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ENERGY STAR® Program Requirements
for Data Center Storage

Draft 1 Version 1.0
Partner Commitments

The following are the terms of the ENERGY STAR Partnership Agreement as it pertains to the manufacturing of ENERGY STAR qualified data center storage products (herein: ‘storage product’ or ‘storage’). The ENERGY STAR Partner must adhere to the following program requirements:

• comply with current ENERGY STAR Eligibility Criteria, defining the performance criteria that must be met for the marketing and sale of ENERGY STAR qualified storage products and specifying the testing criteria for storage products. EPA may, at its discretion, conduct tests on products that are referred to as ENERGY STAR qualified. These products may be obtained on the open market, or voluntarily supplied by Partner at EPA’s request;

• comply with current ENERGY STAR Identity Guidelines, describing how the ENERGY STAR marks and name may be used. Partner is responsible for adhering to these guidelines and for ensuring that its authorized representatives, such as advertising agencies, dealers, and distributors, are also in compliance;

• qualify at least one ENERGY STAR storage product within one year of activating the storage product portion of the agreement. When Partner qualifies a product, it must meet the specification in effect at that time;

Note: EPA will consider all Partners to be provisional until they have qualified a product under this specification. Once Partner has qualified a storage product, their organization will be listed on the ENERGY STAR Web site and will be given access to the ENERGY STAR certification and partner logos.

• provide clear and consistent identification of ENERGY STAR qualified storage products and storage product families. Partner must use the ENERGY STAR mark in all of the following ways:
  o the ENERGY STAR mark shall be included on the product specification sheet on the Partner’s Web site where product information is displayed. This mark shall serve as a hyperlink from the manufacturer’s specification sheet to the ENERGY STAR Power and Performance Data Sheet for the qualified storage product or storage product family;
  o the ENERGY STAR mark shall appear on the ENERGY STAR Power and Performance Data Sheet; and
  o the ENERGY STAR mark shall be used to identify qualified storage products and storage product families in electronic and printed marketing collateral materials, including but not limited to user manuals, product guides, and marketing brochures.
Note: The concept of “product family” is included in this first draft as a basis for discussion. The product family concept is included in the Version 1.0 ENERGY STAR computer server specification and implementation details are still under revision. The family concept may be well suited to the data center storage product category due to the high degree of customization and configurability of storage products. Stakeholders are encouraged to submit feedback on the suitability of the product family concept for storage, specifically with regard to the needs of their own sales channels.

- work with Value Added Resellers (VARs) of Partner’s products to ensure that storage products remain in compliance with ENERGY STAR requirements. Any party within the distribution channel of an ENERGY STAR qualified storage product that alters the power profile of a product after its date of manufacture through hardware or software modifications must ensure that the product continues to meet the ENERGY STAR requirements through delivery to the end customer. If the product ceases to meet the requirements, it may not be marketed or sold as ENERGY STAR qualified;
- if a VAR makes any modifications to a product qualified to this specification, re-brands the product, and promotes it as ENERGY STAR, the VAR must become an ENERGY STAR Partner and follow the requirements outlined in this specification;
- provide to EPA, on an annual basis, an updated list of ENERGY STAR qualifying storage products. Once the Partner submits its first list of ENERGY STAR qualified storage products, the Partner will be listed as an ENERGY STAR Partner. Partner must provide annual updates in order to remain on the list of participating product manufacturers;

Note: Effective March 30, 2010, products may no longer be labeled by manufacturers (including product packaging, product literature, Web sites, etc.) until qualifying product information, including a lab report, is submitted to and approved by EPA.

- provide to EPA, on an annual basis, unit shipment data or other market indicators to assist in determining the market penetration of ENERGY STAR. Specifically, Partner must submit the total number of ENERGY STAR qualified storage products shipped (in units by model) or an equivalent measurement as agreed to in advance by EPA and Partner. Partner is also encouraged to provide ENERGY STAR qualified unit shipment data segmented by meaningful product characteristics (e.g., capacity, size, or other as relevant), total unit shipments for each model in its product line, and percentage of total unit shipments that qualify as ENERGY STAR. The data for each calendar year should be submitted to EPA, preferably in electronic format, no later than the following March and may be provided directly from the Partner or through a third party. The 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;
- notify EPA of a change in the designated responsible party or contacts for storage products within 30 days.

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:

- consider energy efficiency improvements in company facilities and pursue the ENERGY STAR mark for buildings;
• purchase ENERGY STAR qualified 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 qualified product information to employees for use when purchasing products for their homes;

• ensure the power management feature is enabled on all ENERGY STAR qualified 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 qualified product models;

• feature the ENERGY STAR mark(s) on Partner Web site and in other promotional materials. If information concerning ENERGY STAR is provided on the Partner Web site as specified by the ENERGY STAR Web Linking Policy (this document can be found in the Partner Resources section on the ENERGY STAR Web site at www.energystar.gov), EPA may provide links where appropriate to the Partner Web site. The Partner shall comply with the ENERGY STAR Web Linking Policy;

