ENERGY STAR® Servers
Server Energy Use Evaluation – Resources
February 23, 2011

Introduction

This document provides program updates as a foundation for EPA's assembly of a dataset for all servers with 1-4 processor sockets in all form factors (rack-mounted, pedestal, and blade), as listed in the scope for the Draft 1 Version 2.0 ENERGY STAR Computer Servers Specification. For a discussion of data needs and background, please refer to the *Server Energy Use Evaluation – Discussion Document*.

EPA encourages stakeholders to provide data in both Idle State and at full utilization as described further in this document. Tracked changes in the text identify revisions to Draft 1 references and are based on stakeholder comment received over the summer of 2010. For the purposes of this effort, all definitions not included in this document should be assumed to be identical to Draft 1.

1 DEFINITIONS

A. Computer Server: A computer that provides services and manages networked resources for client devices (e.g., desktop computers, notebook computers, thin clients, wireless devices, PDAs, IP telephones, other computer servers, or other network devices). A computer server is sold through enterprise channels for use in data centers and office/corporate environments. A computer server is primarily accessed via network connections, versus directly-connected user input devices such as a keyboard or mouse. For purposes of this specification, a computer server must meet **all** of the following criteria:

1) is marketed and sold as a computer server;

2) is designed for and listed as supporting one or more computer server operating systems (OS) and/or hypervisors, and is targeted to run user-installed enterprise applications;

3) is packaged and sold with one or more ac-dc or dc-dc power supplies; and

4) is designed such that all processors have access to shared system memory and are independently visible to a single OS or hypervisor.

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Note: EPA removed the provision for ECC memory from the Computer Server definition, since ECC is now present in the Resilient Server sub-type definition.

Provision 4 remains as a holdover from the Version 1.0 definition. However, EPA is interested in revisiting the rationale for this provision with stakeholders, specifically to determine if it is still necessary in the general server definition or if it would better be placed elsewhere (e.g., sub-type definition, discussion of nodes versus sockets, etc.).

B. Computer Server Types

1) Managed Server: A computer server that is designed for a high level of availability in a highly managed environment. For purposes of this specification, a managed server must meet **all** of the following criteria:

i) is designed to be configured with redundant power supplies; and

ii) contains an installed dedicated management controller (e.g., service processor).

2) Blade System: A system comprised of a blade chassis and one or more removable blade servers

and/or other units (e.g., blade storage, blade network equipment). Blade systems provide a scalable means for combining multiple blade server or storage units in a single enclosure, and are designed to allow service technicians to easily add or replace (hot-swap) blades in the field.

i) Blade Server: A computer server that is designed for use in a blade chassis. A blade server is a high-density device that functions as an independent computer server and includes at least one processor and system memory, but is dependent upon shared blade chassis resources (e.g., power supplies, cooling) for operation. A processor or memory module that is intended to scale up a standalone server is not considered a Blade Server.

(a) *Multi-bay Blade Server*: A blade server requiring more than one bay for installation in a blade chassis.

ii) Blade Chassis: An enclosure that contains shared resources for the operation of blade servers, blade storage, and other blade form-factor devices. Shared resources provided by a chassis may include power supplies, data storage, and hardware for dc power distribution, thermal management, system management, and network services.

iii) Blade Storage: A storage device that is designed for use in a blade chassis. A blade storage device is dependent upon shared blade chassis resources (e.g., power supplies, cooling) for operation.

3) Fully Fault Tolerant Server: A computer server that is designed with complete hardware redundancy, in which every computing component is replicated between two nodes running identical and concurrent workloads (i.e., if one node fails or needs repair, the second node can run the workload alone to avoid downtime). A fully fault tolerant server uses two systems to simultaneously and repetitively run a single workload for continuous availability in a mission critical application.

