



ENERGY STAR[®] Program Requirements for Data Center Storage

Draft 1 Version 1.0

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ENERGY STAR[®] Program Requirements for Data Center Storage

Draft 1 Version 1.0 Partner Commitments

22 Commitment

23 **Note:** The Partner Commitments section will be expanded in the final specification to include new
24 ENERGY STAR testing requirements and other program changes proposed in the Enhanced Program
25 Plan for ENERGY STAR products. EPA will work with interested stakeholders to develop these new
26 requirements, and will be hosting a series of stakeholder meetings focused specifically on testing. Please
27 visit the ENERGY STAR Web site at www.energystar.gov/mou for additional information on the proposed
28 requirements and planned meetings.

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

- 32 • comply with current ENERGY STAR Eligibility Criteria, defining the performance criteria that must
33 be met for the marketing and sale of ENERGY STAR qualified storage products and specifying
34 the testing criteria for storage products. EPA may, at its discretion, conduct tests on products that
35 are referred to as ENERGY STAR qualified. These products may be obtained on the open market,
36 or voluntarily supplied by Partner at EPA's request;
- 37 • comply with current ENERGY STAR Identity Guidelines, describing how the ENERGY STAR
38 marks and name may be used. Partner is responsible for adhering to these guidelines and for
39 ensuring that its authorized representatives, such as advertising agencies, dealers, and
40 distributors, are also in compliance;
- 41 • qualify at least one ENERGY STAR storage product within one year of activating the storage
42 product portion of the agreement. When Partner qualifies a product, it must meet the specification
43 in effect at that time;

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

- 47 • provide clear and consistent identification of ENERGY STAR qualified storage products and
48 storage product families. Partner must use the ENERGY STAR mark in all of the following ways:
 - 49 ○ the ENERGY STAR mark shall be included on the product specification sheet on the
50 Partner's Web site where product information is displayed. This mark shall serve as a
51 hyperlink from the manufacturer's specification sheet to the ENERGY STAR Power and
52 Performance Data Sheet for the qualified storage product or storage product family;
 - 53 ○ the ENERGY STAR mark shall appear on the ENERGY STAR *Power and Performance*
54 *Data Sheet*, and
 - 55 ○ the ENERGY STAR mark shall be used to identify qualified storage products and storage
56 product families in electronic and printed marketing collateral materials, including but not
57 limited to user manuals, product guides, and marketing brochures.

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Note: The concept of “product family” is included in this first draft as a basis for discussion. The product family concept is included in the Version 1.0 ENERGY STAR computer server specification and implementation details are still under revision. The family concept may be well suited to the data center storage product category due to the high degree of customization and configurability of storage products. Stakeholders are encouraged to submit feedback on the suitability of the product family concept for storage, specifically with regard to the needs of their own sales channels.

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- work with Value Added Resellers (VARs) of Partner’s products to ensure that storage products remain in compliance with ENERGY STAR requirements. Any party within the distribution channel of an ENERGY STAR qualified storage product that alters the power profile of a product after its date of manufacture through hardware or software modifications must ensure that the product continues to meet the ENERGY STAR requirements through delivery to the end customer. If the product ceases to meet the requirements, it may not be marketed or sold as ENERGY STAR qualified;

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- if a VAR makes any modifications to a product qualified to this specification, re-brands the product, and promotes it as ENERGY STAR, the VAR must become an ENERGY STAR Partner and follow the requirements outlined in this specification;

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- provide to EPA, on an annual basis, an updated list of ENERGY STAR qualifying storage products. Once the Partner submits its first list of ENERGY STAR qualified storage products, the Partner will be listed as an ENERGY STAR Partner. Partner must provide annual updates in order to remain on the list of participating product manufacturers;

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

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- provide to EPA, on an annual basis, unit shipment data or other market indicators to assist in determining the market penetration of ENERGY STAR. Specifically, Partner must submit the total number of ENERGY STAR qualified storage products shipped (in units by model) or an equivalent measurement as agreed to in advance by EPA and Partner. Partner is also encouraged to provide ENERGY STAR qualified unit shipment data segmented by meaningful product characteristics (e.g., capacity, size, or other as relevant), total unit shipments for each model in its product line, and percentage of total unit shipments that qualify as ENERGY STAR. The data for each calendar year should be submitted to EPA, preferably in electronic format, no later than the following March and may be provided directly from the Partner or through a third party. The data will be used by EPA only for program evaluation purposes and will be closely controlled. If requested under the Freedom of Information Act (FOIA), EPA will argue that the data is exempt. Any information used will be masked by EPA so as to protect the confidentiality of the Partner;

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- notify EPA of a change in the designated responsible party or contacts for storage products within 30 days.

