ENERGY STAR® Program Requirements for Data Center Storage

Eligibility Criteria
Final Draft Version 1.0

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

1 DEFINITIONS

A. Product Types:

1) 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 may be composed of integrated storage controllers, storage devices, embedded network elements, software, and other devices. For purposes of this specification, a storage product is a unique configuration of one or more SKUs, sold and marketed to the end user as a Storage Product.

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

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

B. Storage Product 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 products. A SAN consists of a communication infrastructure, which provides physical connections, and a management layer, which organizes the connections, storage controllers / devices, and computer systems so that data transfer is secure and robust.

Note: EPA has clarified that the Storage Area Network definition is intended to define the network infrastructure between computer systems and storage products as a whole, rather than the individual components of a storage product.

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

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

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

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

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

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

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

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

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

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

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

78 6) Interconnect Element: Devices which provide for interconnection functionality within a storage
79 area network. Examples include SAN Switches, etc.

80 E. Other Data Center Equipment:

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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[TM] Power Efficiency
Measurement Specification" Version 2.0.0 rev 1, 12 December, 2012. Further detail may be found at
www.snia.org/green.

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.

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.

F. <u>Capacity</u>: 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) <u>Assigned Capacity</u>: 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 thin provisioning 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) <u>Effective Capacity</u>: The amount of data stored on a storage product, plus the amount of unused formatted capacity in the system.

3) <u>Formatted (Usable) Capacity</u>: The total amount of bytes available to be written after a storage product or storage 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.

| 128 | 4) | Free Space: The amount of unused, formatted capacity as reported by the storage product. |

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.

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 not initiated by the user.

    i) Ready Idle: The state in which a storage product is able to respond to arbitrary I/O requests within the MaxTTFD 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 MaxTTFD 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 MaxTTFD 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.

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. Note: Storage PSUs may be Field Replaceable Units (FRUs), but in some cases may be further integrated with the storage product.

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 or standby outputs shall be less than or equal to 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.

Note: Based on stakeholder feedback from Draft 4, EPA will allow the total rated output from all additional PSU outputs that are not primary or standby outputs to equal up to 20 watts, rather than less than 20 watts as proposed in the Draft 4.

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

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

182 I. Product Family: A group of models/configurations that share a set of common attributes that are
183   variations on a basic design.

184 1) Common Product Family Attributes: A set of features common to all models/configurations
185   within a product family that constitute a common basic design. All models/configurations
186   within a product family must share the following:

187   i)   made by the same manufacturer;

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

189   iii) utilize the same model of storage controller;

190   iv) fall under the same taxonomy category; and

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

192 2) Optimal Configuration: A product configuration that lies between the minimum and maximum
193   qualified configurations and is representative of a product with maximum peak energy
194   efficiency performance (performance/watt) for a given workload. This configuration is
195   provided by the manufacturer and may be optimized for the following workload types:

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

198   ii) Streaming: A workload optimized primarily for sequential I/O usage, measured in MiB per
199   second per watt;

200   iii) Capacity: A workload optimized for maximum storage as measured by GB (Raw
201   Capacity) per watt.

202 **Note**: EPA has clarified that the Optimal Configuration shall be the maximum peak energy efficiency
203 value for a given workload. Also, the metric for capacity workload has been clarified as GB (Raw
204 Capacity) per watt.

205 3) Fixed Qualification Range: Defined by testing product configurations at the Optimal
206   Configuration and at points that are 40% smaller and 15% larger in storage device count than
207   the Optimal Configuration. This qualification range is fixed at 20% smaller and 5% larger
208   than the Optimal Configuration. Product configurations which are unable to be configured for
209   either the Fixed Maximum or Fixed Minimum Qualified Configuration are not required to
210   perform that respective test. In such a case, the qualification range is limited to the region
211   between the Optimal Configuration and whichever one of the Fixed Configurations is tested.

212   i)   Fixed Maximum Qualified Configuration: A product configuration that includes the
213   combination of base components that generates a system which is 5% larger in storage
214   device count than the Optimal Configuration.

215   (a) This number may be rounded up to the nearest drawer boundary.

216   ii) <u>Fixed Minimum Qualified Configuration</u>: A product configuration that includes the
217   combination of base components that generates a system which is 20% smaller in
218   storage device count compared to the Optimal Configuration.

219   (a) This number may be rounded down to the nearest drawer boundary.

> **Note**: EPA has revised the rounding guidance to apply to all storage products, which aligns with the changes in testing data requirements in Section 3.5 below.
>
> **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.