4) Resilient Server: A computer server that is designed with resiliency, RAS, and self-correction features integrated in the micro-architecture of the CPU and chipset to ensure data resiliency and accuracy. A resilient server is often used for a limited set of workloads that may include business processing, decision support, or handling of virtualized workloads. For purposes of this specification, a resilient server must meet **all** of the following criteria:

i) contains hot-swappable components (e.g., I/O, hard drives, and ac-dc power supplies);

ii) contains multiple physical banks of memory and I/O busses;

iii) provides machine check architecture (i.e., both Fault Isolation and Resiliency;

iv) provides memory fault detection and system recovery though DRAM chip sparing, extended ECC, and mirrored memory;

v) provides support for error-correcting code (ECC) and/or buffered memory (including both buffered DIMMs and buffered on board (BOB) configurations);

vi) provides end-to-end bus retry; and

vii) supports on-line expansion/retraction of hardware resources without the need for operating system reboot ("on-demand" features).

5) Multi-node Server: A computer server that is designed with two or more independent server nodes that share a single enclosure and one or more power supplies. In a multi-node server, power is distributed to all nodes through shared power supplies. Server nodes in a multi-node server are not designed to be hot-swappable.

i) Dual-node Server: A common multi-node server configuration consisting of two server nodes.

6) Server Appliance: A computer server that is bundled with a pre-installed operating system and application software that is used to perform a dedicated function or set of tightly coupled functions. Server appliances deliver services through one or more networks (e.g., IP or SAN), and are typically managed through a web or command line interface. Server appliance hardware and software configurations are customized by the vendor to perform a specific task (e.g., name

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services, firewall services, authentication services, encryption services, and voice-over-IP (VoIP) services), and are not intended to execute user-supplied software.

7) High Performance Computing (HPC) System: A system designed with multiple, centrally-managed nodes connected with high-speed interconnect technology. An HPC system is intended to maximize performance in parallel and computationally-intensive workloads. HPC system power management features are typically removed or disabled. An HPC system includes a larger number of memory controllers compared to a general-purpose computer server in order to maximize data bandwidth available to the processors. For the purposes of this specification, an HPC server must be clearly identified as an HPC server in marketing literature and product specification sheets, and must be sold as an HPC server or system.

8) Direct Current (Dc) Server: A computer server that is designed solely to operate on a dc power source.

C. Computer Server Form Factors

1) Rack-mounted Server: A computer server that is designed for deployment in a standard 19-inch data center rack as defined by EIA-310, IEC 60297, or DIN 41494. For the purposes of this specification, a blade server is considered under a separate category and excluded from the rack-mounted category.

2) Pedestal Server: A self-contained computer server that is designed with PSUs, cooling, I/O devices, and other resources necessary for stand-alone operation. The frame of a pedestal server is similar to that of a tower client computer.

D. Computer Server Components

1) Power Supply Unit (PSU): A device that converts ac or dc input power to one or more dc power outputs for the purpose of powering a computer server. A computer server PSU must be self-contained and physically separable from the motherboard and must connect to the system via a removable or hard-wired electrical connection.

i) Ac-Dc Power Supply: A PSU that converts line-voltage ac input power into one or more dc power outputs for the purpose of powering a computer server.

ii) Dc-Dc Power Supply: A PSU that converts line-voltage dc input power to one or more dc outputs for the purpose of powering a computer server. For purposes of this specification, a dc-dc converter (also known as a voltage regulator) that is internal to a computer server and is used to convert a low voltage dc (e.g., 12 V dc) into other dc power outputs for use by computer server components is not considered a dc-dc power supply.

iii) Single-output Power Supply: A PSU that is designed to deliver the majority of its rated output power to one primary dc output for the purpose of powering a computer server. Single-output PSUs may offer one or more standby outputs that remain active whenever connected to an input power source. For purposes of this specification, the total rated power output from any additional PSU outputs that are not primary and standby outputs shall be no greater than 20 watts. PSUs that offer multiple outputs at the same voltage as the primary output are considered single-output PSUs unless those outputs (1) are generated from separate converters or have separate output rectification stages, or (2) have independent current limits.

iv) Multi-output Power Supply: A PSU that is designed to deliver the majority of its rated output power to more than one primary dc output for the purpose of powering a computer server. Multi-output PSUs may offer one or more standby outputs that remain active whenever connected to an input power source. For purposes of this specification, the total rated power output from any additional PSU outputs that are not primary and standby outputs is greater than or equal to 20 watts.

