ENERGY STAR® Program Requirements for Data Center Storage

Eligibility Criteria
Draft 4 Version 1.0

1 Following is the Draft 4 ENERGY STAR Version 1.0 product specification for Data Center Storage. A
2 product shall meet all of the identified criteria if it is to earn the ENERGY STAR.

3 **Note:** EPA has developed Draft 4 to use the Emerald™ Version 2.0 test specification. EPA is aware of
4 ongoing testing to verify the performance of some aspects of Emerald Version 2.0 and reserves the right
5 to revert to Emerald Version 1.0 based on its interpretation of the results of this testing. If reverting is
6 necessary, EPA will notify stakeholders of the decision prior to the publication of the Final Draft of
7 ENERGY STAR Version 1.0 for Data Center Storage.

8 1 DEFINITIONS

9   A. <u>Product Types</u>:

10   1) <u>Storage Product</u>: A fully-functional storage system that supplies data storage services to
11   clients and devices attached directly or through a network. Components and subsystems that
12   are an integral part of the storage product architecture (e.g., to provide internal
13   communications between controllers and disks) are considered to be part of the storage
14   product. In contrast, components that are normally associated with a storage environment at
15   the data center level (e.g., devices required for operation of an external SAN) are not
16   considered to be part of the storage product. A storage product may be composed of
17   integrated storage controllers, storage devices, embedded network elements, software, and
18   other devices. For purposes of this specification, a storage product is a unique configuration
19   of one or more SKUs, sold and marketed to the end user as a Storage Product.

20   2) <u>Storage Device</u>: A collective term for disk drives (HDDs), solid state drives (SSDs), tapes
21   cartridges, and any other mechanisms providing non-volatile data storage. This definition is
22   specifically intended to exclude aggregating storage elements such as RAID array
23   subsystems, robotic tape libraries, filers, and file servers. Also excluded are storage devices
24   which are not directly accessible by end-user application programs, and are instead
25   employed as a form of internal cache.

26   3) <u>Storage Controller</u>: A device for handling storage request via a processor or sequencer
27   programmed to autonomously process a substantial portion of I/O requests directed to
28   storage devices (e.g., RAID controllers, filers).

29   B. <u>Storage Product Connectivity</u>:

30   1) <u>Direct-attached Storage (DAS)</u>: One or more dedicated storage devices that are physically
31   connected to one or more servers.

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

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

39   C. Capacity Optimizing Methods (COMs): The reduction of actual data stored on storage devices
40   through a combination of hardware and / or software. Common COMs include:

41   1) Thin Provisioning: A technology that allocates the physical capacity of a volume or file system
42   as applications write data, rather than allocating all the physical capacity at the time of
43   provisioning.

44   **Note**: EPA has made a small revision to the thin provisioning definition based on stakeholder feedback
45   from Draft 3, changing the word "reallocating" to "allocating" to reflect actual system functionality. EPA
46   welcomes feedback on the change made to this definition.

47   2) Data Deduplication: The replacement of multiple copies of data – at variable levels of
48   granularity – with references to a shared copy in order to save storage space and/or
49   bandwidth.

50   3) Compression: The process of encoding data to reduce its size. For the purpose of this
51   specification, only lossless compression (i.e., compression using a technique that preserves
52   the entire content of the original data, and from which the original data can be reconstructed
53   exactly) is recognized.

54   4) Delta Snapshots: A type of point-in-time copy that preserves the state of data at an instant in
55   time by storing only those blocks that are different from an already existing full copy of the
56   data.

57   D. Storage Taxonomy[1]: A categorization scheme for use in segmenting the data center storage
58   market by end-use application and key product characteristics. The major categories of the
59   taxonomy that are referenced in this document are as follows:

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

65   2) Near-online Storage: Storage products that are intended to service a mixture of Random and
66   Sequential I/O requests with a short to moderate response time. Near-online storage
67   products offer an asymmetrical response; a portion of data may be accessible in ≤ 80
68   milliseconds, while other data may be accessible in > 80 milliseconds.

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

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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 as defined in "SNIA Emerald™ Power Efficiency
Measurement Specification" Version 2.0 rev 1 4 October, 2012. Further detail may be found at
www.snia.org/green.

4) <u>Removable Media Library</u>: 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.

5) <u>Adjunct Storage Products</u>: Products which closely support storage devices by adding in real time value or additional control capabilities not present in the storage device(s) itself. Examples include SAN based virtualization controllers, NAS gateways, or other storage services. A key feature of these products is that no end user data is primarily stored on Adjunct Storage products, though data may be held in cache or other working buffers.

6) <u>Interconnect Element</u>: Devices which provide for interconnection functionality within a storage area network. Examples include SAN Switches, etc.

E. <u>Other Data Center Equipment</u>:

1) <u>Computer Server</u>: 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-dc or dc-dc power supplies; and

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

Note: The revised Computer Server definition presented here is from the Final Draft Version 2.0 ENERGY STAR Computer Server specification.

2) <u>Network Equipment</u>: 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) <u>Power Distribution Unit (PDU)</u>: 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.

   i) <u>Intelligent Power Distribution Unit (iPDU)</u>: A PDU with additional functionality to provide operational measurements of power consumption and environmental temperature.

4) <u>Blade Storage</u>: A storage product that is designed for use in a blade chassis. A blade storage product is dependent upon shared blade chassis resources (e.g., power supplies, cooling) for operation.