• 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, communicate, and/or promote Partner’s activities, provide an EPA representative, or include news about the event in the ENERGY STAR newsletter, on the ENERGY STAR Web pages, etc. The plan may be as simple as providing a list of planned activities or planned milestones that Partner would like EPA to be aware of. For example, activities may include: (1) increase the availability of ENERGY STAR labeled products by converting the entire product line within two years to meet ENERGY STAR guidelines; (2) demonstrate the economic and environmental benefits of energy efficiency through special in-store displays twice a year; (3) provide information to users (via the Web site and user’s manual) about energy-saving features and operating characteristics of ENERGY STAR qualified products, and (4) build awareness of the ENERGY STAR partnership and brand identity by collaborating with EPA on one print advertorial and one live press event;

• provide quarterly, written updates to EPA as to the efforts undertaken by Partner to increase availability of ENERGY STAR qualified products, and to promote awareness of ENERGY STAR and its message;

• join EPA’s SmartWay Transport Partnership to improve the environmental performance of the company’s shipping operations. SmartWay Transport 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 Climate Leaders Partnership to inventory and reduce greenhouse gas emissions. Through participation companies create a credible record of their accomplishments and receive EPA recognition as corporate environmental leaders. For more information on Climate Leaders, visit www.epa.gov/climateleaders;

• 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, visit www.epa.gov/grnpower.
Below is the Version 1.0 product specification for ENERGY STAR qualified data center storage products. A product must meet all of the identified criteria if it is to earn the ENERGY STAR.

Note: EPA has been actively engaged with a wide variety of stakeholders during development of this first draft data center storage specification. Many parties have submitted comments and feedback on behalf of their individual organizations and as part of larger industry groups such as the Storage Networking Industry Association (SNIA) and The Green Grid. In many cases, the sum of individual contributor submissions and broad industry organization perspective has been more valuable than the individual parts. There are numerous references to the contributions of industry organizations throughout this draft specification – this is intended both to properly attribute the content to those who worked hard to develop a consolidated industry perspective, and to encourage further dialog about the content as part of a vendor- and organization-agnostic voluntary energy efficiency program.

This draft specification builds off of the Specification Framework that was distributed for industry review in late 2009. EPA reviewed substantial written feedback from stakeholders on the framework document, and has since conducted a series individual and group meetings to further develop the ENERGY STAR perspective on storage energy efficiency. EPA is grateful for the efforts of all contributors to this effort to date, and continues to welcome feedback from all interested stakeholders on this and future draft versions of the specification.

1. Definitions

Note: Many of the definitions in this document have been aligned with definitions in the Fall 2009 edition of the SNIA Dictionary. Notes have been added to this document to describe any substantive deviations from that document.

A. Storage Product: A fully-functional storage system that supplies data storage services to clients and devices attached directly or through a network. Components and subsystems that are an integral part of the storage product architecture (e.g., to provide internal communications between controllers and disks) are considered to be part of the storage product. In contrast, components that are normally associated with a storage environment at the data center level (e.g., devices required for operation of an external SAN) are not considered to be part of the storage product. A storage product composed of integrated storage controllers, storage media, embedded network elements, software, and other devices. For purposes of this specification, a storage product is a unique configuration of one or more SKUs prepared for sale to an end user.

Note: A concise and unambiguous definition for “Storage Product” is critical to the success of this program. It is the storage product that will ultimately be subject to ENERGY STAR qualification. Subsystems and components of storage products will not be eligible for qualification. This definition is a work in progress – included in Draft 1 is a composite of best efforts by EPA and other industry organizations to date.
At the February 2 meeting, stakeholders suggested that the storage product definition and storage taxonomy may need to be broad enough to apply to products such as: hybrid storage solutions that include servers and database engines in addition to disk storage; hybrid storage solutions with combinations of SSD and HDD, HDD and tape or optical storage, etc.; scale-out systems and subsystems; and bare-bones JBOD (“just a bunch of disks”) products that consist only of a drawer and a collection of HDDs. EPA welcomes additional feedback on the types of products that should be eligible to carry the ENERGY STAR label, especially with regard to the way products or SKUs are marketed and sold to end-users.

1) **Storage Element**: Any device designed and built primarily for the purpose of persistent data storage and delivery. This definition specifically encompasses disk drives, tape drives, RAID array subsystems, robotic tape libraries, filers, and file servers.

2) **Storage Device**: A collective term for disks, tape devices, disk array subsystems, and any other mechanisms capable of non-volatile data storage. This definition specifically excludes aggregating storage elements such as RAID array subsystems, robotic tape libraries, filers, and file servers.

   i) **Storage Media**: The material in a storage device on which data is recorded. Storage media includes solid state, magnetic (e.g., hard disk, tape), and optical media.

**Note:** Stakeholders have suggested that two terms are needed in this specification to differentiate between “aggregating” and “non-aggregating” storage product components. Per the SNIA Dictionary, the term “Storage Element” is proposed to encompass “aggregating” subsystems such as RAID subsystems, file servers, etc.; whereas “Storage Device” is used for stand-alone components. EPA continues to investigate the implications of this definition structure, and may delete one or more definitions if they are immaterial to this specification in order to reduce complexity. EPA welcomes continued stakeholder feedback on this topic.