227   4) <u>Flexible Qualification Range</u>: Defined by testing product configurations at the Optimal
228   Configuration and at two manufacturer chosen points, one smaller than the Fixed Minimum
229   Qualified Configuration and one larger than the Fixed Maximum Qualified Configuration.
230   This qualified range is extended out to the smaller and larger points, provided they are
231   within 15% of the Optimal Configuration's performance/watt.

232   i) <u>Flexible Maximum Qualified Configuration:</u> A product configuration that includes a
233   combination of base components that generate a system which is larger in storage device
234   count than the Fixed Maximum Qualified Configuration and which is within 15% of the
235   Optimal Configuration performance/watt, validated through the testing data requirements
236   in Section 3.5 below.

237   (a) Performance will be measured using the appropriate relative weighting of workloads
238   defined in Table 6.

239   (b) Modeled data may not be used for Expanded Maximum Qualified Configuration
240   submissions.

241   ii) <u>Flexible Minimum Qualified Configuration:</u> A product configuration that includes a
242   combination of base components that generate a system which is smaller in storage
243   device count than the Fixed Minimum Qualified Storage Configuration and which is within
244   15% of the Optimal Configuration performance/watt, validated though the testing data
245   requirements in Section 3.5 below.

246   (a) Performance will be measured using the appropriate relative weighting of workloads
247   defined in Table 6.

248   (b) Modeled data may not be used for Expanded Minimum Qualified Configuration
249   submissions.

> **Note**: EPA has clarified that manufacturers may choose qualification ranges based on either fixed points (-20%, +5% device count) or flexible points (provided min and max points are within 15% performance/watt of the Optimal Configuration). Flexible point values are validated through the testing data requirements which are provided in detail in Section 3.5 below.

254   5) <u>Mixed Qualification Range</u>: Defined by testing one of the fixed points in 1.I.3 and one of the
255   flexible points in 1.I.4, provided they are on opposite sides of the Optimal Configuration.
256   On the side with the Flexible Configuration, the qualification range is extended from the
257   Optimal Configuration out to the chosen flexible point. If the Fixed Minimum Qualified
258   Configuration was chosen, the range is kept to 20% smaller than the Optimal Configuration.
259   If the Fixed Maximum Qualified Configuration was chosen, the range is kept to 5% larger.

6) <u>Systems Composed of Combinations of Single Device Optimal Configurations</u>: A product family which has demonstrated more than one Single Device Optimal Configuration may be sold as ENERGY STAR qualified using a combination of those Single Device Optimal Configurations, provided all of the following apply:

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

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

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

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

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

   vi) Allocation of Optimal Configurations is also used when a storage product provides Block I/O capability in addition to NAS capabilities. In this usage, the system wide percentage of defined allocations will include the portion of the system providing NAS functionality.

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

7) <u>Systems Composed of Multiple Device Types in an Optimal Configuration</u>: An Optimal Configuration that contains more than one type of addressable storage device may be qualified as part of an ENERGY STAR product family provided **all** of the following apply:

   i) System features used during qualification of Multiple Device Configurations must include automated storage tiering for those portions of the Multiple Device Configurations containing mixed storage devices.

   ii) The ratio of the different storage devices in the qualified Multiple Device Configuration must be maintained as closely as possible during testing of the required Minimum and Maximum Qualified Configurations, as well as in all configurations sold as ENERGY STAR qualified.

   iii) Multiple Device Configurations may be combined with Single Device Configurations under the same product family, and combinations of Multiple and Single Device Configurations from that family may be sold as ENERGY STAR qualified.

   iv) End-user selectable automated storage tiering functionality must be included with all Multiple Device Configurations sold as ENERGY STAR qualified,

   v) All other conditions in Section 1.I.5 above for both Single Device Optimized Configurations and Multiple Device Optimized Configurations must be met.

Note: After significant additional discussion with stakeholders, the above language in Section 6 is designed to allow manufacturers to qualify a single Optimal Configuration with multiple storage device types provided that it meets all of the requirements listed above. The new Hot Band workload referenced later in this specification and the test method evaluates these mixed device configurations in a way that provides meaningful end user data, if automated storage tiering technology is enabled during testing.

303　　　　　　8)　Capacity Optimization Family Restriction: Since the scope in 2.1.1 only encompasses
304　　　　　　　　Online systems, a product family may not be based solely on Capacity Optimized
305　　　　　　　　Configurations. Every storage device submitted for qualification under Capacity Optimized
306　　　　　　　　Configurations must also include one or more Transaction Optimized Configuration(s)
307　　　　　　　　and/or Streaming Optimized Configuration(s) using the same storage device. A Capacity
308　　　　　　　　Optimized Configuration may only be submitted as an addition to one (or more) of the other
309　　　　　　　　optimizations.