5) <u>Cache</u>: Temporary storage used to transparently store transitory data and which is not directly addressable by end-user applications. Primarily used for expediting access to or from (typically) slower devices.

119 **Note**: EPA has replaced the term "media" with "devices" in the Cache definition to be consistent with
120 other definitions within this section that reference similar "devices".

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

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

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

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

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

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

143   G. Operational States:

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

145   2) Idle State: An operational state in which the storage product is capable of completing I/O
146   transactions, but no active I/Os are requested or pending. The system may, however, be
147   servicing self-initiated I/Os from background data protection and cleansing, and other
148   operations not initiated by the user.

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

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

160   H. Power Supply Unit (PSU): A device that converts ac or dc input power to one or more dc power
161   outputs for the purpose of powering a storage product. A storage PSU must be self-contained
162   and physically separable from the system and must connect to the system via a removable or
163   hard-wired electrical connection. Note: Storage PSUs may be Field Replaceable Units (FRUs),
164   but in some cases may be further integrated with the storage product.

165　　　　　1) <u>Ac-Dc Power Supply</u>: A PSU that converts line-voltage ac input power into one or more dc
166　　　　　　　power outputs.

167　　　　　2) <u>Dc-dc Power Supply</u>: A PSU that converts line-voltage dc input power to one or more dc
168　　　　　　　power outputs. For purposes of this specification, a dc-dc converter (also known as a voltage
169　　　　　　　regulator) that is internal to a storage product and is used to convert a low voltage dc (e.g., 12
170　　　　　　　V dc) into other dc power outputs for use by storage product components is not considered a
171　　　　　　　dc-dc power supply.

172　　　　　3) <u>Single-output Power Supply</u>: A PSU that is designed to deliver the majority of its rated output
173　　　　　　　power to one primary dc output. Single-output PSUs may offer one or more standby outputs
174　　　　　　　that remain active whenever connected to an input power source. For purposes of this
175　　　　　　　specification, the total rated power output from all additional PSU outputs that are not primary
176　　　　　　　and standby outputs shall be less than 20 watts. PSUs that offer multiple outputs at the same
177　　　　　　　voltage as the primary output are considered single-output PSUs unless those outputs (1) are
178　　　　　　　generated from separate converters or have separate output rectification stages, or (2) have
179　　　　　　　independent current limits.

180　　　　　4) <u>Multi-output Power Supply</u>: A PSU that is designed to deliver the majority of its rated output
181　　　　　　　power to more than one primary dc output for the purpose of powering a storage product.
182　　　　　　　Multi-output PSUs may offer one or more standby outputs that remain active whenever
183　　　　　　　connected to an input power source. For purposes of this specification, the total rated power
184　　　　　　　output from all additional PSU outputs that are not primary and standby outputs must be
185　　　　　　　greater than or equal to 20 watts.

186　　　　　5) <u>Redundant Power Supplies</u>: Two or more PSUs that are configured to maintain uninterrupted
187　　　　　　　output load in the event of failure of one PSU.

188　　I. <u>Product Family</u>: A group of models/configurations that share a set of common attributes that are
189　　　　variations on a basic design.

190　　　　　1) <u>Common Product Family Attributes</u>: A set of features common to all models/configurations
191　　　　　　　within a product family that constitute a common basic design. All models/configurations
192　　　　　　　within a product family must share the following:

193　　　　　　　i)　made by the same manufacturer;

194　　　　　　　ii)　be from the same model line or machine type;

195　　　　　　　iii)　utilize the same model of storage controller;

196　　　　　　　iv)　fall under the same taxonomy category; and

197　　　　　　　v)　contain equal or greater amount of cache than the corresponding qualified configuration.

198　　　　　2) <u>Optimal Configuration</u>: A product configuration that lies between the minimum and maximum
199　　　　　　　qualified configurations and is representative of a product with maximum sellable energy
200　　　　　　　efficiency performance (performance/watt) for a given workload. This configuration is
201　　　　　　　provided by the manufacturer and can be optimized for the following workload types:

202 **Note**: EPA has clarified that the maximum sellable energy efficiency performance in the Optimal
203 Configuration is measured in performance/watt. The specific unit for performance varies depending on the
204 type of Optimal Configuration (e.g. I/O per second, MB per second, and GB per second)

205　　　　　　　i)　Transaction: A workload optimized for random I/O usage measured in I/O per second per
206　　　　　　　　　watt;

207　　　　　　　ii)　Streaming: A workload optimized primarily for sequential I/O usage, measured in MB per
208　　　　　　　　　second per watt;

209　　　　　　　iii)　Capacity: A workload optimized for maximum storage as measured by GB per watt.

3) <u>Maximum Qualified Configuration (Default)</u>: A product configuration that includes the combination of base components that generates a system which is 5% larger in storage device count than the optimal configuration.

   i) For Online 3 and Online 4 systems, the number may be rounded up to the nearest drawer boundary.

   ii) Drawer rounding is not applicable to Online 2 systems.

4) <u>Minimum Qualified Configuration (Default)</u>: A product configuration that includes the combination of base components that generates a system which is 20% smaller in storage device count compared to the optimal configuration.

   i) For Online 3 and Online 4 systems, the number may be rounded down to the nearest drawer boundary.

   ii) Drawer rounding is not applicable to Online 2 systems.

