2 digit tolerance of the displayed value's least significant digit. For example, if the screen luminance value is 90 candela per meter squared (cd/m^2) and the LMD's least significant digit is a tenth of one cd/m^2, 2% of 90 cd/m^2 would be 1.8 cd/m^2 and a 2 digit tolerance of the least significant digit would be 0.2 cd/m^2. Thus, the displayed value would need to be 90 ± 2 cd/m^2 (1.8 cd/m^2 + 0.2 cd/m^2).

Note: The term "nit" is sometimes used instead of the official SI unit cd/m^2. One nit is equivalent to one cd/m^2.

E) Power Meter: Power meters shall possess the following attributes:

1) Crest Factor:

a) An available current crest factor of 3 or more at its rated range value; and

b) A bound on the current range of 10 milliamperes (mA) or less.

2) Minimum Frequency Response: 3.0 kilo-hertz (kHz)

3) Minimum Resolution:

a) 0.01 W for measurement values less than 10 W;

b) 0.1 W for measurement values from 10 W to 100 W; and

c) 1.0 W for measurement values greater than 100 W.

4) <u>Measurement Accuracy</u>: Measurement uncertainty as introduced by the instrument that measures the input power to the unit under test (UUT), including any external shunts.

a) Power measurements with a value greater than or equal to 0.5 W shall be made with an uncertainty of less than or equal to 2% at the 95% confidence level.

b) Power measurements with a value less than 0.5 W shall be made with an uncertainty of less than or equal to 0.01 W at the 95% confidence level.

5 TEST CONDUCT

5.1 Guidance for Implementation of IEC 62623

The Test Conduct shall be carried out according to the requirements in IEC 62623, "Desktop and Notebook Computers – Measurement of Energy Consumption" Edition 1.0, 2012-10 (IEC 62623 Ed. 1.0, 2012-10) reference with the following guidance.

A) Thin Clients and Workstations shall be configured in a manner identical to Desktops (non-integrated) unless otherwise specified. Slates/Tablets shall be configured in a manner identical to Notebooks unless otherwise specified. Portable All-In-One Computers shall be configured in a manner identical to Integrated Desktops unless otherwise specified.

1) Thin Clients shall run intended terminal/remote connection software during all tests.

B) Wake on LAN (WoL) settings shall be in as shipped condition for testing Sleep Mode and Off Mode.

C) For models that do not offer a Sleep Mode enabled by default, Section 6.2 shall measure power in the lowest-latency user-activated mode or state that preserves machine state and is enabled by default.

1) If no such state separate from Long Idle State or Off Mode exists, the measurement in Section 6.2 shall be skipped.

D) For Long Idle Mode Testing (Section 6.3), the UUT shall be allowed no more than 20 minutes from the point of ceased user input before measurements must be started. If any default settings cause the UUT to enter Long Idle after 20 minutes, begin taking measurements when the UUT has reached the 20 minute mark. Display sleep settings shall be set to default for Long Idle Mode Testing.

E) For Alternative Low Power Mode Testing (Section 6.3), the UUT shall be allowed no more than 20 minutes from the point of ceased user intput before measurements must be started. If any default settings cause the UUT to enter the Alternative Low Mode after 20 minutes, begin taking measurements when the UUT has reached the 20 minute mark. Display sleep settings shall be set to default for Alternative Low Power Mode Testing. When conducting the test in section 6.3, replace all instances of "long idle mode" with "alternative low power mode.[1]"

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[1] For the purposes of this test method and until such time that the Version 7.1 specification is finalized, "Alternative Low Power Mode" is defined as: A low power mode that the computer enters automatically after a period of inactivity or by manual selection that is defined by the display turning off and the computer entering a state of reduced functionality. A computer with Alternative Low Power Mode must maintain immediate responsiveness to network connections or user interface devices. P_{ALPM} represents the average power measured when in the Alternative Low Power Mode. Upon finalization of the Version 7.1 specification, "Alternative Low Power Mode" will refer to the definition in the final 7.1 specification.

F) For Short Idle Mode Testing (Section 6.4), the UUT shall be allowed no more than five minutes from the point of ceased user input before measurements must be taken. Display sleep settings shall be disabled for Short Idle Mode Testing. If any other default settings cause the UUT to exit Short Idle during the measurement time, extend the settings so that the UUT remains in short idle for the duration of the measurement. The short idle test can either be conducted one time or multiple times. If conducted multiple times, then the average of all runs should be reported.