3) **Storage Controller**: A device for handling storage requests that includes a processor or sequencer programmed to autonomously process a substantial portion of I/O requests directed to storage devices. RAID controllers and filers are examples of storage controllers.

**B. Storage System Connectivity:**

1) **Direct-attached Storage (DAS)**: One or more dedicated storage devices that are physically connected to one or more servers.

2) **Network Attached Storage (NAS)**: One or more dedicated storage devices that connect to a network and provide file access services to remote computer systems.

3) **Storage Area Network (SAN)**: A network whose primary purpose is the transfer of data between computer systems and storage elements and among storage elements. A SAN consists of a communication infrastructure, which provides physical connections, and a management layer, which organizes the connections, storage elements, and computer systems so that data transfer is secure and robust.

**C. Data Storage Efficiency**: [TBD]

**Note:** Storage system software is an important contributor to overall system energy efficiency. Reducing the number of disk drives in a system through the use of software features such as data deduplication, data compression, delta snapshots, thin provisioning and RAID 5/6 should be considered in any calculation of overall storage system energy efficiency. The Capacity Optimization Subgroup (COS) of the SNIA Green Storage Technical Work Group (TWG) is currently working to characterize the various software contributions to system efficiency with the goal of developing a single “data storage efficiency” metric. EPA supports the efforts of the SNIA COS and intends to evaluate future software metrics for inclusion in the ENERGY STAR Data Center Storage specification, either in the form of reporting requirements or qualification requirements.
D. **Storage Taxonomy**¹: A categorization scheme for use in segmenting the data center storage market by end-use application and key product characteristics. The major categories of the taxonomy that are referenced in this document are as follows:

**Note:** One objective of the ENERGY STAR specification development process is to define requirements that are consistent across several taxonomy categories, in order to simplify the specification for both vendors and end users. Further, the ongoing data collection process and subsequent stakeholder commentary may identify necessary deviations from the included draft definitions. The rationale for any such deviations will be documented and shared with the stakeholder community.

1) **Online Storage**: Storage products that are intended to service a mixture of Random and Sequential I/O requests with a short response time. All data stored in Online storage must be accessible in \( \leq 80 \text{ ms} \), unless the storage product is in a Deep Idle state. Online storage is typically comprised of one or more HDDs or SSDs and a storage controller, and provides primary data storage to supplement a Computer Server’s internal memory.

2) **Near-online Storage**: Storage products that are intended to service a mixture of Random and Sequential I/O requests with a short to moderate response time. Near-online storage products offer an asymmetrical response; a portion of data may be accessible in \( \leq 80 \text{ ms} \), while other data may be accessible in \( > 80 \text{ ms} \).

3) **Virtual Media Library**: Storage products that are intended to service primarily Sequential I/O, with a short response time. The media in a Virtual Media Library (e.g., HDD, optical disk) is not designed to be physically removed from the system. All data stored in the Virtual Media Library must be assessable in \( \leq 80 \text{ ms} \), unless the storage product is in a Deep Idle state. Virtual Media Libraries are intended primarily for moderate and long term data storage.

4) **Removable Media Library**: Storage products that are intended to service primarily Sequential I/O, with a moderate to long response time. The media (e.g., tape cartridge, optical disk) in a Removable Media Library is designed to be physically removed from the storage product. Removable Media Libraries are intended primarily for long term data archiving.

E. **Other Data Center Equipment**

1) **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 and other network devices). Computer servers are sold through enterprise channels for use in data centers and office/corporate environments. Computer servers are 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:

   i) is marketed and sold as a computer server;
   
   ii) is designed for and listed as supporting computer server operating systems (OS) and/or hypervisors, and is targeted to run user-installed enterprise applications;
   
   iii) provides support for error-correcting code (ECC) and/or buffered memory (including both buffered DIMMs and buffered on board (BOB) configurations);
   
   iv) is packaged and sold with one or more ac-ac or dc-dc power supplies; and
   
   v) 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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¹ The ENERGY STAR storage taxonomy is consistent with the taxonomy developed by the Storage Networking Industry Association Green Storage Initiative. Further detail may be found at [www.snia.org/green](http://www.snia.org/green).
2) **Network Equipment**: A device whose primary function is to provide data connectivity among an arbitrary combination of devices connected to its several ports. Data connectivity is achieved via the routing of data packets encapsulated according to Internet Protocol, Fibre Channel, InfiniBand or other standard protocol. Examples of network equipment commonly found in data centers are routers and switches.

3) **Uninterruptible Power Supply (UPS)**: A device that is intended to supply limited-duration, emergency electrical power to connected IT equipment in the event of a power grid failure.

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**Note**: EPA recently commenced development of an ENERGY STAR UPS specification. The UPS definition will be updated in the future to align with the definitions used in the UPS program.

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4) **Power Distribution Unit (PDU)**: A single- or three-phase power strip designed for data center use. A PDU may include instrumentation for metering power input and output, switched outlets for control of individual receptacles, or other advanced features.