Note: EPA has renamed the Maximum and Minimum Configurations to Maximum and Minimum Qualified Configurations, as stakeholder feedback suggested the previous names were unclear and could be mistaken as actual system maximum and minimum capability rather than the configurations that are chosen specifically for ENERGY STAR certification.

Drawer rounding in the maximum and minimum qualified configurations is applicable to Online 3 and Online 4 systems only. Stakeholder feedback stated that the previous 150 storage device limit in Draft 3 was too restrictive for some Online 3 systems.

The following is an example to illustrate this Product Family approach and related concepts:

Example: A manufacturer submits a transaction optimized system with an Optimal Configuration of 192 storage devices, 16 drawers containing 12 storage devices each. The calculated range of ENERGY STAR qualification for this system, without rounding, is 154 to 202 storage devices. The resulting size of the qualified product family after drawer rounding would be 144 to 204 storage devices, or 12 to 17 drawers containing 12 storage devices each.

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5) <u>Expanded Maximum Qualified Configuration (Optional)</u>: A manufacturer may submit additional physical data points using configurations which contain a number of Storage Devices higher than the required Maximum Qualified Configuration defined above if the expanded performing point is within 15% of the Optimal Configuration performance (performance/watt). The required Maximum Qualified Configuration point above can be replaced with this new higher count of storage devices.

   i) Performance will be measured using the appropriate relative weighting of workloads defined in Table 6.

   ii) Modeled data may not be used in Expanded Maximum Qualified Configuration submissions.

6) <u>Expanded Minimum Qualified Configuration (Optional)</u>: A manufacturer may submit additional physical data points using configurations which contain a number of Storage Devices less than the required Minimum Qualified Configuration defined above if the expanded performing point is within 15% of the Optimal Configuration performance (performance/watt). The required Minimum Qualified Configuration point above can be replaced with this new lower count of storage devices.

   i) Performance will be measured using the appropriate relative weighting of workloads defined in Table 6.

253   ii)   Modeled data may not be used in Expanded Minimum Qualified Configuration
254   submissions.

255 **Note**: EPA received stakeholder requests to add an expanded maximum qualified configuration modeled
256 after the existing expanded minimum qualified configuration in Draft 3. After further discussion with
257 stakeholders regarding this request, the allowable change of performance when expanding both the
258 maximum and minimum qualified configurations has been increased to 15%. EPA welcomes stakeholder
259 feedback on these proposed revisions. This change will enable a more representative range of product
260 sizes to qualify, therefore providing more information to end-users about the behavior of their storage
261 systems both below and above the optimally-sized point.

262   7)   Systems Composed of Combinations of Single Device Optimal Configurations: A product
263   family which has demonstrated more than one Optimal Configuration may be sold as
264   ENERGY STAR qualified using a combination of those Optimal Configurations, provided **all**
265   of the following apply:

266   i)   Combined systems are configured using only those storage devices, or validated
267   replacement storage devices (Section 3.6), and configuration options which were used in
268   the individual qualified Optimal Configurations.

269   ii)   The combined system consists of percentage allocation of storage devices, or validated
270   replacement storage devices (Section 3.6), from one or more Optimal Configurations.

271   iii)   The total sum of all percent allocations of storage devices drawn from the Optimal
272   Configurations must equal 100%.

273   iv)   After allocation, storage devices and drawers are rounded per the Maximum and
274   Minimum Qualified Configuration rules above.

275   v)   When rounding to a drawer, storage devices are added or removed (as appropriate) to
276   maintain storage device percentages in the same proportion as the proportion used in the
277   combined system configuration prior to drawer rounding.

278   vi)   Allocation of Optimal Configurations is also used when a storage product provides Block
279   I/O capability in addition to NAS capabilities. In this usage, the system wide percentage of
280   defined allocations will include the portion of the system providing NAS functionality.
281   There are no constraints on the size of the NAS portion of the system.

282   vii) Multiple transaction or streaming optimizations may be submitted to incorporate different
283   storage device technologies and customer usage needs.

284 **Note**: EPA has included validated replacement storage devices in items i and ii above to remain
285 consistent with Section 3.6 below. Item vi has also been revised per stakeholder suggestions to add
286 clarity on drawer rounding guidance when multiple Optimal Configurations are combined. EPA welcomes
287 feedback on these changes.

288   8)   Capacity Optimization Family Restriction: A product family may not be based solely on
289   Capacity Optimizations. Every storage device submitted for qualification under Capacity
290   Optimization must also include one or more transaction optimized configuration(s) and/or
291   streaming optimized configuration(s) using the same storage device. A Capacity
292   Optimization may only be submitted as an addition to one (or more) of the other
293   optimizations.

J.   Other Definitions:

   1) Centralized Controller Storage: A storage product comprised of a storage controller which has a full view of all the storage devices in the storage product.   Addition of one or more redundant storage controllers to a system which shares the same full system view also meets this definition.

   2) Distributed Controller Storage: A storage product comprised of two or more discreet storage controllers, each of which have a partial view to a partition of the overall system's storage devices, combined with an overall integration or aggregation function resulting in a single storage product view of attached servers. Each of these discrete storage controllers may, or may not, be deployed with some level of redundancy.

   3) Field-replaceable Unit (FRU): A unit, or component of a system that is designed to be replaced "in the field;" i.e., without returning the system to a factory or repair depot. Field replaceable units may either be customer-replaceable, or their replacement may require trained service personnel.

   4) 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.