G) Desktops, Integrated Desktops, Notebook Computers, Portable All-In-One Computers , and Slates/Tablets shall be tested for Idle, Sleep, and Off Mode with Full Network Connectivity ("Proxying") features using the as shipped setting.

H) Celluar network connections shall be disabled for testing. Additionally, Bluetooth should be left as-shipped.

I) It is permitted to use hardware or software to disable the battery for testing. Any software used to disable the battery must be built into the operating system or must be bundled with the system as shipped. Instructions to run this software needs to be publicly available (e.g. listed on a website).

This hardware or software can only disconnect the battery from the system; no extra power management features can be turned on by this hardware or software. When using this option, it can be verified that the software disconnect is only disabling the battery by performing a comparison test. Measure long idle with the battery connected (i.e. without using the hardware or software disconnect) for one or more full cycles per IEC 62301, section B.2.3, and verify that this measurement is approximately equal to the measurement with the software disconnect.

Any hardware or software used to disable the battery needs to be reported.

J) If the UUT is demonstrating cylical behavior during the long idle, alternative low power mode, sleep mode, or off mode measurement, it is permissible, but not required, to use an extended measurement capturing one or more full cycles per IEC 62301, section B.2.3.

5.2 Preparing Display Luminance of Notebooks, Integrated Desktops, Slates/Tablets and Portable All-In-One Computers

A) Before performing any tests, disable display dimming, display Sleep Mode, Computer Sleep Mode, and automatic brightness control (ABC) in the Computer settings. Document all settings that were changed from the default configuration.

  1) If ABC cannot be disabled, position a light source such that at least 300 lux directly enters the ABC sensor.

B) Display the three vertical bar video signal as defined in section 3.2.1.3 of IEC 60107-1, "Methods of measurement on receivers for television broadcast transmissions – Part 1: General conditions – Measurements at radio and video frequencies" Edition 3.0, 1997 (IEC 60107-1 Ed. 3.0, 1997). The three bar image shall be configured using the default image display application.

C) Devices with a cold cathode fluorescent lamp (CCFL) backlight shall warm-up for at least 30 minutes. All other displays shall warm-up for at least 5 minutes.

D) With the LMD, measure the luminance in the center of the display.

E) Calibrate the UUT display brightness to the closest brightness setting that is at least 90 cd/m^2 for Notebook Computers, at least 150 cd/m^2 for Integrated Desktop Computers, Portable All-In-One Computers and Slates/Tablets. If the UUT's brightest setting cannot achieve the specified brightness, then set the UUT display to the brightest setting.

F) The display shall be configured with the ENERGY STAR test image, which can be found here[2]. For Desktops, Integrated Desktops, Notebook Computers and Portable All-In-One Computers it may be set as the "desktop background" (wallpaper) or shown via an image display application. The image shall be scaled to completely fill the display area. For Slates/Tablets, the display shall be configured with the default image display application.

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[2] https://www.energystar.gov/ia/partners/images/ComputerTestingImage.bmp

G) Optional setting for units with multiple integrated displays. Configure all displays in the same way using the previous steps. The displays do not have to be configured sequentially (i.e. warmup times can be done simultaneously for all displays). For notebook computers, all displays must be set to the closest brightness setting that is at least 90 cd/m^2 for every display. For Integrated Desktop Computers, Portable All-In-One Computers and Slates/Tablets, all displays must be set to the closest brightness setting that is at least 150 cd/m^2 for every display.

H) For all testing specified in Section 6, the UUT shall not be rebooted or restarted until after the power measurements for Long Idle Mode and Short Idle Mode tests are taken.

I) Slate/Tablet and Portable All-In-One Computers shall be tested with a docking station only if it is shipped with the product and is the only way to power the device mains.

6 TEST PROCEDURES FOR ALL PRODUCTS

6.1 UUT Preparation

UUT preparation shall be performed according to IEC 62623, Ed.1.0, 2012-10, Section 5.2: Test Setup; with the additional guidance in Section 5 of this document.