310　　　J.　Other Definitions:

311　　　　　　1)　Scale-Up Storage: A storage product comprised of a discreet storage controller (with or
312　　　　　　　　without redundancy), which has a full view of all the storage devices in the storage product.
313　　　　　　　　Incremental storage capacity is added by the addition of storage devices under the control
314　　　　　　　　of the existing storage controller.

315　　　　　　2)　Scale-Out Storage: A storage product capable of being comprised of two or more discreet
316　　　　　　　　storage controllers (with or without redundancy), combined with an overall integration or
317　　　　　　　　aggregation function resulting in a single storage product view for attached servers. Each
318　　　　　　　　discreet storage controller often has a partial view to a partition of the overall system's
319　　　　　　　　storage devices, but this is not a fixed requirement.   Incremental storage capacity is added
320　　　　　　　　by the addition of storage devices under the control of the existing storage controller(s)
321　　　　　　　　and/or addition of additional storage devices along with additional controller(s).

322　**Note**: Based on stakeholder feedback, EPA has renamed the centralized and distributed controller
323　definitions "Scale-up storage" and "Scale-out storage". The centralized and distributed controller storage
324　definition names were introduced in Draft 4 to provide additional clarity, but stakeholders have since
325　stated that scale-up and scale-out are common industry accepted terms and should remain as initially
326　proposed in the Draft 3.

327　The definitions have been revised slightly to clarify how redundant controllers are accounted for when
328　categorizing a system as scale-up or scale-out.

329　　　　　　3)　Automated Storage Tiering: Automatic movement of data between different types of
330　　　　　　　　storage devices. Tiering may occur within a single storage product or may span multiple
331　　　　　　　　storage products. For the purposes of this specification, only tiering within a single storage
332　　　　　　　　product is applicable. If automated storage tiering is enabled during testing, then the multi-
333　　　　　　　　storage device groups necessary for tiering may be represented as single storage devices
334　　　　　　　　when determining testing and qualification ranges and when calculating storage device
335　　　　　　　　allocations. The ratio of each single storage device within the multi-storage device group
336　　　　　　　　must remain as constant as possible.

337　**Note**: EPA has provided a definition for Automated Storage Tiering, a capability that allows storage
338　products to intelligently organize and store data across multiple types of storage devices within the same
339　product.

340　EPA has also proposed that for qualification and testing data requirements, multiple storage devices may
341　represent a single "storage device" if automated storage tiering functionality is enabled and the ratio of
342　each storage device in this combination remains as close as possible.

343　EPA intends to site the upcoming SNIA Emerald^{TM} Power Efficiency Measurement Specification, Version
344　2.0.1 in the Final Specification and Test Method. The Version 2.0.1 revision provides additional guidance
345　on testing storage products with automated storage tiering functionality.

4) <u>Field-replaceable Unit (FRU):</u> 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.

5) <u>High-availability (HA):</u> 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.

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

7) <u>RAS Features:</u> 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) <u>Reliability Features:</u> 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) <u>Availability Features:</u> Features that support a storage product's ability to maximize normal operating time and minimize planned and unplanned down time.

   iii) <u>Serviceability Features:</u> Features that support a storage product's ability to be serviced (e.g., hot-plugging).

   iv) <u>Advanced Data Recovery Capability</u>: A collective term used in this specification to refer to error detection and correction features such as RAID, mirroring / grid technology, or other comparable advanced error detection and recovery systems

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Note: Based on stakeholder feedback from Draft 4, EPA has removed the previous Parity RAID definition and replaced it with a more general Advanced Data Recovery Capability definition. This definition aligns with the description of Parity RAID requirement found in Draft 4. The definition supports scope inclusion terminology found in Section 2.1.1.iv.a, which was introduced in Draft 4.

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   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.

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

9) <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.

10) <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.

389   ii) <u>Random Write</u>: Any I/O load whose consecutively issued write requests do not specify
390   adjacently addressed data. The term random I/O is commonly used to denote any I/O
391   load that is not sequential, whether or not the distribution of data locations is indeed
392   random.

393   iii) <u>Sequential Read</u>: An I/O load consisting of consecutively issued read requests to
394   adjacently addressed data.