   5) Maximum Time to First Data (MaxTTFD): The maximum time required to start receiving data from a storage product to satisfy a read request for arbitrary data.

   6) 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) Parity RAID: A collective term used in this specification to refer to any RAID system that achieves better efficiency than RAID 1 (i.e., mirroring).

v) <u>Non-disruptive Serviceability</u>: 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.

7) <u>Physical Data</u>: Data generated by testing a storage product using the ENERGY STAR Test Method for Data Center Storage.

8) <u>Modeled Data</u>: Data generated from an algorithmic tool, designed either by the ENERGY STAR Partner or a third party, which generates estimated test results (e.g., power, performance) for a set of storage product configuration inputs.

9) <u>Read/Write</u>:

   i) <u>Random Read</u>: 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) <u>Random Write</u>: 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) <u>Sequential Read</u>: An I/O load consisting of consecutively issued read requests to adjacently addressed data.

   iv) <u>Sequential Write</u>: An I/O load consisting of consecutively issued write requests to adjacently addressed data.

10) <u>Response Time</u>: The time required for the UUT to complete an I/O request.

11) <u>Unit Under Test (UUT)</u>: The storage product being tested.

2 QUALIFYING PRODUCTS

2.1 Included Products

2.1.1 Products that meet all of the following conditions are eligible for ENERGY STAR qualification, with the exception of products listed in Section 2.2:

   i. meet the definition of a Storage Product provided in Section 1 of this document;

   ii. do not fall within the exceptions identified in Section 2.2 of this document;

   iii. are comprised of one or more SKUs and be able to be purchased in a single order from a storage product vendor;

   iv. are characterized within the Online 2, 3, or 4 Storage Taxonomy categories[2] with the following additional criteria;

   a) contain a controller with advanced data recovery capability such as RAID, mirroring/ grid technology, or other comparable advanced error detection and recovery systems;

   b) support Block I/O storage functions either entirely or as an additional capability, with the exception of object based storage; and

   c) implement centralized or distributed controller storage.

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[2] As defined in the "SNIA Emerald™ Power Efficiency Measurement Specification," Version 2.0, Rev 1 (6 October 2013).

375 | **Note**: Based on stakeholder feedback from Draft 3, EPA has clarified that all products submitted for
376 | qualification must include a controller with advanced data recovery capability, including but not limited to
377 | RAID. The RAID only requirement in Draft 3 was too restrictive given newer storage architectures.

378 Additionally, scale up storage has been renamed centralized controller storage, and scale-out storage has
379 been renamed distributed controller storage. Both architecture types are included in the scope of this
380 Version 1.0.

2.2   Excluded Products

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382   2.2.1   Products that are covered under other ENERGY STAR product specifications are not eligible
383   for qualification under the ENERGY STAR Data Center Storage specification. The full list of
384   specifications currently in effect can be found at www.energystar.gov/specifications.

385   2.2.2   The following products are specifically excluded from qualification under this specification:

386   i.   Personal / Portable Data Storage Products;

387   ii.   Computer Servers;

388   iii.   Blade Storage Products;

389   iv.   Direct Attached Storage Products

390   v.   Network Attached Storage Products that cannot perform block I/O;

391   vi.   Object Storage Products;

392   vii.   Storage devices in the following categories of the taxonomy: Near-online, Removable Media
393   Library, Virtual Media Library, Adjunct Storage Products, and Interconnect Elements;

394   viii.   Online storage devices without an included RAID controller, e.g. a collection of disks which
395   rely on a PCI add-in card in a server for RAID functions (JBODs);

3   QUALIFICATION CRITERIA

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3.1   Significant Digits and Rounding

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398   3.1.1   All calculations shall be carried out with directly measured (unrounded) values.

399   3.1.2   Unless otherwise specified, compliance with specification limits shall be evaluated using
400   directly measured or calculated values without any benefit from rounding.

401   3.1.3   Directly measured or calculated values that are submitted for reporting on the ENERGY STAR
402   website shall be rounded to the nearest significant digit as expressed in the corresponding
403   specification limit.

3.2   Power Supply Requirements

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405   3.2.1   Power Supply Units (PSUs): PSUs used in storage products eligible under this specification shall
406   meet the following requirements when tested using the *EPRI Generalized Internal Power Supply*
407   *Efficiency Test Protocol, Rev. 6.6* (available at www.efficientpowersupplies.org).

408   i.   Efficiency: A storage product PSU shall meet efficiency requirements as specified in Table 1.

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Table 1: Efficiency Requirements for PSUs

PSU Type	Rated Output Power	20% Load	50% Load	100% Load
Non-Redundant Capable PSU	All Output Levels	85%	88%	85%
Redundant Capable PSU	All Output Levels	85%	89%	85%

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411   ii. <u>Power Factor</u>: A storage product PSU shall meet power factor requirements as specified in
412   Table 2.

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Table 2: Power Factor Requirements for PSUs

PSU Type	Rated Output Power	20% Load	50% Load	100% Load
Non-Redundant Capable PSU	All Output Levels	0.80	0.90	0.95
Redundant Capable PSU	≤ 500 watts	0.80	0.90	0.95
	500 watts < Output ≤ 1000 watts	0.80	0.90	0.95
	> 1000 Watts	0.80	0.90	0.95

414   iii. <u>Efficiency and Power Factor in Embedded Equipment</u>: Embedded PSUs that power primary
415   components of the storage product, including controllers and drawers, must meet the
416   requirements in Table 1 and Table 2. Embedded PSUs that do not power primary
417   components of the storage product are not subject to PSU requirements.