2) I/O Device: A device which provides data input and output capability between a computer server and other devices. An I/O device may be integral to the computer server motherboard or may be connected to the motherboard via though expansion slots (e.g., PCI, PCIe). Examples of I/O devices include discrete Ethernet devices, InfiniBand devices, RAID/SAS controllers, and Fibre

Channel devices.

i) I/O Port: Physical circuitry within an I/O device where an independent I/O session can be established. A port is not the same as a connector receptacle; it is possible that a single connector receptacle can service multiple ports of the same interface.

3) Motherboard: The main circuit board of the server. For purposes of this specification, the motherboard includes connectors for attaching additional boards and typically includes the following components: processor, memory, BIOS, and expansion slots.

4) Processor: The logic circuitry that responds to and processes the basic instructions that drive a server. For purposes of this specification, the processor is the central processing unit (CPU) of the computer server. A typical CPU is a physical package to be installed on the server motherboard via a socket or direct solder attachment. The CPU package may include one or more processor cores.

5) Memory: For purposes of this specification, memory is a part of a server external to the processor in which information is stored for immediate use by the processor.

6) Hard Drive (HDD): The primary computer storage device which reads and writes to one or more rotating magnetic disk platters.

7) Solid State Drive (SSD): A disk drive that uses memory chips instead of rotating magnetic platters for data storage.

E. Other Data Center Equipment

1) Network Equipment: A device whose primary function is to pass data among various network interfaces, providing data connectivity among connected devices (e.g., routers and switches). Data connectivity is achieved via the routing of data packets encapsulated according to Internet Protocol, Fibre Channel, InfiniBand or similar protocol.

2) Storage Equipment: A system composed of integrated storage controllers, storage devices (e.g., hard drives or solid state storage) and software that provides data storage services to one or more computer servers. While storage equipment may contain one or more embedded processors, these processors do not execute user-supplied software applications but may execute data-specific applications (e.g., data replication, backup utilities, data compression, install agents).

3) Uninterruptible Power Supply (UPS): A device intended to maintain continuity of power to electrical loads in the event of a disruption to expected utility power supply. The ride-through time of a UPS varies from seconds to tens of minutes. UPS designs offer a range of features, from acting as a temporary power source to the load during a power disruption, to conditioning the power reaching the load under normal operation. UPSs contain energy storage mechanisms to supply power to the attached load in the event of full disruption from the utility.

F. Computer Server Power States

1) Idle State: The operational state in which the OS and other software have completed loading, the computer server is capable of completing workload transactions, but no active workload transactions are requested or pending by the system (i.e., the computer server is operational, but not performing any useful work). For systems where ACPI standards are applicable, Idle State correlates only to ACPI System Level S0.

2) Active State: The operational state in which the computer server is carrying out work in response to prior or concurrent external requests (e.g., instruction over the network). Active state includes **both** (1) active processing and (2) data seeking/retrieval from memory, cache, or internal/external storage while awaiting further input over the network.

G. Other Key Terms:

1) Controller System: A computer or computer server that manages a benchmark evaluation process. The controller system performs the following functions:

i) start and stop each segment (phase) of the performance benchmark;

ii) control the workload demands of the performance benchmark;

iii) start and stop data collection from the power analyzer so that power and performance data from each phase can be correlated;

iv) store log files containing benchmark power and performance information;

v) convert raw data into a suitable format for benchmark reporting, submission and validation; and

vi) collect and store environmental data, if automated for the benchmark.

2) Network Client (Testing): A computer or computer server that generates workload traffic for transmission to a UUT connected via a network switch.

3) RAS Features: An acronym for reliability, availability, and serviceability features. RAS is sometimes expanded to RASM, which adds "Manageability" criteria. The three primary components of RAS as related to a computer server are defined as follows:

i) *Reliability Features*: Features that support a server's ability to perform its intended function without interruption due to component failures (e.g., component selection, temperature and/or voltage de-rating, error detection and correction).

ii) *Availability Features*: Features that support a server's ability to maximize operation at normal capacity for a given duration of downtime (e.g., redundancy [both at micro- and macro-level]).

iii) *Serviceability Features*: Features that support a server's ability to be serviced without interrupting operation of the server (e.g., hot plugging).

4) Server Processor Utilization: The ratio of instantaneous processor computing activity to full-load processor computing activity at a specified voltage and frequency.

H. System Configuration

3) Product Family:

Note: The following definitions are described further in the accompanying Server Energy Use Evaluation – Discussion Document.