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

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

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

2   QUALIFYING PRODUCTS

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2.1   Included Products

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401   2.1.1   Products that meet all of the following conditions are eligible for ENERGY STAR qualification,
402   with the exception of products listed in Section 2.2:

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

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

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

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

409   a) contain a controller with advanced data recovery capability

410   b) support Block I/O storage functions either entirely or as an additional capability; and

411   c) implement scale-up or scale-out storage.

412 **Note**: EPA has simplified the language in the controller requirement under Section 2.1.1.iv.a, by moving
413 the language describing advanced data recovery capability to the definition section above.

414 The reference to object based storage in Section 2.1.1.iv.b has been removed and specified in Section
415 2.2.

416 Additionally, in Section 2.1.1.iv.c, the terms centralized controller storage and distributed controller
417 storage definitions have reverted back to scale-up and scale-out storage respectively, as explained in the
418 definition section above. Both architecture types will remain in the scope of Version 1.0.

2.2   Excluded Products

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420   2.2.1   Products that are covered under other ENERGY STAR product specifications are not eligible
421   for qualification under the ENERGY STAR Data Center Storage specification. The full list of
422   specifications currently in effect can be found at www.energystar.gov/specifications.

423   2.2.2   The following products are specifically excluded from qualification under this specification:

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[2] As defined in the "SNIA Emerald™ Power Efficiency Measurement Specification," Version 2.0.0, Rev 1 (12 December 2012).

	i.	Personal / Portable Data Storage Products;
	ii.	Computer Servers;
	iii.	Blade Storage Products;
	iv.	Direct Attached Storage Products
	v.	Network Attached Storage Products that cannot perform block I/O;
	vi.	Storage Products capable of object based storage;
	vii.	Storage devices in the following categories of the taxonomy: Near-online, Removable Media Library, Virtual Media Library, Adjunct Storage Products, and Interconnect Elements;

> **Note**: EPA has clarified that storage products capable of any level of object based storage are excluded from scope in Version 1.0. Additionally, the previous exclusion for products without a RAID controller has been removed, as advanced data recovery capability is addressed in Section 2.1.1.iv.a above.

3   QUALIFICATION CRITERIA

3.1   Significant Digits and Rounding

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

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

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

3.2   Power Supply Requirements

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

   i.   Efficiency and Power Factor in Primary Embedded Equipment: Embedded PSUs that power primary components of the storage product, including controllers and drawers, must meet the requirements in Table 1 and Table 2.

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

Table 1: Efficiency Requirements for PSUs

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

3.2.3   Power Factor: A storage product PSU shall meet power factor requirements as specified in Table 2.

Table 2: Power Factor Requirements for PSUs

PSU Type	Rated Output Power	20% Load	50% Load	100% Load
Redundant and Non-Redundant Capable PSU	All Output Levels	0.80	0.90	0.95

      i. Embedded PSUs that do not power primary components of the storage product are not subject to PSU requirements.

Note: EPA has consolidated Table 1 and Table 2 into a single row each, as the requirements are the same for all PSUs (equivalent to 80 PLUS Silver requirements which can be found at: http://www.plugloadsolutions.com/80PlusPowerSupplies.aspx#).

3.3   Power Modeling Requirements

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

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:

Note: EPA has removed the Parity RAID requirement as Section 2.1.1.iv.a above states that all storage products must contain a controller with Advanced Data Recovery Capability to be in scope. Parity RAID is one of the acceptable forms of error detection and correction listed in the Advanced Data Recovery and Capability definition.

      i. *Adaptive Active Cooling*: A storage product must utilize adaptive cooling technologies that reduce the energy consumed by the cooling technology in proportion to 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 removed the reference to ambient air temperature conditions in proximity to the storage product as to not exclude other types of potential cooling (e.g. liquid cooling).

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

485

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]

486

487

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

3.5   Information Reporting Requirements

489
490
491

3.5.1   <u>Active and Idle State Efficiency Disclosure</u>: To qualify for ENERGY STAR, all active and idle state test results based on workload tests listed in Table 5 shall be reported:

492

Table 5: Required Workload Tests for all Configurations

Workload Test
Hot Band
Random Read
Random Write
Sequential Read
Sequential Write
Ready Idle[3]

493
494
495

Note: EPA has simplified and renamed Table 5 above to clarify the required tested workloads for all qualified configurations. Additional information on which workload testing data will be made available on the ENERGY STAR website is now found in Table 7 under Section 3.5.7.