6.2 Sleep Mode Testing

Sleep Mode power shall be measured according to IEC 62623, Ed.1.0, 2012-10, Section 5.3.3: Measuring Sleep Mode; with the additional guidance in Section 5 of this document.

6.3 Long Idle Mode Testing

Long Idle Mode power shall be measured according to IEC 62623, Ed.1.0, 2012-10, Section 5.3.4: Measuring Long Idle Mode; with the additional guidance in Section 5 of this document.

6.4 Short Idle Mode Testing

Short Idle Mode power shall be measured according to IEC 62623, Ed.1.0, 2012-10, Section 5.3.5: Measuring Short Idle Mode; with the additional guidance in Section 5 of this document.

6.5 Off Mode Testing

Off Mode power shall be measured according to IEC 62623, Ed.1.0, 2012-10, Section 5.3.2: Measuring Off Mode; with the additional guidance in Section 5 of this document.

6.6 Additional Testing For Reporting

For Notebook Computers, repeat the Short Idle test with the display brightness set to the closest setting that is at least 150 cd/m^2 for all displays.

7 TEST PROCEDURES FOR WORKSTATIONS

7.1 Maximum Power Test

The maximum power for Workstations is found by the simultaneous operation of two industry standard benchmarks: Linpack to stress the core system (e.g., processor, memory, etc.) and SPECviewperf® (latest available version for the UUT) to stress the system's Graphics Processing Unit (GPU). This test shall be repeated three times on the same UUT, and all three measurements shall fall within a ± 2% tolerance relative to the average of the three measured maximum power values. The average power should be used for qualification and/or TEC calculations.

Note: Workstations may certify configurations using Microsoft Windows® OS as a proxy for Linux for the maximum power test, as SPEC does not currently support a version of SPECviewperf® capable of running on the Linux OS.

Additional information on these benchmarks, including free downloads, can be found at the following locations as specified in Table 3.

Table 3: Benchmark Information for Maximum Power Test

Benchmark	Website
Linpack	http://www.netlib.org/linpack/
SPECviewperf	http://www.spec.org/benchmarks.html#gpc

A) <u>UUT Preparation:</u>

1) Connect a power meter capable of measuring true power to an ac line voltage source set to the appropriate voltage/frequency combination for the test. The meter shall have all the attributes listed in Section 4.1 E). The meter shall also store and output the maximum power measurement reached during the test or be capable of another method of determining maximum power.

2) Plug the UUT into the measurement power outlet on the meter. No power strips or uninterruptible power supply (UPS) units shall be connected between the meter and the UUT.

3) Record the ac voltage.

4) Boot the UUT and, if not already installed, install Linpack and SPECviewperf as indicated on the above Websites.

5) Set Linpack with all the defaults for the given architecture of the UUT and set the appropriate array size "n" for maximizing power draw during the test.

6) Ensure all technical guidelines relevant to running the benchmark set by the Standard Performance Evaluation Corporation (SPEC) organization for running SPECviewperf have been met.

7) For additional information regarding Linpack setup, see Section 9.1 Typical Linpack Starting Parameters.

B) <u>Maximum Power Testing:</u>

1) Set the meter to begin accumulating true power values at a rate greater than or equal to one reading per second, and begin taking measurements.

2) Run SPECviewperf and as many simultaneous instances of Linpack as needed to fully stress the system. Recommended setup information can be found in Section 9.1 C).

3) Accumulate power values until SPECviewperf and all Linpack instances have completed running. Record the maximum power value attained during the test.

4) The following data shall also be recorded:

   a) Value of "n" (the array size) used for Linpack;

   b) Number of simultaneous copies of Linpack run during the test;

   c) Version of SPECviewperf run for test;

   d) All compiler optimizations used in compiling Linpack and SPECviewperf; and

e) A precompiled binary for end users to download and run both SPECviewperf and Linpack. These can be distributed either through a centralized standards body such as SPEC, by the original equipment manufacturer (OEM), or by a related third party.

7.2 Benchmark Test

The benchmark test shall be performed by running both benchmarks listed below separately. The UUT shall be rebooted before testing with each benchmark. Additional information on these benchmarks, including downloads, can be found at the following locations specified in Table 4. All testing shall be performed with the latest available version of the benchmarks.