418 **Note**: EPA is proposing to remove the 10% load PSU requirements in Table 1 and Table 2. Based on
419 discussions with stakeholders, EPA's review of available data has shown that storage products do not
420 typically operate at those low load points and their PSUs are often not tested at a 10% load point, creating
421 additional test burden if it were to be required. Additionally, EPA surveyed 80 PLUS Silver level data and
422 determined that the vast majority of power supply products that meet the 20%, 50%, and 100% load
423 requirements also meet the 10% requirements, so energy savings should be realized in those few cases
424 where a product operates near 10% PSU load. EPA will provide the option of reporting performance at
425 10% load at the time of qualificaiton.

426 ## 3.3   Power Modeling Requirements

427   3.3.1 <u>Power Modeling Presale tool</u>: For Online 4 systems that qualify using modeled data, EPA
428   expects that a power modeling tool characterizing the storage product will be made available
429   to manufacturer qualified purchasers of the product. The power modeling tool must provide an
430   estimated power usage of a deployed configuration based on user-selected configuration
431   characteristics. Online 4 systems that are qualified using modeled data are expected to make
432   performance/watt data available to manufacturer qualified purchasers of the product.

433 **Note**: EPA has clarified that for manufacturers of Online 4 systems that submit modeled data for
434 qualification purposes, EPA expects that manufacturers will make performance/watt data available to
435 qualified purchasers of their products.

436

3.4   Energy Efficiency Feature Requirements

3.4.1   To qualify for ENERGY STAR, a storage product must contain the following features, implemented as specified:

i.   *Parity RAID*: A storage product must offer a form of Parity RAID, mirroring/ grid technology, or other comparable advanced error detection and recovery systems.

Note: EPA has revised the Parity RAID requirement to include alternative Grid architectures that implement advanced error detection and recovery systems which are unlike traditional Parity RAID solutions. EPA welcomes stakeholder feedback on this addition.

ii.   *Adaptive Active Cooling*: A storage product must utilize adaptive cooling technologies that reduce the energy consumed by the cooling technology in proportion to ambient air temperature conditions in proximity to the storage product and the current cooling needs to the storage product. (e.g., reduction of variable speed fan or blower speeds at lower ambient air temperature). This requirement is not applicable to devices that employ passive cooling.

Note: EPA has added clarification that devices within a storage product that use only passive cooling are not required to meet the adaptive cooling requirements in Section 3.4.

3.4.2   A storage product shall make available for purchase to the end user configurable / selectable features listed in Table 3 in quantities greater than or equal to those listed in Table 4.

Table 3: Recognized COM Features

Feature	Verification Requirement
COM: Thin Provisioning	SNIA verification test
COM: Data Deduplication	SNIA verification test
COM: Compression	SNIA verification test
COM: Delta Snapshots	SNIA verification test[3]

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[3] SNIA defined verification techniques for the COMs listed in Table 3 can be found in the "SNIA Emerald™ Power Efficiency Measurement Specification" Version 1.0 released 23 August 2011. Further detail may be found at www.snia.org/green.

456

457 **Table 4: COM Requirements for Online 2, 3, and 4 Systems**

Storage Product Category	Minimum number of COMs required to be made available
Online 2	0
Online 3	1
Online 4	1

458 **Note:** Based on stakeholder feedback from Draft 3 and EPA's own analysis, EPA has revised the number
459 of COMs that are required to be available for the Online 3 and Online 4 categories. Stakeholders have
460 provided examples of older storage products in the market that cannot offer multiple COM features, but
461 can still produce competitive performance/watt results overall. EPA welcomes stakeholder feedback on
462 the proposed levels set in Table 4.

463 ## 3.5   Information Reporting Requirements
464

465   3.5.1   <u>Active and Idle State Efficiency Disclosure</u>: To qualify for ENERGY STAR, all active and idle
466   state test results shall be reported

467   i.   Test results shall be provided in the <u>Power and Performance Data Sheet</u> (PPDS) as defined
468   in Table 5.
469

470 **Table 5: Active and Idle State EfficiencyTest Results Displayed in the ENERGY STAR PPDS**

Workload Test	Transaction Optimization	Streaming Optimization	Capacity Optimization
Hot Band	Required	Optional	Optional
Random Read	Required	Optional	Optional
Random Write	Required	Optional	Optional
Sequential Read	Optional	Required	Optional
Sequential Write	Optional	Required	Optional
Ready Idle	Required	Required	Required

471

472 **Note**: EPA is adopting the Version 2.0 SNIA Emerald^{TM} Power Efficiency Measurement Specification in
473 the Version 1.0 Data Center Storage test method. In the Version 2.0 Emerald^{TM} specification, mixed
474 workloads in Table 5 have been replaced with the "Hot Band" workload which more accurately addresses
475 systems with caching ability. Additional details on the Hot Band workload can be found in the Version 2.0
476 Emerald^{TM} specification: http://www.snia.org/sites/default/files/EmeraldMeasurementV2_0_1.pdf.

477 EPA maintains its proposal of evaluating storage products using a predetermined Active and Idle State
478 testing methodology, with results to be reported via the ENERGY STAR program as part of the PPDS.