496
497
498

3.5.2   <u>Workload Weighting Requirements</u>: The weighted percentages shown in Table 6 shall be used to calculate the appropriate Optimal Configuration point for a given storage product.

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[3] SNIA defined verification techniques for the COMs listed in Table 3 and workload tests in Table 5 can be found in the "SNIA Emerald™ Power Efficiency Measurement Specification" Version 2.0.0 released 12 December, 2012. Further detail may be found at www.snia.org/green.

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%

Note: The hot band workload test is a combination of random and sequential workloads, developed off a series of real world end-user workloads collected by industry. The hot band workload is skewed towards random workloads, and therefore will represent random workloads in transaction based configurations when calculating workload weightings. Random workloads will still be tested and submitted as required by Table 5 above.

3.5.3 <u>Testing Data Requirements for Scale-up Storage Products using only Physical Data</u>: The following test data is required for each configuration submitted for qualification as ENERGY STAR:

    i. The manufacturer must choose a workload type for testing from 1.I.2.

    ii. The manufacturer must choose a storage device representative of its highest deployed volume for the chosen workload.

    iii. The manufacturer may determine to test either a Fixed Size Qualification Range, a Flexible Size Qualification Range, or a Mixed Qualification Range.

    iv. For the chosen workload type, highest deployed volume storage device, and qualification range, physical data for all 6 measurements listed in Table 5 shall be submitted for a manufacturer determined Single or Multiple Device Optimal Configuration point. Additionally:
        a) If a fixed range, two additional points must be tested, one 40% smaller and one 15% larger in storage device count compared to the Optimal Configuration.
        b) If a flexible range, two additional points must be tested. The points are manufacturer determined. One must be at least 40% smaller and the other at least 15% larger in storage device count compared to the Optimal Configuration.
        c) If a mixed range, test the smaller (larger) fixed point at 40% smaller (15% larger) in storage device count, and test the larger (smaller) manufacturer determined flexible point.

    v. To include any additional storage devices (not chosen in 3.5.3.ii) for the selected workload, physical data for all 6 measurements listed in Table 5 shall be submitted for all of the following system sizes for each additional storage device:

        (a) A manufacturer determined Single or Multiple Device Optimal Configuration point. No additional smaller or larger points are necessary.
        (b) Configurations using additional storage devices qualified under 3.5.3.v will assume the qualification range of the configuration qualified under 3.5.3.iv.

    vi. To qualify additional workload types, repeat the above starting at 3.5.3.i for a different workload.

    vii. The following rules apply to all testing above:

        (a) Test points with storage device counts smaller and larger than the Optimal Configuration may be rounded down and up, respectively, to the nearest drawer boundary.

(b) Configurations consisting *exclusively* of SSD storage devices are not required to submit physical test point results. Note this exclusion does not apply to configurations consisting of mixed storage devices where one of the devices is a SSD or when a SSD storage device is representative of the highest deployed volume by the manufacturer.

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

(d) If the storage product is not marketed with storage device configurability or scalability needed to achieve either the smaller or larger test points above, then these points are not required.

(e) As noted in 1.I.8, a product family may not be based solely on Capacity workload Optimized Configurations. Every storage device submitted for qualification under Capacity Optimized Configurations must also include one or more Transaction workload Optimized Configuration(s) and/or Streaming workload Optimized Configuration(s) using the same storage device. A Capacity workload Optimized Configuration may only be submitted as an addition to one (or more) of the other optimizations.

(f) As noted in 1.J.3, if automated storage tiering is enabled during testing, then the multi-storage device groups necessary for tiering may be counted as single storage devices when determining testing and qualification ranges and when calculating storage device allocations. The ratio of each single storage device within the multi-storage device group must remain as constant as possible across different test points.

> **Note**: EPA has modified Section 3.5.3 to define testing data requirements for all scale-up storage products which are submitted with physical data only. EPA has made the following changes in this section:
>
> - Simplified the language and flow.
>
> - Clarified that smaller and larger data points are not required for storage devices that are not representative of the highest deployed volume by the manufacturer for the respective workload.
>
> - Clarified that the physical testing exclusion for SSD storage devices does not apply if the SSD storage device is the highest deployed volume by the manufacturer for the respective workload.