5) **Blade System**: A system comprised of a blade chassis and one or more removable blade servers, blade storage, or blade network equipment devices. Blade systems provide a scalable means for combining multiple blade server or storage devices in a single enclosure, and are designed to allow service technicians to easily add or replace (hot-swap) blades in the field.

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**Note**: EPA previously included definitions for Blade Server, Blade Storage, and Blade Chassis in the Specification Framework document. Per stakeholder suggestions, these definitions have been removed from this document and consolidated under the term Blade System in accordance with the SNIA dictionary. Due to small market share and lack of test data, EPA does not intend to include blade form-factor storage products under the scope of this initial Version 1.0 specification. As blade system definitions and requirements are developed under the ENERGY STAR Computer Servers program, they will be assessed for inclusion in future versions of this specification.

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F. **Capacity**: Capacity is reported in units of either binary bytes (1 MiB = 1,048,576 Byte) or decimal bytes (1 MB = 1,000,000 Byte).

1) **Assigned Capacity**: The amount of space on a system or data container which has been allotted to be written by an end user or application. (Note: For capacity-optimizing systems, an assigned capacity number represents a promise that that amount of space will be provided on demand; usable capacity is allocated as the container is written too. For fully-provisioned systems, usable capacity must be committed at the same time the container is allocated.)

2) **Effective Capacity**: The amount of data stored on a storage system, plus the amount of unused formatted capacity in the system.

3) **Formatted (Usable) Capacity**: The total amount of bytes available to be written after a system or device has been formatted for use (e.g., by an object store, file system or block services manager). Formatted capacity is less than or equal to raw capacity. It does not include areas set aside for system use, spares, RAID parity areas, checksum space, host- or file system-level remapping, "right sizing" of disks, disk labeling and so on. However, formatted capacity may include areas that are normally reserved – such as snapshot set-asides – if these areas may be configured for ordinary data storage.

4) **Free Space**: The amount of unused, formatted capacity as reported by the storage product.

5) **Raw (Addressable) Capacity**: The sum total amount of addressable capacity of the storage devices in a storage product. The raw capacity of a storage device is commonly understood to be the number of bytes available to be written via SCSI or equivalent protocol. It does not include unaddressable space, ECC (error correcting code) data, remap areas, inter-sector gaps, etc.
G. Operational States:

1) **Active State**: The state in which a storage product is processing external I/O requests.

**Note**: The SNIA Dictionary defines Active State as, “An operational state in which a Storage Product can consistently maintain a level of service implied by its taxonomy rating. This generally means that most or all of its storage elements are fully-powered and active, and that background data cleansing and other operations are as active as I/O load allows.” EPA is proposing a simplified definition for purposes of this specification, and welcomes stakeholder comment on the suitability of the proposed definition.

2) **Idle State**: An operational state in which the Storage Product is capable of completing I/O transactions, but no active I/Os are requested or pending. The system may, however, be servicing self-initiated I/Os from background data protection and cleansing, and other operations.

   i) **Ready Idle**: The state in which a storage product is able to respond to I/O requests within the MaxTTD limits for its taxonomy category, but is not receiving external I/O requests. The storage product may perform routine housekeeping tasks during Ready Idle, provided such operations do not compromise the product’s ability to meet MaxTTD requirements.

   ii) **Deep Idle**: A state in which one or more storage product components or subsystems have been placed into a low-power state for purpose of conserving energy. A storage product in Deep Idle may not be able to respond to I/O requests within the MaxTTD limits for its taxonomy category, and may need to perform a managed ‘wake-up’ function in order to return to a Ready Idle or Active state. Deep Idle capability must be a user-selected, optional feature of the Storage Product.

**Note**: A definition for “Hardware Idle” has been proposed by stakeholders as an addition to this specification. This definition is not included at this time, since EPA intends to focus on energy efficiency of systems in use, and true “hardware idle” states are believed to be uncommon for in-use storage products. The definition may be reinserted into subsequent drafts if references to a “hardware idle” state are included in the specification.

H. **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 storage product. A storage PSU must be self-contained and physically separable from the system and must connect to the system via a removable or hard-wired electrical connection. Storage PSUs may be Field Replaceable Units (FRUs), but in some cases may be further integrated with the storage product.

**Note**: Stakeholders have asked for clarification as to whether storage PSUs must by definition be Field Replaceable Units (FRUs). EPA has added a statement about FRUs to the above definition with the intention of differentiating storage PSUs from embedded voltage regulators. However, EPA wants to ensure that integrated PSUs are included in testing if they are the primary power supply for a particular storage product. EPA seeks feedback on whether the proposed language successfully supports this intent.

1) **Ac-dc Power Supply**: A PSU that converts line-voltage ac input power into one or more dc power outputs.

2) **Dc-dc Power Supply**: A PSU that converts line-voltage dc input power to one or more dc power outputs. For purposes of this specification, a dc-dc converter (also known as a voltage regulator) that is internal to a storage product and is used to convert a low voltage dc (e.g., 12 V dc) into other dc power outputs for use by storage product components is not considered a dc-dc power supply.
3) **Single-output Power Supply**: A PSU that is designed to deliver the majority of its rated output power to one primary dc output. 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 all additional PSU outputs that are not primary and standby outputs shall be less 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.