479 3.5.2 The weighted percentages shown in Table 6 shall be used to calculate the appropriate Optimal
480   Configuration point for a given storage product.
481

482 **Table 6: Workload Weighting Requirements**

Workload Test	Transaction Optimization	Streaming Optimization	Capacity Optimization
Hot Band	100%	0%	0%
Sequential Read	0%	70%	0%
Sequential Write	0%	30%	0%
Ready Idle	0%	0%	100%

483

484 **Note**: Table 6 has been revised to include the new Hot band workload designed to measure transaction
485 systems which incorporate caching. Transaction systems that do not use caching are also assessed
486 accurately by this workload.

487 The above table includes a revised percentage weighting of four workloads with the intent that they will
488 provide a reasonable representation of each Optimization category. The EPA welcomes feedback on the
489 revised allocation of workloads, both in terms of weighting and workload inclusion. Based on discussions
490 with stakeholders, the above numbers are believed to be reasonable assumptions for workload
491 weightings.

492 3.5.3 Testing Data Requirements for Online 2 and Online 3 Centralized Controller Storage Products:
493   The following testing data is required for each configuration reported for qualification as
494   ENERY STAR:

495   i. Physical data for all 6 measurements listed in Table 5 shall be submitted for all of the
496   following system sizes:

497   (a) Manufacturer determined Optimal Configuration point;

498   (b) One additional data submission per storage product of a Transaction Optimized
499   Configuration and / or Sequential Optimized Configuration (as appropriate) at a
500   manufacturer chosen point at least 40% smaller in storage device count compared to
501   the optimal configuration, rounded down to the nearest drawer boundary or partial
502   drawer if one drawer; and

503   (c) One additional data submission per storage product of a Transaction Optimized
504   Configuration and / or Sequential Optimized Configuration (as appropriate) at a
505   manufacturer chosen point at least 15% larger in storage device count compared to
506   the Optimal Configuration, rounded up to the nearest drawer boundary;

507   (d) Configurations selected for additional data points (b) and (c) shall utilize storage
508   devices representative of the highest deployed volume by the manufacture for the
509   respective workload.

510   (e) Additional data points (b) and (c) are not required if the manufacturer has not
511   submitted an Optimal Configuration point for the given workload.

512   (f) Additional data points (b) and (c) are not required if the storage product is not
513   marketed with storage device quantity configurability.

514   (g) Configurations consisting *exclusively* of SSD storage devices are not required to
515   submit physical test point results. Note this exclusion does **not** apply to Optimal
516   Configurations consisting of mixed storage devices where one of the devices is an
517   SSD.

518

519   ii. Modeled data for all 6 measurements listed in Table 5 may optionally be submitted for all
520   system sizes listed above, as well as any other system sizes the manufacturer wishes to
521   provide.

522

523   iii. Verification testing of COM features (table 3) specified by the storage product shall be
524   executed at least once using storage devices of the vender's choice. Once verified there is
525   no requirement to re-execute the verification testing procedure with different storage devices.

526   3.5.4   Testing Data Requirements for Online 4 Centralized Controller Storage Products: The
527   following testing data is required for each configuration submitted for qualification as ENERGY
528   STAR:

529   i. Physical data for all 6 measurements listed in Table 5 shall be submitted for the following
530   system size:
531   (a) Manufacturer determined Optimal Configuration point.
532   (b) Configurations consisting *exclusively* of SSD storage devices are not required to
533   submit physical test point results. Note this exclusion does **not** apply to Optimal
534   Configurations consisting of mixed storage devices where one of the devices is an
535   SSD.

536

537   ii. Verification testing of COM features (table 3) specified by the storage product shall be
538   executed at least once using storage devices of the vender's choice. Once verified there is
539   no requirement to re-execute the verification testing procedure with different storage devices.

540   iii. Modeled data for all 6 measurements listed in Table 5 shall be submitted for all of the
541   following system sizes;

542   (a) Manufacturer determined Optimal Configuration point;

543   (b) At least 6 manufacturer chosen points smaller in storage device count compared to
544   the Optimal Configuration, with the smallest point being at least 40% smaller in
545   storage device count; and

546   (c) At least 6 manufacturer chosen points larger in storage device count compared to the
547   optimal configuration, with the largest point being at least 15% larger in storage
548   device count.

549   (d) Additional data points (b) and (c) are not required if the storage product is not
550   marketed with storage device quantity configurability.

551

552   iv. Additional modeled data for all 6 measurements listed in Table 5 may optionally be submitted
553   for other system sizes that the manufacturer wishes to provide.

554   v. If accurate modeled data for an Online 4 storage product submission cannot be provided,
555   manufacturers may use the full testing requirements for Online 2 and Online 3 in lieu of the
556   Online 4 testing requirements.

557   3.5.5   Testing Data Requirements for all Distributed Controller Storage Products: The following test
558   data is required for each configuration submitted for qualification as ENERGY STAR:

559   i. All testing and data requirements of Sections 3.5.3 and 3.5.4 shall be followed.

560   ii. When testing, the smallest marketed quantity of storage controllers or nodes shall be tested.

561   iii. Additional systems with a larger quantity of storage controllers may be optionally submitted.

> **Note**: EPA has proposed specific testing requirements for distributed controller storage. These products shall follow the same testing procedures as centralized controller storage products, testing the configuration with the smallest marketed quantity of storage controllers available. EPA is aware of distributed controller storage products which have a fixed number of storage devices per node. These systems shall make all measurements with the fixed number of storage devices allowed in the storage product. EPA welcomes stakeholder feedback on this proposal.