95 **Performance for Special Distinction**

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

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- consider energy efficiency improvements in company facilities and pursue the ENERGY STAR mark for buildings;

- 101 • purchase ENERGY STAR qualified products. Revise the company purchasing or procurement
102 specifications to include ENERGY STAR. Provide procurement officials' contact information to
103 EPA for periodic updates and coordination. Circulate general ENERGY STAR qualified product
104 information to employees for use when purchasing products for their homes;
- 105 • ensure the power management feature is enabled on all ENERGY STAR qualified displays and
106 computers in use in company facilities, particularly upon installation and after service is performed;
- 107 • provide general information about the ENERGY STAR program to employees whose jobs are
108 relevant to the development, marketing, sales, and service of current ENERGY STAR qualified
109 product models;
- 110 • feature the ENERGY STAR mark(s) on Partner Web site and in other promotional materials. If
111 information concerning ENERGY STAR is provided on the Partner Web site as specified by the
112 ENERGY STAR Web Linking Policy (this document can be found in the Partner Resources
113 section on the ENERGY STAR Web site at www.energystar.gov), EPA may provide links where
114 appropriate to the Partner Web site. The Partner shall comply with the ENERGY STAR Web
115 Linking Policy;
- 116 • provide a simple plan to EPA outlining specific measures Partner plans to undertake beyond the
117 program requirements listed above. By doing so, EPA may be able to coordinate, communicate,
118 and/or promote Partner's activities, provide an EPA representative, or include news about the
119 event in the ENERGY STAR newsletter, on the ENERGY STAR Web pages, etc. The plan may be
120 as simple as providing a list of planned activities or planned milestones that Partner would like
121 EPA to be aware of. For example, activities may include: (1) increase the availability of ENERGY
122 STAR labeled products by converting the entire product line within two years to meet ENERGY
123 STAR guidelines; (2) demonstrate the economic and environmental benefits of energy efficiency
124 through special in-store displays twice a year; (3) provide information to users (via the Web site
125 and user's manual) about energy-saving features and operating characteristics of ENERGY STAR
126 qualified products, and (4) build awareness of the ENERGY STAR partnership and brand identity
127 by collaborating with EPA on one print advertorial and one live press event;
- 128 • provide quarterly, written updates to EPA as to the efforts undertaken by Partner to increase
129 availability of ENERGY STAR qualified products, and to promote awareness of ENERGY STAR
130 and its message;
- 131 • join EPA's SmartWay Transport Partnership to improve the environmental performance of the
132 company's shipping operations. SmartWay Transport works with freight carriers, shippers, and
133 other stakeholders in the goods movement industry to reduce fuel consumption, greenhouse
134 gases, and air pollution. For more information on SmartWay, visit www.epa.gov/smartway;
- 135 • join EPA's Climate Leaders Partnership to inventory and reduce greenhouse gas emissions.
136 Through participation companies create a credible record of their accomplishments and receive
137 EPA recognition as corporate environmental leaders. For more information on Climate Leaders,
138 visit www.epa.gov/climateleaders;
- 139 • join EPA's Green Power partnership. EPA's Green Power Partnership encourages organizations
140 to buy green power as a way to reduce the environmental impacts associated with traditional fossil
141 fuel-based electricity use. The partnership includes a diverse set of organizations including
142 Fortune 500 companies, small and medium businesses, government institutions as well as a
143 growing number of colleges and universities, visit www.epa.gov/grnpower.



ENERGY STAR[®] Program Requirements for Data Center Storage

Draft 1 Version 1.0 Eligibility Criteria

Below is the Version 1.0 product specification for ENERGY STAR qualified data center storage products. A product must meet all of the identified criteria if it is to earn the ENERGY STAR.

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

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

1. Definitions

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

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

Note: A concise and unambiguous definition for “Storage Product” is critical to the success of this program. It is the storage product that will ultimately be subject to ENERGY STAR qualification. Subsystems and components of storage products will not be eligible for qualification. This definition is a work in progress – included in Draft 1 is a composite of best efforts by EPA and other industry organizations to date.