4) **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 storage product. 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 all additional PSU outputs that are not primary and standby outputs must be greater than or equal to 20 watts.

5) **Redundant Power Supplies**: Two or more PSUs that are configured to maintain uninterrupted output load in the event of failure of one PSU.

### I. Product Family: [TBD]

**Table 1: Product Family Requirements**

<table>
<thead>
<tr>
<th>Base Component</th>
<th>Same Part Number Required?</th>
<th>Same Technical Specifications Required?</th>
<th>Same Quantity Required?</th>
<th>Notes</th>
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1) **Maximum Configuration**: A product configuration that includes the combination of base components that generates the maximum possible power consumption within a product family. [TBD]

2) **Minimum Configuration**: A product configuration that includes the combination of base components that generates the least possible power consumption within a product family. [TBD]

3) **Typical Configuration**: A product configuration that lies between the minimum and maximum configurations and is representative of a product with high volume sales. [TBD]

4) **Base Configuration**: A product configuration that does not qualify for additional power allowances. The base configuration is [TBD].

**Note**: A placeholder “Product Family” definition is included in this draft – this structure is analogous to that from the ENERGY STAR Computer Servers program. EPA may or may not choose to define product families once the initial data collection process and data analysis is complete. These definitions will be developed or deleted, accordingly.

### J. Other Definitions:

1) **Field-replaceable Unit (FRU)**: A system component that is designed to be replaced by customers or service personnel in the field, without requiring that the system be returned to a factory or other site for repair.

2) **High-availability (HA)**: The ability of a system to perform its function continuously (without interruption) for a significantly longer period of time than the reliabilities of its individual components would suggest. High availability is most often achieved through failure tolerance.
3) **Maximum Sustainable Performance**: Maximum I/O per second (IOPS) or GiB/s that the UUT is able to deliver under a specified workload. For purposes of this specification, it is suggested that "sustainable" performance is that which ensures the maximum achievable data rate, excludes any transient system caching effects, and can be maintained to within ±5% for the duration of the measurement phase.

4) **Maximum Time to Data (MaxTTD)**: The maximum time before an entire data object is accessible within the constraints imposed by its storage media. For random-access media, a data object is accessible when any byte may be accessed. For sequential-access media, a data object is accessible when the requested object has begun streaming from a previously inactive drive.

5) **RAS Features**: An acronym for reliability, availability, and serviceability features. RAS is sometimes also expanded to RASM, which adds “Manageability” criteria. The three primary components of RAS as related to storage products are defined as follows:
   i) **Reliability Features**: Features supporting a storage product’s ability to perform its intended function without interruption due to component failures. Technologies applied to increase reliability include: component selection (MTBF), redundancy (both at a micro and macro levels), temperature and/or voltage de-rating, error detection and correction technologies.
   ii) **Availability Features**: Features that support a storage product’s ability to maximize normal operating time and minimize planned and unplanned down time.
   iii) **Serviceability Features**: Features that support a storage product’s ability to be serviced (e.g., hot-plugging).
   iv) **Non-disruptive Serviceability**: Support for continued availability of data and response times during all FRU and service operations; including break/fix, code patches, software/firmware upgrades, configuration changes, data migrations, and system expansion.

6) **Read/Write**:
   i) **Random Read**: Any I/O load in which consecutively issued read requests do not specify adjacently addressed data. The term random I/O is commonly used to denote any I/O load that is not sequential, whether or not the distribution of data locations is indeed random.
   ii) **Random Write**: Any I/O load whose consecutively issued write requests do not specify adjacently addressed data. The term random I/O is commonly used to denote any I/O load that is not sequential, whether or not the distribution of data locations is indeed random.
   iii) **Sequential Read**: An I/O load consisting of consecutively issued read requests to adjacently addressed data.
   iv) **Sequential Write**: An I/O load consisting of consecutively issued write requests to adjacently addressed data.

7) **Response Time**: The time required for the UUT to complete an I/O request.

8) **Single Point of Failure (SPOF)**: One component or path in a system, the failure of which would make the system inoperable.

9) **Unit Under Test (UUT)**: The Storage Product being tested.

**Note**: Definitions for “I/O Adapter” and “I/O Port” that were included in the specification framework have been removed from this draft since there are no direct references are included in this document. Several other terms have been suggested for inclusion but have not yet been added to this draft for the same reasons. These terms include: “Storage Protection,” “Small Computer System Interface (SCSI),” “Count Key Data (CKD),” and “Fixed Block Architecture (FBA).” Should reference definitions of these terms be needed later in the specification development cycle, they will be added to this section of the document.
2. Qualifying Products

2.1. Included Products

To be eligible for ENERGY STAR qualification under this specification, a product must:

1) meet the definition of a storage product provided in Section 1 of this document;
2) not fall within the exceptions identified in Section 2.2 of this document;
3) be able to be tested to the provisions specified in Appendix A of this document;
4) be comprised of one or more SKUs and be able to be purchased in a single order from a system vendor;
5) be characterized within one of the following storage taxonomy categories:
   i) Online;
   ii) Near-online;
   iii) Virtual Media Library; or
   iv) Removable Media Library.