    3.5.6   Data for a standardized PPDS shall be submitted for each ENERGY STAR qualified storage product or storage product family.

        i.   Partners are encouraged to provide one set of data for each ENERGY STAR qualified product configuration, though provision of a data set for each qualified product family is also acceptable.

        ii.   Whenever possible, Partners must also provide a hyperlink to a more detailed power calculator on their website that purchasers can use to understand power and performance data for specific configurations within the product family.

    3.5.7   Information presented in the PPDS will be located on the ENERGY STAR website once the specification is finalized. The PPDS contains the following information:

        i.   Product model name, model number, and SKU or other configuration identification number;

        ii.   A list of important product characteristics, including;

                (a) System configuration;

                (b) Storage controller details;

                (c) Software configuration;

                (d) Storage controller power supply information;

                (e) Storage device drawer power supply information;

                (f) Storage devices used per optimization points

                (g) Input power and environmental characteristics during testing;

                (h) System power optimization capabilities;

                (i) Inlet air temperature and power consumption reporting capabilities.

> **Note**: EPA has replaced storage media with storage devices for consistency with the definitions section above.

        iii.   A list of qualified system configurations, including maximum, minimum and optimal configurations of qualified product families;

        iv.   Data from required active and idle state test reporting;

> **Note**: EPA has clarified that active and idle test results that are required to be published in Table 5 above will be published in the PPDS.

        v.   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;

599　　　　　vi. A list of power management and other power saving features available and enabled by
600　　　　　　　default;

601　　　　　vii. Information on product power measurement and reporting capabilities;

602　　　　　viii. A list of selected data from the ASHRAE Thermal Report; and

603　　　　　ix. For product families, a list of qualified storage products within the family.

3.6　　Storage Device Replacement Requirements

605　　3.6.1　Replacement Storage Devices in As-Shipped Configurations: In order to reduce testing
606　　　　　burden, manufacturers may replace storage devices that were used during qualification with
607　　　　　storage devices that have similar energy efficiency performance/watt compared to the device
608　　　　　being replaced after qualification. Storage product manufacturers must submit specification
609　　　　　sheets from the storage device vendors for the original and replacement devices to validate
610　　　　　the following:

611　　　　　i. No change in **any** of the following categories:

612　　　　　　　(a) Form factor

613　　　　　　　(b) Interface type, quantity, and transfer speed

614　　　　　ii. No reduction in the following features:

615　　　　　　　(a) Data Capabilities (e.g. Self-encryption)

616　　　　　　　(b) Power Management-related features and capabilities (e.g. Power Down Modes)

617　　　　　iii. Reported values within ± 5% for **all** of the following categories:

618　　　　　　　(a) Average Seek Time

619　　　　　　　(b) Sustained Transfer Rate

620　　　　　　　(c) Average Latency

621　　　　　　　(d) Reported average power consumption in like modes of operation

622　　　　　　　(e) Rotational Speed

623　　　　　　　　　(i) Not applicable to Non-Rotational storage devices

624　　　　　　　　　(ii) If the storage device is capable of multiple spindle speeds, the discreet speeds
625　　　　　　　　　　　must be within 5%, and the criteria for entering each of those speeds must be the
626　　　　　　　　　　　same.

627　　　　　ii) Equal or greater reported values for the following categories:

628　　　　　　　(a) Capacity

629　　　　　　　(b) Cache Size

630　　3.6.2　Performance Improvement Cap: Replacement of a storage device in a storage product that
631　　　　　leads to a change of greater than 20% of the overall system performance (performance/watt)
632　　　　　as defined by Table 6 (with the exception of the Ready Idle metric) will require testing of a new
633　　　　　Optimal Configuration for inclusion in the product family definition.

Note: EPA has simplified Section 3.6 based on stakeholder feedback on Draft 3. The resulting single list of requirements is applicable to both rotational and non-rotational storage devices unless otherwise noted. EPA has revised the requirements for the following categories which were previously located in the "no allowable changes" Section 3.6.1.i:

- Power Management-related features: EPA has clarified that these features cannot be removed in replacement devices, but additional functionality can be introduced in replacement devices.

- Rotational Speed: EPA received stakeholder feedback that tolerance should be provided for minor differences in device speed between different vendors and that multiple speed devices should be supported. The rotational speed requirement is not applicable to non-rotational storage devices.

- Cache Size: EPA received stakeholder feedback that newer storage devices may contain additional cache and should not be disqualified from the drive substitution provision.

3.7   Standard Performance Data Measurement and Output Requirements

Note: EPA continue to strive for harmonization between the ENERGY STAR Computer Server and Storage specifications and has updated this section to align with the Servers Final Draft Version 2.0 currently out for stakeholder comment. Changes compared to the previous Draft 3 are noted below.

3.7.1   <u>Data Elements</u>: Online 3 and Online 4 storage products shall be capable of measuring and reporting the following data elements:

    i.   <u>Input Power</u>, in watts. 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

    ii.   <u>Inlet Air Temperature (optional)</u>, in degrees Celsius, with accuracy of ± 2°C.

Note: Based on discussions with stakeholders, EPA is proposing to eliminate the standard performance data measurement and output requirements for Online 2 systems, as EPA has determined that the cost of supporting the required infrastructure is disproportionate to the cost of the storage product itself. As such, only Online 3 and Online 4 storage products will be required to meet the data elements requirements in 3.7.1.