3.5.4   Testing Data Requirements for Scale-up Storage Products using Physical and Modeled Data: The following test data is required for each configuration submitted for qualification as ENERGY STAR:

i.   The manufacturer must choose a workload type for testing from 1.I.2.

ii.   The manufacturer must choose a storage device representative of its highest deployed volume for the chosen workload.

iii. The manufacturer may determine to test either a Fixed Size Qualification Range, a Flexible Size Qualification Range, or a Mixed Qualification Range.

iv.   For the chosen workload type, highest deployed volume storage device, and qualification range, physical data for all 6 measurements listed in Table 5 shall be submitted for a manufacturer determined Single or Multiple Device Optimal Configuration point. Additionally:
    a) If a fixed range, two additional points must be tested, one 40% smaller and one 15% larger in storage device count compared to the Optimal Configuration.
    b) If a flexible range, two additional points must be tested. The points are manufacturer determined. One must be at least 40% smaller and the other at least 15% larger in storage device count compared to the Optimal Configuration.

582   c) If a mixed range, test the smaller (larger) fixed point at 40% smaller (15% larger) in
583   storage device count, and test the larger (smaller) manufacturer determined flexible point.

585   v. If manufacturer generated modeled data for all physical measurements submitted in Section
586   3.5.4.iv above are within ±5%, modeled data shall be submitted for all of the following system
587   sizes;

588   (a) Manufacturer determined Optimal Configuration points for all other storage devices
589   qualified for the respective workload type that are not defined in Section 3.5.4.ii
590   above;

591   (b) At least 6 manufacturer chosen points smaller in storage device count compared to
592   the Optimal Configuration, with two of those points being at least 10% smaller than
593   the small physical point tested in 3.5.4.iv

594   (c) At least 6 manufacturer chosen points larger in storage device count compared to the
595   Optimal Configuration, with two of those points being at least 10% larger than the
596   large physical point tested in 3.5.4.iv

597   vi. To qualify additional workload types, repeat the above starting at 3.5.4.i for a different
598   workload.

600   vii. The following rules apply to all testing above: See Section 3.5.3.vii

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601 **Note**: EPA has modified Section 3.5.4 to define testing data requirements for all scale-up storage
602 products which are submitted with physical and modeled data. EPA has made the following changes in
603 this section:

604 - Clarified that only the storage device representative of the highest deployed volume by the manufacturer
605 for the respective workload shall be physically tested at the Optimal Configuration point.

606 - Simplified the language and flow.

607 - Clarified that data points for smaller and larger sizes are not required for storage devices that are not
608 representative of the highest deployed volume by the manufacturer for the respective workload. This
609 change results in only testing additional physical end points for one storage device per workload type.

610 - Clarified that the physical testing exclusion for SSD storage devices does not apply if the SSD storage
611 device is the highest deployed volume by the manufacturer for the respective workload.

612 - Revised modeled data collection. The collection of Optimal Configuration modeled points replaces the
613 need for physical testing for drives that are not the highest deployed volume by the manufacturer for the
614 respective workload, resulting in a reduction of testing burden, while still collecting important energy
615 efficiency information for end-users.

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616   3.5.5   <u>Testing Data Requirements for all Distributed Controller Storage Products</u>: The following test
617   data is required for each configuration submitted for qualification as ENERGY STAR:

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

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

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

621   3.5.6   Data for display on the ENERGY STAR website shall be submitted for each ENERGY STAR
622   qualified storage product or storage product family.

623 **Note:** EPA no longer intends to use a standardized PPDS for Data Center Storage. EPA is currently
624 developing the Qualified Product eXchange (QPX) document which will be used to collect all reported test
625 data for ENERGY STAR certification. Manufacturers, CBs, and labs will have an opportunity to review this
626 document prior to finalization. All data the EPA intends to publish will be displayed on the Qualified
627 Product List (QPL) on the ENERGY STAR website. A subset of high level purchaser-oriented information
628 will be presented in the new ENERGY STAR Product Finder Tool, which can be found at:
629 http://www.energystar.gov/productfinder/

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

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

636   3.5.7   The following information will be displayed on the ENERGY STAR website:

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

638   ii. A list of important product characteristics, including;

639   (a) System configuration;

640   (b) Storage controller details (e.g. model name and number);

641   (c) Software configuration;

642   (d) Storage controller power supply information;

643   (e) Storage device drawer power supply information;

644   (f) Storage devices used per optimization points

645   (g) Input power and environmental characteristics during testing;

646   (h) System power optimization capabilities;

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

648   iii. A list of qualified system configurations, including maximum, minimum and optimal
649   configurations of qualified product families; Power consumption and performance data, along
650   with guaranteed accuracy levels for all power and temperature measurements, disclosure of
651   the time period used for data averaging, and a hyperlink to a detailed power calculator, as
652   available;