Note: EPA is aware of several types of “hybrid” storage systems that do not fit well with the established taxonomy, and has received test data for at least one such system. These systems may, for example, combine attributes of a removable media library with attributes of an online storage system to meet the needs of a specific application. Hybrid systems may also include highly capable, server-like storage controllers with, for example, the ability to natively host third-party applications. EPA continues to investigate the best means of categorizing and evaluating these types of devices to ensure that products are treated fairly within the ENERGY STAR program, and welcomes further test data, product examples and application details, and stakeholder comments on these topics.

Note: In the October 2009 test procedure workshop, stakeholders inquired about the risks of qualifying products that use components or subsystems from 3rd-party vendors. EPA believes that by specifying test procedures and requirements at the system level, Partners will have the most flexibility to source components and subsystems that will allow their products to earn the ENERGY STAR. The primary exception to this system-level efficiency approach is for power supplies. However, the practice of requiring high-efficiency PSUs is a cornerstone of the ENERGY STAR Computers and Servers programs, and represents a simple and effective path to improved efficiency across a product’s full range of operation.

2.2. Excluded Products

Products that are covered under other ENERGY STAR product specifications are not eligible for qualification under the ENERGY STAR Data Center Storage specification. The full list of specifications currently in effect can be found at www.energystar.gov/products. Also excluded from qualification under this specification are products which are being considered for future ENERGY STAR programs.

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

1) Personal / Portable Data Storage Products
2) Computer Servers
3) Computers (Laptop, Desktop, Small Workstation, Thin-client, Game Console)
4) Data Center Network Equipment
3. Energy Efficiency Criteria

Products must meet all of the requirements specified below to be eligible for ENERGY STAR qualification under this specification.

3.1. PSU Efficiency Criteria

To qualify for ENERGY STAR, a storage product must be configured with PSUs that meet or exceed the applicable efficiency requirements specified in Table 2.

<table>
<thead>
<tr>
<th>PSU Type</th>
<th>Rated Output Power</th>
<th>10% Load</th>
<th>20% Load</th>
<th>50% Load</th>
<th>100% Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>TBD</td>
<td>TBD</td>
<td>TBD</td>
<td>TBD</td>
<td>TBD</td>
<td>TBD</td>
</tr>
</tbody>
</table>

Note: Because storage PSUs are often installed in redundant configurations, EPA intends to focus its efforts on encouraging (1) the use of PSUs that are most efficient at low loads (<40%) for use in redundant active/active configurations, (2) right-sizing of PSUs to application requirements, and (3) novel approaches to redundant PSU installations to allow for greater overall system efficiencies.

The ENERGY STAR Computer Server specification establishes efficiency and power factor requirements at 10%, 20%, 50%, and 100% load points. Stakeholders are encouraged to provide feedback regarding the usefulness of these load points as a basis for evaluation of storage PSUs, and suggestions for other ways to reward efficient PSU subsystem architectures.

Further, the EPA’s initial approach is to require that all storage product PSUs, including those used to power both spinning disks and controllers, meet ENERGY STAR qualification criteria. It may be necessary to define unique efficiency requirements for the various types of PSUs used in storage products, especially given the long lifetimes of some storage products (and corresponding long refresh cycles for PSUs) – further stakeholder feedback on this proposal is welcome. EPA also continues to track the efforts of Climate Savers Computing Initiative and 80 PLUS® to develop unique testing and efficiency criteria for storage PSUs, and intends harmonize requirements with these programs, after industry review and comment, as appropriate.

3.2. PSU Power Factor Criteria

To qualify for ENERGY STAR, a storage product must be configured with PSUs that meet or exceed the applicable power factor requirements specified in Table 3, under all loading conditions for which output power is greater than or equal to [TBD] watts. Partners are required to measure and report PSU power factor under loading conditions of less than [TBD] watts, though no minimum power factor requirements are applicable.

<table>
<thead>
<tr>
<th>PSU Type</th>
<th>Rated Output Power</th>
<th>10% Load</th>
<th>20% Load</th>
<th>50% Load</th>
<th>100% Load</th>
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</tr>
</tbody>
</table>

Note: EPA will not be implementing Net Power Loss (NPL) requirements in the Version 1.0 specification. During the computer server specification development process, stakeholders expressed broad concern with the approach, both in terms of testing burden and familiarity with the NPL concept in both manufacturer and end user communities. EPA continues to believe that power supply requirements should show the impact of power supply sizing and sourcing practices, and intends to address this in future versions of the specification. EPA also urges further research or pilot programs on NPL to evaluate benefits of the metric to end users.
3.3. Active State Efficiency Criteria

To qualify for ENERGY STAR, a storage product must [TBD].

Note: Active state efficiency requirements will be developed in more detail in subsequent draft specifications, following the completion of the first round of data collection and analysis. One goal of the ENERGY STAR program is to develop a simple, easy-to-understand energy performance metric for data center storage products. To that end, the ongoing data collection process will ideally result in one or more metrics (such as GB/Watt or IOPS/Watt) that is applicable across all storage products within a taxonomy category.