179 At the February 2 meeting, stakeholders suggested that the storage product definition and storage
180 taxonomy may need to be broad enough to apply to products such as: hybrid storage solutions that
181 include servers and database engines in addition to disk storage; hybrid storage solutions with
182 combinations of SSD and HDD, HDD and tape or optical storage, etc.; scale-out systems and subsystems;
183 and bare-bones JBOD (“just a bunch of disks”) products that consist only of a drawer and a collection of
184 HDDs. EPA welcomes additional feedback on the types of products that should be eligible to carry the
185 ENERGY STAR label, especially with regard to the way products or SKUs are marketed and sold to end-
186 users.

- 187 1) Storage Element: Any device designed and built primarily for the purpose of persistent data
188 storage and delivery. This definition specifically encompasses disk drives, tape drives, RAID
189 array subsystems, robotic tape libraries, filers, and file servers.
- 190 2) Storage Device: A collective term for disks, tapes, disk arrays, tape arrays, and any other
191 mechanisms capable of non-volatile data storage. This definition specifically excludes aggregating
192 storage elements such as RAID array subsystems, robotic tape libraries, filers, and file servers.
- 193 i) Storage Media: The material in a storage device on which data is recorded. Storage media
194 includes solid state, magnetic (e.g., hard disk, tape), and optical media.

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

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

205 B. Storage System Connectivity:

- 206 1) Direct-attached Storage (DAS): One or more dedicated storage devices that are physically
207 connected to one or more servers.
- 208 2) Network Attached Storage (NAS): One or more dedicated storage devices that connect to a
209 network and provide file access services to remote computer systems.
- 210 3) Storage Area Network (SAN): A network whose primary purpose is the transfer of data between
211 computer systems and storage elements and among storage elements. A SAN consists of a
212 communication infrastructure, which provides physical connections, and a management layer,
213 which organizes the connections, storage elements, and computer systems so that data transfer is
214 secure and robust.

215 C. Data Storage Efficiency: [TBD]

216 **Note:** Storage system software is an important contributor to overall system energy efficiency. Reducing
217 the number of disk drives in a system through the use of software features such as data deduplication,
218 data compression, delta snapshots, thin provisioning and RAID 5/6 should be considered in any
219 calculation of overall storage system energy efficiency. The Capacity Optimization Subgroup (COS) of the
220 SNIA Green Storage Technical Work Group (TWG) is currently working to characterize the various
221 software contributions to system efficiency with the goal of developing a single “data storage efficiency”
222 metric. EPA supports the efforts of the SNIA COS and intends to evaluate future software metrics for
223 inclusion in the ENERGY STAR Data Center Storage specification, either in the form of reporting
224 requirements or qualification requirements.

225 D. Storage Taxonomy¹: A categorization scheme for use in segmenting the data center storage market
226 by end-use application and key product characteristics. The major categories of the taxonomy that are
227 referenced in this document are as follows:

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

- 233 1) Online Storage: Storage products that are intended to service a mixture of Random and
234 Sequential I/O requests with a short response time. All data stored in Online storage must be
235 accessible in ≤ 80 ms, unless the storage product is in a Deep Idle state. Online storage is
236 typically comprised of one or more HDDs or SSDs and a storage controller, and provides primary
237 data storage to supplement a Computer Server's internal memory.
- 238 2) Near-online Storage: Storage products that are intended to service a mixture of Random and
239 Sequential I/O requests with a short to moderate response time. Near-online storage products
240 offer an asymmetrical response; a portion of data may be accessible in ≤ 80 ms, while other data
241 may be accessible in > 80 ms.
- 242 3) Virtual Media Library: Storage products that are intended to service primarily Sequential I/O, with a
243 short response time. The media in a Virtual Media Library (e.g., HDD, optical disk) is not designed
244 to be physically removed from the system. All data stored in the Virtual Media Library must be
245 assessable in ≤ 80 ms, unless the storage product is in a Deep Idle state. Virtual Media Libraries
246 are intended primarily for moderate and long term data storage.
- 247 4) Removable Media Library: Storage products that are intended to service primarily Sequential I/O,
248 with a moderate to long response time. The media (e.g., tape cartridge, optical disk) in a
249 Removable Media Library is designed to be physically removed from the storage product.
250 Removable Media Libraries are intended primarily for long term data archiving.