Product Family

4) Tested Product Configurations: A set of features common to all models/configurations within a product family that constitute a common basic design. All models/configurations within a product family must share the following:

i) be from the same model line;

ii) share the same form factor (i.e., rack-mounted, blade, pedestal);

iii) share PSUs with both the same rated maximum output and greater than or equal to the rated efficiency of the tested configurations at all required load points specified in Section 3.2 (i.e., 10%, 20%, 50%, and 100% for single-output; 20%, 50%, and 100% for multi-output). For the purposes of testing, configurations shall use PSUs in non-redundant configuration.

1) Product Family Tested Product Configurations: The required representative tests that cover an ENERGY STAR Product Family.

i) Low-end Performance Configuration: The combination of PSUs, Memory, Storage (HDD/SDD), and I/O devices that represents the lowest-price computing platform within the Product Family.

ii) High-end Performance Configuration: The combination of PSUs, Memory, Storage

Deleted: A group of product configurations that is comprised of base components with the same technical and power specifications. In order to be considered a product family for the purpose of this specification, (1) the family may contain only rack-mounted, only pedestal, or only blade servers (not a combination) and (2) **all** product configurations within the product family must include a combination of base components as specified in .

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(HDD/SDD), and I/O devices that represents either the highest-price or highest-performance computing platform within the Product Family.

iii) Typical Configuration: A product configuration that lies between the Minimum and Maximum Power configurations and is representative of a product with high volume sales.

iv) Minimum Power Configuration: The minimum configuration that is able to boot and execute supported OSs. The Minimum Configuration contains the least number of installed PSUs, Memory, Storage (HDD/SDD), and I/O devices, that is both offered for sale and capable of meeting ENERGY STAR requirements.

v) Maximum Power Configuration: The vendor-selected combination of components that maximize power usage within the Product Family once assembled and operated. The Maximum Configuration contains the greatest number of installed PSUs, Memory, Storage (HDD/SDD), and I/O devices that is both offered for sale and capable of meeting ENERGY STAR requirements.

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2 QUALIFYING PRODUCTS

Note: The following section contains the program scope for Version 2 of the Server specification.

2.1 *INCLUDED PRODUCTS*

A product must meet the definition of a Computer Server provided in *Section 0* of this document to be eligible for ENERGY STAR qualification under this specification. Eligibility under Version 2.0 is limited to blade-, rack-mounted, or pedestal form factor computer servers with no more than four processor sockets. Products explicitly excluded from Version 2.0 are identified in *Section 2.2*.

2.2 *EXCLUDED PRODUCTS*

Products that are covered under other existing ENERGY STAR product specifications are not eligible for qualification under the ENERGY STAR Computer Server specification. The list of specifications currently in effect can be found at www.energystar.gov/products.

The following products are specifically excluded from qualification under this specification:

- Fully Fault Tolerant Servers;
- Server Appliances;
- Storage Equipment including Blade Storage; and
- Network Equipment.

Note: Stakeholders should refer to the Draft 1 specification for definitions of Fully Fault Tolerant Servers, Server Appliances, and Storage Equipment.

Appendix A:
ENERGY STAR Computer Server Test Method

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1 OVERVIEW

The following test method shall be used for determining compliance with requirements in the ENERGY STAR Product Specification for Computer Servers, and when acquiring test data for reporting of Full Load power on the ENERGY STAR Power and Performance Data Sheet.

2 APPLICABILITY

The following test method is applicable to all products eligible for qualification under the ENERGY STAR Product Specification for Computer Servers.

Products must be tested with hardware and software features and capabilities in the default, or "as-shipped" configuration, unless otherwise specified in this document. This procedure is intended to be followed in the specified sequence for UUT configuration in Appendix A *Section A*) and testing in *Section 6*.

3 DEFINITIONS

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

4 TEST SETUP

A) Input Power: Input power shall be as specified in Table 1.