3.7.2   <u>Reporting Implementation</u>:

    i.   Data shall be made available in a published or user-accessible format that is readable by third-party, non-proprietary management systems;

    ii.   Data shall be made available to end users and third-party management systems over a standard network connection;

    iii.   Data shall be made available via 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, iPDU, or pre-installed OS);

    iv.   When an open and universally available data collection and reporting standard becomes available, manufacturers should incorporate the universal standard into their products.

674   3.7.3   <u>Sampling Requirements</u>:

675   i.   *Input power*: Input power measurements must be sampled internally to the storage product
676   at a rate of greater than or equal to measurement per contiguous 10 second period. A
677   rolling average, encompassing a period of no more than 30 seconds, must be sampled
678   internally to the storage product at a frequency of greater than or equal to once per ten
679   seconds.

680   ii.   *Inlet air temperature (optional)*: Inlet air temperature measurements must be sampled
681   internally to the storage product at a rate of greater than or equal to 1 measurement every
682   10 seconds.

683   iii.   *Timestamping*: Systems that implement time stamping of environmental data shall sample
684   internally to the storage product data at a rate of greater than or equal to 1 measurement
685   every 30 seconds.

686   iv.   *Management Software*: All sampled measurements shall be made available to external
687   management software either via an on-demand pull method, or via a coordinated push
688   method. In either case the system's management software is responsible for establishing
689   the data delivery time scale while the storage product is responsible to assuring data
690   delivered meets the above sampling and currency requirements.

---

691 **Note**: EPA proposes that systems which incorporate timestamping of environmental data (power and
692 temperature) shall be subject to proposed data reporting frequency requirements in Section 3.7.3.iii. The
693 frequency of reporting measurement requirements i and ii have been revised to provide more clarity.
694 Timestamped data can be assembled in time-order at a later date, providing increased flexibility for users
695 of systems that offer this capability. In an effort to encourage timestamping capability, EPA has relaxed
696 the reporting frequency requirements to encourage its use.

697 EPA has also added requirement iv to provide guidance on how the storage product is expected to
698 interact with external management software to ensure that the data can be accessed by the end-user.

---

699   3.7.4   <u>Documentation Requirements</u>: The following information shall be included in the PPDS:

700   i.   Guaranteed accuracy levels for power and temperature measurements, and
701   ii.   The time period used for data averaging.

702   3.7.5   Section 3.7 may be satisfied in Version 1.0 using iPDUs. In order to satisfy the Data Elements
703   requirement, an iPDU must:
704   i.   Meet all requirements for accuracy, sampling, and data reporting;
705   ii.   Be made available for sale and delivery with qualified ENERGY STAR storage products.

706 # 4   TESTING

707 ## 4.1   Test Methods

708   4.1.1   Test methods identified in Table 7 shall be used for purposes of evaluating active and idle
709   state storage product energy efficiency.

710   **Table 7: Test Methods for ENERGY STAR Qualification**

Product Type	Test Method
All	ENERGY STAR Test Method for Data Center Storage Equipment, Rev. February 2013.

711 **Note**: The reference in this table is revised to point to the ENERGY STAR Test Method. This document, a
712 draft of which is distributed with this Draft 4 Specification, references the SNIA Emerald^{TM} Power
713 Efficiency Measurement Specification, Version 2.0 Rev 1 (6 October 2012).

714 **4.2   Number of Units Required for Testing**

715   4.2.1   Representative Models shall be selected for testing per the following requirements:

716   i.   For qualification of an individual product model, a product configuration equivalent to that
717   which is intended to be marketed and labeled as ENERGY STAR is considered the
718   Representative Model;

719   ii.   For qualification of a product family one or more Optimization Configurations shall be tested
720   and submitted. Within the range defined by the Maximum Qualified Configuration, Minimum
721   Qualified Configuration, and Optimal Configuration, manufacturers continue to be held
722   accountable for any efficiency claims made about their products, including those not tested or
723   for which data was not reported;

724 # 5   EFFECTIVE DATE

725   5.1.1   <u>Effective Date</u>: The Version 1.0 ENERGY STAR Data Center Storage specification shall take
726   effect in **July 2013**. To qualify for ENERGY STAR, a product model shall meet the ENERGY
727   STAR specification in effect on its date of manufacture. The date of manufacture is specific to
728   each unit and is the date on which a unit is considered to be completely assembled.

729   5.1.2   <u>Future Specification Revisions</u>: EPA reserves the right to change this specification should
730   technological and/or market changes affect its usefulness to consumers, industry, or the
731   environment. In keeping with current policy, revisions to the specification are arrived at through
732   stakeholder discussions. In the event of a specification revision, please note that the ENERGY
733   STAR qualification is not automatically granted for the life of a product model.

734 **Note**: As a reminder, the Data Center Storage program would have a slightly delayed effective date to
735 enable lab accreditation to the ENERGY STAR Test Method and Certification Bodies to prepare for the
736 certification process. Therefore, EPA will choose an effective date approximately 3 months following
737 finalization.

738 # 6   CONSIDERATIONS FOR FUTURE REVISIONS

739 **Note**: This section will be updated in further drafts to capture issues that, while excluded from the Version
740 1.0 specification, may be reevaluated in future versions.

741 TBD