3.4. Idle State Efficiency Criteria

To qualify for ENERGY STAR, a storage product must [TBD].

Note: EPA understands that true idle conditions occur only infrequently in most data center storage applications. A placeholder for idle state requirements is included in this draft specification pending the results of data analysis. One important focus of the EPA data analysis is to assess whether idle state energy efficiency can be a suitable proxy for active state energy efficiency.

3.5. Power Management Requirements

1) Power Management Function: To qualify for ENERGY STAR, a storage product must offer the following power management features: [TBD]

2) Power Management Disclosure: To qualify for ENERGY STAR, all power management features offered by the storage product must be itemized on the Power and Performance Data Sheet, along with an indication of which features are enabled by default.

3.6. Additional Requirements

Note: EPA proposed including Energy Efficient Ethernet (EEE) per IEEE 802.3az as a requirement for all physical layer Ethernet protocols in an early draft of the Version 2.0 servers specification. Although this requirement was removed in subsequent drafts due to a lack of compatible hardware, EPA remains interested in future requirements for EEE in all IT-related specifications, including storage. Stakeholders are asked to comment on the availability and applicability of EEE or other energy-efficient communication protocols (e.g., Fibre Channel) for data center storage.

4. Standard Information Reporting Requirements

4.1. Power and Performance Data Sheet (PPDS)

A PPDS must be published for each ENERGY STAR qualified storage product. The PPDS must be posted on the Partner’s Web site alongside information on qualified products.

Note: An example PPDS for the ENERGY STAR Computer Servers program is available on the ENERGY STAR Product Development Web page at www.energystar.gov/NewSpecs under the link for Data Center Storage. Stakeholders are encouraged to review the example data sheet and send comments regarding data fields that should be included in a PPDS for data center storage products. EPA plans to distribute a first draft of the storage PPDS for stakeholder review along with the next draft of the data center storage product specification in the coming months.
Partners are encouraged to provide one data sheet for each ENERGY STAR qualified storage product, though EPA will also accept a data sheet for each qualified storage product family. A product family PPDS must include data for Maximum, Minimum and Typical configurations as defined in Section 1 of this document. Whenever possible, Partners must also provide a hyperlink to a more detailed power calculator on their Web site that purchasers can use to understand power and performance data for specific products within the product family.

Templates for the Power and Performance Data Sheet can be found on the ENERGY STAR Web site at [future]. EPA may periodically revise the template, and will notify Partners of the revision process. If using the ENERGY STAR PPDS, Partners should always use the most recent version posted on the ENERGY STAR Web site.

Partners are encouraged to use the PPDS template provided by EPA, but may also create their own template provided that it is approved by EPA and contains the following information, at a minimum:

1) product model name, model number, and SKU or other configuration identification number;
2) a list of important product characteristics; including [TBD]
3) a list of qualified system configurations, including maximum, minimum and typical configurations of qualified product families;
4) power consumption and performance data, along with guaranteed accuracy levels for all power and temperature measurements, disclosure of the time period used for data averaging, and a hyperlink to a detailed power calculator, as available;
5) additional power and performance data for at least one benchmark as chosen by the Partner;

Note: The requirement to report additional benchmarks is taken from the ENERGY STAR Computer Servers program and may not be applicable to the storage product category, since there are not as wide a variety of storage benchmarks available for vendors to choose from. EPA would like additional feedback from stakeholders regarding the suitability of this requirement.

6) a list of power management and other power saving features available and enabled by default;
7) information on product power measurement and reporting capabilities;
8) a list of selected data from the ASHRAE Thermal Report; and
9) for product families, a list of qualified storage products within the family.

5. Standard Performance Data Measurement and Output Requirements

To qualify for ENERGY STAR, a storage product must report data on input power consumption (W), and inlet air temperature (°C). Data must be made available in a published or user-accessible format that is readable by third-party, non-proprietary management software over a standard network.

Note: The requirements in this section are similar to those in the Draft 1 Version 2.0 ENERGY STAR Computer Servers specification. For storage, EPA would like to assess the relative costs and benefits of power, temperature, and other data reporting at the rack, shelf, or component (PSU, disk) level. Stakeholders are encouraged to comment on examples of reporting strategies in use today, and provide examples of other data points that may help data center managers and other end users to make informed decisions to improve the energy performance of their storage systems.

1) Implementation: To qualify for ENERGY STAR:
i) a storage product must make energy performance data available to end users via either embedded components or add-in devices that are packaged with the storage product (e.g., a service processor, embedded power or thermal meter or other out-of-band technology); and

ii) when an open and universally available data collection and reporting standard becomes available, manufacturers shall incorporate the universal standard into their systems.

2) Measurement Accuracy: To qualify for ENERGY STAR:

i) input power measurements must be reported with accuracy of less than or equal to 5% of the actual value for measurements greater than 200 W, through the full range of operation. For measurements less than or equal to 200 W, the accuracy must be less than or equal to 10 W times the number of installed PSUs; and

Note: During the October 2009 test procedure workshop, stakeholders asked whether the “percent error” approach to power measurement should be applicable across the board, with no 10 W limit in place. EPA intends to assess this request prior to the next draft specification after reviewing recent storage PSU test data from SNIA & 80 PLUS.

ii) inlet air temperature measurements must be reported with an accuracy of less than or equal to 2 °C.