Table 1: Input Power Requirements for Computer Servers

Product Type	Supply Voltage	Voltage Tolerance	Maximum Total Harmonic Distortion	Frequency	Frequency Tolerance
Servers with Ac-Dc Single-Output PSUs	230 Vac	+/- 1.0 % (*for products which are rated for ≤ 1.5 kW maximum Power*) or +/- 4.0 % (*for products which are rated for > 1.5 kW maximum Power*)	2.0 % (*for products which are rated for ≤ 1.5 kW maximum Power*) or 5.0 % (*for products which are rated for > 1.5 kW maximum Power*)	50 Hz or 60 Hz	+/- 1.0 %
Servers with Ac-Dc Multi-Output PSUs1	230 Vac and/or 115 Vac			@ 230 Vac: 50 Hz or 60 Hz @ 115 Vac: 60 Hz	+/- 1.0 %
Optional Testing Conditions For Ac-Dc Japanese Market Dc Servers	100 Vac			50 Hz or 60 Hz	+/- 1.0 %
	+/- 53 Vdc	+/- 1.0 V		N/A	N/A

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B) Ambient Temperature: Ambient temperature shall be from 18 °C to 27 °C.

C) Relative Humidity:

1) *Low-End Moisture*: 5.5 °C Dew Point

2) *High-End Moisture*: 60% Relative Humidity, 15 °C Dew Point.

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

1) Crest Factor: An available current crest factor of 3 or more at its rated range value. For analyzers that do not specify the current crest factor, the analyzer must be capable of measuring an amperage spike of at least 3 times the maximum amperage measured during any 1-second sample.

2) Minimum Frequency Response: 3.0 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.

E) Measurement Accuracy:

1) 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.

2) 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 *PSU TEST CONFIGURATION*

Note: Removed from this document as it does not apply to system testing.

5.2 *ACTIVE MODE EFFICIENCY TEST CONFIGURATION*

The Partner must test and report power and efficiency test results for all computer servers. Testing shall be conducted as follows:

A) As-shipped Condition: Products shall be tested in their "as-shipped" configuration, which includes both hardware configuration and system settings, unless otherwise specified in this test method. Where relevant, all options and software shall be set to their default condition.

B) Measurement Location: All power measurements shall be taken at a point between the ac or dc power source and the unit under test (UUT). No UPS units may be connected between the power meter and the UUT. The power meter shall remain in place until all Idle and full load power data is fully recorded.

C) Power Supplies: All PSUs must be connected and operational.

Deleted: Power supplies must be tested for ENERGY STAR qualification using the most recent version of the *Generalized Internal Power Supply Efficiency Test Protocol* maintained by the Electric Power Research Institute (EPRI) and found at . Testing shall be conducted as follows:¶
<#>Test Conditions: Power supplies shall be tested using the input test conditions specified in . Ac-dc multi-output power supplies capable of operating at both 230 and 115 volts input shall be tested at both input voltages for purposes of ENERGY STAR qualification. Ac-dc multi-output power supplies capable of operating at only one of these indicated voltages must test only at the applicable voltage. Testing at 230 volts may be done at either 50Hz or 60Hz.¶
<#>10% Loading Condition**:** Single-output power supplies shall be tested at 10% loading in addition to the standard 20%, 50% and 100% loading conditions indicated in the test procedure. ¶
<#>Fan Power: When testing Multi-output power supplies, internal fan power must be included in the measurement and efficiency calculation. When testing Single-output power supplies, internal fan power must not be included in the measurement and the efficiency calculation. ¶
<#>Efficiency and Power Factor Reporting: Power supplies must meet the levels presented in the Version 2.0 specification without the assistance of rounding. When submitting power supply efficiency and power factor results to ENERGY STAR, manufacturer shall report to the first decimal place (e.g., 85.2%) and three decimal points (e.g., 0.856), respectively.¶

1) UUTs with Multiple PSUs: All power supplies must be connected to the ac or dc power source and operational during the test. If necessary, a Power Distribution Unit (PDU) may be used to connect multiple power supplies to a single source. If a PDU is used, any overhead electrical use from the PDU shall be included in the measurement of Idle power for the UUT.

D) Power Management and Operating System: The as-shipped operating system or a representative operating system must be installed. Products that are shipped without operating systems must be tested with a representative OS installed. For all tests, manufacturers must ensure that only the power management techniques and/or power saving features which are enabled on shipment are those enabled on systems under test. Any power management features which require the presence of an operating system (i.e. those that are not explicitly controlled by the BIOS or management controller) must be tested using only those power management features enabled by the operating system by default.