Table 4: Information for Benchmark Testing

Benchmark	Website
Linpack	http://www.netlib.org/linpack/
SPECviewperf	http://www.spec.org/benchmarks.html#gpc

A) UUT Preparation:

 1) The UUT shall be setup identical to Step 1) through Step 4) of Section 7.1 A)

 2) If not already installed, install the benchmark as indicated on the websites listed in Table 4.

 3) Configure the benchmark as specified in Section 7.2 B).

 4) Time Measurement: Time measurements may be performed with a standard stopwatch or other time keeping device with a resolution of at least 1 second.

B) Benchmark Configurations:

 1) Linpack

   a) Configure the Linpack settings identically to the maximum power workstation test (e.g. Follow Step 5) and Step 7) of Section 7.1 A)).

   b) Run as many simultaneous instances of Linpack as needed to fully stress the system. Recommended settings would be to set the number of simultaneous instances of Linpack equal to the number of logical and/or physical CPU cores of the system.

 2) SPECviewperf

   a) Configure the settings identically to the maximum power workstation test (e.g. Follow Step 6) of Section 7.1 A)).

C) Benchmark Testing:

 1) Set the meter to begin accumulating true power values at a rate of greater than or equal to one reading per second and begin power and time measurement.

 2) Execute the benchmark.

 3) Stop time measurement and accumulate power values for the entire duration of the benchmark run.

 4) The following data shall be reported:

   a) Linpack

     i. Value of "n" (the array size) used for Linpack;

     ii. Number of instances of Linpack simultaneously run on the system;

     iii. All compiler options used in compiling Linpack;

  iv. Energy consumed over the duration of the test; and

  v. Linpack output file in text format which contains system performance in floating point operations per second (Flops) in addition to other Linpack parameters (e.g. number of tests, problem size, etc.).

 b) SPECviewperf

  i. Version of SPECviewperf used;

  ii. All compiler optimizations used in compiling SPECviewperf;

  iii. Duration of the test;

  iv. Energy consumed over the duration of the test; and

  v. All files and folders present in the Result folder of SPECviewperf suite shall be reported.

8 REFERENCES

A) IEC 62301 Edition 2.0 2011-01, Household electrical appliances – Measurement of standby power.

B) IEC 60107-1 Edition 3.0 1197-04, Methods of measurement on receivers for television broadcast transmissions – Part 1: General Considerations – Measurements at radio and video frequencies.

C) IEC 62623 Edition 1.0 2012-10, Desktop and notebook computers – Measurement of energy consumption

9 APPENDIX: BENCHMARK PARAMETERS

9.1 Typical Linpack Starting Parameters

Below are some typical starting values for the use of Linpack for testing Workstations. These values are starting points and not meant to be binding. The tester is free to use the settings most advantageous to their UUT. Platform and Operating System (OS) will have a significant impact on the applicability of these starting values. The below assumes Linux as the test OS.

A) Number of equations (problem size): See Equation.

B) Leading dimensions of array: See Equation.

The matrix size (the combination of number of equations and leading dimensions of array) should be the maximum size that will fit in the Random Access Memory (RAM) on the machine.
This AWK script will calculate matrix size on a Linux machine:

```
awk '
    BEGIN {
        printf "Maximum matrix dimension that will fit in RAM on this machine: "
    }
    /^MemTotal:/ {
        print int(sqrt(($2*1000)/8)/1000) "K"
    }
' /proc/meminfo
```

Use the output of this to determine what matrix size to input for both the "Number of equations" and "Leading dimensions of array" inputs. The "Number of equations" will be equal to the printed output. The "Leading dimensions of the array" will be the output rounded up to the nearest multiple of eight.

This calculation can be most easily calculated by taking the memory size, in bytes, of the UUT (denoted as m) and substituting m in Equation 1.

$$\frac{\sqrt{\dfrac{m \times 1000}{8}}}{1000}$$

Equation 1: Memory Size Calculation

C) *Number of trials*: c - 1 where c equals the number of logical and/or physical CPU cores of the system. The tester needs to determine which is more advantageous for the unit. The -1 leaves one core open for use by SPECviewperf.

D) *Data alignment value*: Typically four with Linux systems. The best value to use is the page size boundary of the OS.