653   iv. A list of power management and other power saving features available and enabled by
654   default;

655   v. A list of selected data from the ASHRAE Thermal Report;

656   vi. For product families, a list of qualified storage products within the family; and

657   vii. Energy Efficiency Performance data for required active and idle state test reporting specified
658   in Table 7 below:

659 **Table 7: Active and Idle State Efficiency Test Results Displayed on the ENERGY STAR Website**

Workload Test	Transaction Optimization	Streaming Optimization	Capacity Optimization
Hot Band	Yes	No	No
Random Read	Yes	No	No
Random Write	Yes	No	No
Sequential Read	No	Yes	No
Sequential Write	No	Yes	No
Ready Idle	Yes	Yes	Yes

660

661 **Note:** EPA has created Table 7 above to clarify which active and idle state test results will be displayed
662 on the ENERGY STAR website. This table is similar to the previous Table 5 in Draft 4, but replaces the
663 terms "required" and "optional" and with "yes" and "no" to further clarify which data will be displayed. EPA
664 will no longer provide the option of displaying information that is not required in this Version 1.0
665 specification. .

666 ## 3.6   Storage Product Family Variation Allowances

667   3.6.1   <u>Storage Product Performance Improvement Cap</u>: Any changes to a storage product after
668   testing (replacement storage devices, storage controller firmware, etc.) shall not lead to a
669   change of greater than 20% of the overall system performance/watt as defined by Table 6
670   (with the exception of the Ready Idle metric). Any combination of changes that cause the
671   storage product's performance/watt value to cross this threshold will require testing of a new
672   Optimal Configuration for inclusion in the product family definition.

673   3.6.2   <u>Replacement Storage Devices in As-Shipped Configurations</u>: In order to reduce testing
674   burden, manufacturers may replace storage devices that were used during qualification with
675   storage devices that have similar energy efficiency (performance/watt) compared to the device
676   being replaced after qualification. Storage product manufacturers must submit specification
677   sheets for the original and replacement devices to validate the following:

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

679   (a) Interface type, quantity, and transfer speed

680   ii.   No reduction in the following features:

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

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

683   iii. Reported values within ± 10% for **all** of the following categories:

684   (a) Average Seek Time

685   (b) Average Latency

686   (c) Reported average power consumption in like modes of operation

687   (d) Rotational Speed

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

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

692 iv. Reported values within -5%/+15% for the following category:

693 (e) Sustained Transfer Rate

694 v. Equal or greater reported values for the following categories:

695 (c) Capacity

696 (b) Cache Size

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697 **Note**: Based on stakeholder feedback and additional research, EPA has further simplified Section 3.6.
698 The resulting single list of requirements is applicable to both rotational and non-rotational storage devices
699 unless otherwise noted. The previous performance improvement cap (previously Section 3.6.2 in Draft 4)
700 now applies to all changes in the storage product in their as-shipped configuration. EPA has revised the
701 following requirements in Section 3.6.2 of the Final Draft:

702 - Form factor has been removed as stakeholders raised the concern that there are 3.5" form factor
703 storage devices being sold with 2.5" physical disks within them. In this scenario the 3.5" casing is used to
704 allow the 2.5" physical drive to be used in drawers with other 3.5" form factor devices. EPA is not
705 concerned with the size of the casing surrounding the physical storage disk, only that the size and
706 number of the physical disks remains the same in replacement storage devices. EPA believes that any
707 changes in the size or number of physical disks in the storage device will require retesting due to resulting
708 changes in the reported average power consumption in like modes of operation which will change by
709 greater than 10%, the limit defined in Section 3.6.2.iii.(d) above.

710 - Stakeholders stated that the ± 5% variation in the variables under Section 3.6.2.iii in Draft 4 was overly
711 stringent and did not allow for minor improvements in storage device technology. EPA is proposing to
712 modify the requirement to ± 10% in Section 3.6.2.iii. EPA also looks forward to stakeholder feedback on
713 this change. EPA's intention is to use a number that will not require frequent retesting but which will also
714 ensure that data on the ENERGY STAR qualified product list is reasonably current and data available for
715 development of Version 2.0 in the future will also be relevant to the state of the technology at the time.

716 - Sustained transfer rate has been moved from Section 3.6.2.iii to iv, and has been given a higher allowed
717 upper variance. As capacity in storage devices increases, this variable can rise quicker than the variables
718 in Section 3.6.2.iii, but it does not contribute to significant changes in the over storage product's
719 performance/watt results.