E) Storage (HDD, SSD): Products that do not include pre-installed hard drives (HDD or SSD) must have an identical hardware and software configuration as a product that was tested and qualified with at least one installed hard drive.

F) Blade and Dual/Multi-Node Servers: A Blade or Dual/Multi-Node Server must have identical configurations for each node or blade including all hardware components and software/power management settings. These systems must also be measured in a way to ensure that all power from all tested nodes/blades is being captured by the power meter the entire test.

G) Blade Chassis: [***TBD***]

H) BIOS and UUT System Settings: [***TBD***]

I) I/O and Network Connection: The UUT must have at least one port connected to an Ethernet network switch capable of the UUT's highest and lowest network speeds. The network connection must be live during all tests, and although the link must be ready and able to transmit packets, no specific traffic is required over the connection during testing. The UUT shall be set up with minimal I/O add-in cards; for testing, ensure the server offers at least one Ethernet port (using a single add-in card only if no onboard Ethernet support is offered).

1) Ethernet Connections: Products shipped with support for Energy Efficient Ethernet (compliant with IEEE 802.3az) shall be connected only to Energy Efficient Ethernet compliant network equipment during testing and appropriate measures shall be taken to enable EEE features on both ends of the network link during all tests.

5.3 *UUT PREPARATION*

The Partner must test and report power and efficiency test results for a computer server under the following conditions:

1) Record the UUT manufacturer, model name, and configuration details, including: operating system name and version, processor type and speed, installed power supplies, physical memory, hard drive configuration, installed I/O devices, power management features enabled, etc. Record nameplate power ratings.

a) When testing a blade server, also record the blade chassis model.

2) Install the UUT in a test rack or location. The UUT shall not be physically moved until testing is complete. If the UUT is a blade system, populate the chassis as follows:

a) All blade servers installed in the chassis must be identical.

Deleted: Partners must include details about OS and power management settings used for ENERGY STAR qualification in all program literature.

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Deleted: Note: A blade chassis section has been added above to host guidelines on chassis settings, setup, and features engaged during blade testing in order to ensure uniform testing of blade servers.¶

A system settings provision has been included to host any limited BIOS or hardware optimizations allowable during testing. With the expanded role of software evaluation in Version 2.0, these conditions will establish a consistent testing basis and prevent unrealistic settings from being engaged simply to improve workload performance ("super-tuning"). EPA plans to work with stakeholders to identify a limited list of hardware optimizations allowed for ENERGY STAR testing.¶

Deleted: Note: This condition has been added to allow the efficiency benefits of hardware compliant with the Energy Efficient Ethernet standard to impact the energy-performance of the tested server.¶

Deleted: Note: This section details UUT preparation for active mode efficiency testing of all server types. Included are special considerations for testing of a partially-populated blade chassis for active mode efficiency and testing of a single blade to allow for blade chassis power calculation. ¶

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b) When testing a single blade, install it in the chassis location that is recommended in the manufacturer's documentation for optimal thermal performance. If manufacturer documented recommendations either do not exist or are not available, install the blade in a top corner position in the chassis.

c) When testing a partially-populated blade system, populate 1/2 of available chassis bays, rounding up to the nearest whole power domain if necessary. Populate bays using the following guidelines:

i. According to the blade chassis manufacturer recommendations, with all blades in the same power domain.

ii. If manufacturer documented recommendations either do not exist or are not available: Fill the top row of the chassis first, then proceeding downward. For partially-populated rows, fill from the center outward. For example, when installing six blades in a chassis with 3 rows and 4 bays per row, four blades must be installed into the top row, and two blades must be installed into the center two positions of the middle row.

d) Fill all empty bays with blanking panels or an equivalent airflow restriction for the duration of testing.

Note: The section above covers testing of a half-filled blade chassis, EPA welcomes stakeholders to additionally test and submit data for a fully-populated chassis, as long as half-chassis data is also acquired and forwarded to EPA.

3) Connect the UUT to a live Ethernet (IEEE 802.3) network switch. The live connection must be maintained for the duration of testing, except for brief lapses necessary for transitioning between link speeds. If a controller system is required to provide workload harness control, data acquisition, or other UUT testing support, the controller system shall be connected to the same network switch as the UUT and satisfy all other UUT network requirements.