3) Sampling Requirements: To qualify for ENERGY STAR:

i) input power measurements must be collected at a rate of greater than or equal to one measurement per second. A rolling average, encompassing a period of no more than 30 seconds, must be reported at a frequency of greater than or equal to one per second; and

ii) inlet air temperature measurements must be collected and reported at a rate of greater than or equal to one measurement every 10 seconds.

6. Testing

Partners are required to test and self-certify those products or product families that meet the ENERGY STAR guidelines. A representative sample of storage products shall be tested to ensure that all units will meet ENERGY STAR criteria. Test results must be reported to the EPA, European Commission, or other international governing body using the Data Center Storage Qualifying Product Information (QPI) Form or Online Product Submittal (OPS) tool. The qualification submittal for each product must also include a completed Power and Performance Data Sheet. All testing shall be performed per the ENERGY STAR Data Center Storage Test Procedure that is included as [TBD]. All test results must meet the specified qualification criteria without the assistance of rounding.

Note: During the February 2 meeting, stakeholders inquired about how ENERGY STAR accounts for the energy use of 3rd-party components (e.g., a laptop computer included for storage system diagnostics) during qualification testing. In general, EPA intends for product qualification data to be representative of typical system performance in end-use environments; so a product that is delivered with a 3rd-party component would have to be tested with the component installed and operational. However, an exception to this rule may be granted if the 3rd-party component is (1) not essential to normal operation of the system, (2) used only infrequently, or (3) demonstrated to have a negligible impact on system energy consumption. In this case, EPA may allow for the component to be detached, disabled, or otherwise removed from consideration during qualification testing. EPA welcomes further stakeholder suggestions and rationale for 3rd-party storage system components that should be evaluated for exceptions.
7. Product Qualification

7.1. Storage Product Qualification Requirements

The party that ultimately sells an ENERGY STAR qualified storage product to an end-user is responsible for ensuring that the product meets all applicable ENERGY STAR qualification criteria. The following requirements apply to storage products that are sold to end-users through indirect, 3rd-party sales channels: [TBD]

Note: EPA plans to closely review the reporting and qualification framework for the indirect sales channel (e.g., Value Added Reseller (VAR), distributor) for inclusion in a future draft of this specification. Similar efforts are underway for the Version 2.0 server specification. EPA intends to develop indirect sales channel requirements for accurate marketing and distribution of qualified product offerings within the unique constraints and characteristics of the indirect sales channel.

7.2. Product Family Qualification Requirements

Note: This section is included in anticipation of the development of a “product family” designation for data center storage. Testing and qualification requirements for product families will be detailed in future draft versions of this specification. EPA welcomes stakeholder comments on the applicability of the product family structure from the ENERGY STAR Computer Servers specification to the storage product category.

Partners are encouraged to test and submit individual storage products for qualification to ENERGY STAR. However, several products may be submitted as a product family if all products within the family meet at least one of the following requirements:

1. Individual storage products are built on the same platform and are identical in every respect to the tested, representative storage product except for [TBD]; or

2. Individual products meet the requirements of a product family, as defined in Section 1 of this document. In this case, partners must test and submit power data on [TBD].

Partner must complete one Power and Performance Data Sheet per product family that is submitted for qualification. All storage products within a product family must meet ENERGY STAR requirements, including products for which data is not reported.

If a Partner wishes to qualify individual product configurations within a family that contains non-qualifying products, the Partner must assign a unique identifier to ENERGY STAR qualified storage products. This identifier must be used consistently in association with qualifying products in marketing collateral and on the ENERGY STAR Qualified Product List (e.g., model number A1234 for baseline product configurations and A1234-ES for ENERGY STAR qualifying product configurations).

8. Effective Date

The date that products must meet the requirements specified under the Version 1.0 ENERGY STAR Data Center Storage specification will be defined as the effective date of the agreement.

Qualifying and Marking Products under the Version 1.0 Specification: The effective date for this specification is [TBD]. All products with a date of manufacture on or after this effective date must meet applicable Version 1.0 requirements in order to qualify for ENERGY STAR. The date of manufacture is specific to each unit and is the date (e.g., month and year) on which a unit is considered to be completely assembled.
Note: EPA will likely distribute two or more drafts of the storage specification before publishing the final specification. Subsequent drafts will include revisions based on stakeholder comments on Draft 1, plus additional content to define energy efficiency requirements based on the results of ongoing data collection and analysis. Since data center storage is a new program, eligible storage products will be able to qualify for ENERGY STAR immediately upon finalization of this specification.

Grandfathering: When ENERGY STAR specifications are revised, EPA does not automatically grant continued qualification to products submitted under previous versions of the specification. Any product sold, marketed, or identified by the manufacturing Partner as ENERGY STAR must meet the specification in effect on the date of manufacture of the product.


EPA reserves the right to revise 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 industry discussions. To carry the ENERGY STAR mark, a product model must meet the ENERGY STAR program requirements that are in effect on the date of manufacture of the product.