3.7   Standard Performance Data Measurement and Output Requirements

721 3.7.1   Data Elements: Online 3 and Online 4 storage products shall be capable of measuring and
722 reporting the following data elements at the storage product level:

723 i. Input Power, in watts. Input power measurements must be reported with accuracy of less
724 than or equal to ±5% of the actual value for measurements greater than 200 W, through
725 the full range of operation. For measurements less than or equal to 200 W, the accuracy
726 must be less than or equal to 10 W times the number of installed PSUs; and

727 ii. Inlet Air Temperature (optional), in degrees Celsius, with accuracy of ± 2°C.

---

728 **Note:** EPA has clarified that input power and inlet air temperature measurements shall be collected at the
729 system level in Version 1.0. A storage product is only required to report one value for input power and
730 optionally inlet air temperature, following the sampling guidelines in Section 3.7.3 below.

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731 3.7.2 Reporting Implementation:

      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.

733 3.7.3 Sampling Requirements:

      i.   *Input power*: Input power measurements must be sampled internally to the storage product at a rate of greater than or equal to measurement per contiguous 10 second period.

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

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

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

> **Note:** Based on discussions with stakeholders, EPA is eliminating the rolling average input power calculation requirement in Section 3.7.3.i above. Stakeholders are concerned that end-users request rolling average calculations on scales other than 30 seconds, and that this requirement is too restrictive to be applied across all storage product solutions. In addition, some storage products interact with external software solutions outside of the product itself to create rolling input power averages. EPA continues to encourage stakeholders to provide this rolling average capability to end-users as requested, and will investigate whether it is appropriate to reintroduce this requirement in Version 2.0.

3.7.4 Documentation Requirements: The following information shall be included in the PPDS:

      i.   Guaranteed accuracy levels for power and temperature measurements, and

      ii.   The time period used for data averaging.

3.7.5 Use of iPDUs: Section 3.7 may be satisfied in Version 1.0 using iPDUs. In order to satisfy the Data Elements requirement, an iPDU must:

      i.   Meet all requirements for accuracy, sampling, and data reporting;

      ii.   Be made available for sale and delivery with qualified ENERGY STAR storage products by appearing on the manufacturer's website and/or in marketing material where information on the storage product is displayed.

Note: EPA has clarified that iPDUs which satisfy the requirements in Section 3.7 must be available on the manufacturer's website or in marketing material along with the storage product information. The manufacturer may use third party sources for the iPDUs, but the iPDUs must be listed as a marketed and supported option for the storage product being qualified.

4 TESTING

4.1 Test Methods

4.1.1 Test methods identified in Table 8 shall be used for purposes of evaluating active and idle state storage product energy efficiency.

Table 8: Test Methods for ENERGY STAR Qualification

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

Note: The reference in this table is revised to point to the most up to date ENERGY STAR Test Method revision. This document, a draft of which is distributed with this Final Draft Specification, references the SNIA Emerald™ Power Efficiency Measurement Specification, Version 2.0.0 Rev 1 (December 2012).

4.2 Number of Units Required for Testing

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

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

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

5 EFFECTIVE DATE

5.1.1 Effective Date: The Version 1.0 ENERGY STAR Data Center Storage specification shall take effect on **November 5, 2013**. To qualify for ENERGY STAR, a product model shall meet the ENERGY STAR specification in effect on its date of manufacture. The date of manufacture is specific to each unit and is the date on which a unit is considered to be completely assembled.

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

6 CONSIDERATIONS FOR FUTURE REVISIONS

6.1 **Active and Idle State Efficiency Criteria:** EPA intends to set active and idle state efficiency criteria in Version 2.0 for all storage products in which it has enough data to adequately differentiate products.

6.2 **Right Sizing of Power Supplies:** EPA will investigate opportunities for encouraging right-sizing of power supplies in Version 2.0.

6.3 **Redundant Power Supply Standby:** EPA will investigate requiring redundant power supplies to switch to standby when not in use in Version 2.0. EPA is aware that this circuitry is already offered by some manufacturers in data center products.

6.4 **Expansion of Scope:** EPA will investigate expanding the scope of Version 2.0 to potentially cover larger Online products, as well as Near-Online, Removable Media Libraries, Virtual Media Libraries, and NAS only products. EPA may also explore requirements for SAN equipment if it not covered in the Version 1.0 Large Network Equipment Program Requirements currently under development.

Note: EPA has included considerations for future revisions of the ENERGY STAR Data Center Storage Specification. EPA welcomes feedback on additional topics that should appear in this list prior to finalization.