4) Connect the power analyzers to an ac or dc voltage source set to the appropriate voltage and frequency for the test.

5) Plug the UUT into the measurement power outlet on the power analyzer, as follows:

a) no UPS units shall be connected between the power analyzer and the UUT;

b) the power analyzer shall remain connected until all testing is complete;

c) when testing a single blade server, the UUT shall be metered independently of the blade chassis;

d) when testing a Blade System, power shall be measured at the input of the blade chassis (i.e., at the power supplies that convert data center distribution power to chassis distribution power).

6) If a controller system is being used, connect the data output interface of the power analyzer(s) to the appropriate input of the controller system..

7) Install the workload software on the UUT. Record the installed workload and configuration, including any custom parameters or settings.

8) Record the input voltage and frequency.

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Deleted: measurement server. When testing a single blade, this step is optional if the workload for Idle and full load testing does not require use of a controller system.

Deleted: benchmark

9) Verify that the UUT is configured in its as–shipped configuration.

10) Verify that only those system and hard drive power management features that are enabled upon shipment to a customer are enabled for testing.

6 TEST PROCEDURE

6.1 *POWER AND EFFICIENCY TESTING*

1. Power up the UUT, either by switching it on or connecting it to mains power.
2. If necessary, power up the controller system.
3. Begin recording elapsed time.
4. Between 5 and 15 minutes after the initial boot or log in, set the analyzer to begin accumulating power values at an interval of greater than or equal to 1 reading per second.
   a. When testing using a controller system, the controller system may automate data accumulation and benchmark workload operation provided the measurement interval requirements are met.
5. Engage workload operation.
   a. If the workload does not automate measurement of Idle power, between 5 and 15 minutes after the workload has completed operation, accumulate Idle power values for 5 additional minutes. The UUT must maintain an Idle state throughout this period and must not enter lower power states with limited availability (e.g., server sleep or hibernate states).
6. Record the following data at the end of workload operation:
   a. Average Idle power (arithmetic mean) during either the automated Idle state period or 5 minute test period;
   b. Full power (the maximum power value measured during workload operation).
7. When testing a Blade System, proceed as follows to derive single blade power:
   a. Remove a single blade from the chassis;
   b. Repeat steps 3-6.

7 REPORTING

7.1 *BLADE CHASSIS*

1. Report the following details:
   a. Fan speed control features;
   b. Available chassis cooling options;
   c. Chassis reporting capability (e.g., input power, inlet air temperature or other thermal information, utilization, etc.)

7.2 *LOW POWER MODES*

1. Conduct the following steps for each low power mode available on the system:
   a. Begin recording elapsed time.

Deleted: and commence benchmark workload operation

Deleted: and record the average (arithmetic mean) value observed during that 5 minute period.

Deleted:);

Deleted: benchmark

Deleted:);

Deleted: <#>Intermediate and final workload results at all tested load levels, as applicable.¶ ***<#>CHASSIS POWER TESTING***¶ Complete

Deleted: of

Deleted: representative

Deleted: tested in the selected

Deleted: . Average Idle power is defined as $P_{Single\ Blade(Idle)}$, and full power is defined as P_{Single}

Deleted: *(FULLP)*.

Deleted: <#>Complete testing of the selected blade chassis partially-populated with blades of the same model. ¶ <#>Record measured Idle power ($P_{Chassis(Idle,\ 1/2\ populated)}$) and full power ($P_{Chassis(FullP,\ 1/2\ populated)}$) at the chassis power input.¶ Calculate Chassis Power using

Deleted: formulas

b. Direct the UUT to enter the low power mode to be investigated.

c. After the UUT has reached the low power mode, set the analyzer to begin accumulating power values at an interval of greater than or equal to 1 reading per second.

d. Accumulate power values for the low power mode for 5 minutes and record the average (arithmetic mean) value observed during that 5 minute period. The UUT must maintain the low power mode Idle state throughout this period and must not enter lower power states.

2. Record the following data at the end of each low power mode evaluation:

a. Average power in the low power mode (arithmetic mean);the following details for each low power mode available on the system:

b. Rated or measured latency of the UUT in returning to a ready state from the low power mode.