251 E. Other Data Center Equipment

- 252 1) Computer Server: A computer that provides services and manages networked resources for client
253 devices (e.g., desktop computers, notebook computers, thin clients, wireless devices, PDAs, IP
254 telephones, other computer servers and other network devices). Computer servers are sold
255 through enterprise channels for use in data centers and office/corporate environments. Computer
256 servers are primarily accessed via network connections, versus directly-connected user input
257 devices such as a keyboard or mouse. For purposes of this specification, a computer server must
258 meet all of the following criteria:
- 259 i) is marketed and sold as a computer server;
 - 260 ii) is designed for and listed as supporting computer server operating systems (OS) and/or
261 hypervisors, and is targeted to run user-installed enterprise applications;
 - 262 iii) provides support for error-correcting code (ECC) and/or buffered memory (including both
263 buffered DIMMs and buffered on board (BOB) configurations);
 - 264 iv) is packaged and sold with one or more ac-ac or dc-dc power supplies; and
 - 265 v) is designed such that all processors have access to shared system memory and are
266 independently visible to a single OS or hypervisor.

¹ The ENERGY STAR storage taxonomy is consistent with the taxonomy developed by the Storage
Networking Industry Association Green Storage Initiative. Further detail may be found at
www.snia.org/green.

- 267 2) Network Equipment: A device whose primary function is to provide data connectivity among an
268 arbitrary combination of devices connected to its several ports. Data connectivity is achieved via
269 the routing of data packets encapsulated according to Internet Protocol, Fibre Channel, InfiniBand
270 or other standard protocol. Examples of network equipment commonly found in data centers are
271 routers and switches.
- 272 3) Uninterruptible Power Supply (UPS): A device that is intended to supply limited-duration,
273 emergency electrical power to connected IT equipment in the event of a power grid failure.

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

- 276 4) Power Distribution Unit (PDU): A single- or three-phase power strip designed for data center use.
277 A PDU may include instrumentation for metering power input and output, switched outlets for
278 control of individual receptacles, or other advanced features.
- 279 5) Blade System: A system comprised of a blade chassis and one or more removable blade servers,
280 blade storage, or blade network equipment devices. Blade systems provide a scalable means for
281 combining multiple blade server or storage devices in a single enclosure, and are designed to
282 allow service technicians to easily add or replace (hot-swap) blades in the field.

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

- 290 F. Capacity: Capacity is reported in units of either binary bytes (1 MiB = 1,048,576 Byte) or decimal bytes
291 (1 MB = 1,000,000 Byte).
- 292 1) Assigned Capacity: The amount of space on a system or data container which has been allotted to
293 be written by an end user or application. (Note: For capacity-optimizing systems, an assigned
294 capacity number represents a promise that that amount of space will be provided on demand;
295 usable capacity is allocated as the container is written too. For fully-provisioned systems, usable
296 capacity must be committed at the same time the container is allocated.)
- 297 2) Effective Capacity: The amount of data stored on a storage system, plus the amount of unused
298 formatted capacity in the system.
- 299 3) Formatted (Usable) Capacity: The total amount of bytes available to be written after a system or
300 device has been formatted for use (e.g., by an object store, file system or block services
301 manager). Formatted capacity is less than or equal to raw capacity. It does not include areas set
302 aside for system use, spares, RAID parity areas, checksum space, host- or file system-level
303 remapping, "right sizing" of disks, disk labeling and so on. However, formatted capacity may
304 include areas that are normally reserved – such as snapshot set-asides – if these areas may be
305 configured for ordinary data storage.
- 306 4) Free Space: The amount of unused, formatted capacity as reported by the storage product.
- 307 5) Raw (Addressable) Capacity: The sum total amount of addressable capacity of the storage
308 devices in a storage product. The raw capacity of a storage device is commonly understood to be
309 the number of bytes available to be written via SCSI or equivalent protocol. It does not include
310 unaddressable space, ECC (error correcting code) data, remap areas, inter-sector gaps, etc.

311 **Note:** Capacity definitions in this draft are per the SNIA Dictionary. EPA welcomes stakeholder feedback
312 on the suitability and implications of these definitions.

313 G. Operational States:

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

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

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

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

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

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

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

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

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

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

- 355 3) Single-output Power Supply: A PSU that is designed to deliver the majority of its rated output
356 power to one primary dc output. Single-output PSUs may offer one or more standby outputs that
357 remain active whenever connected to an input power source. For purposes of this specification,
358 the total rated power output from all additional PSU outputs that are not primary and standby
359 outputs shall be less than 20 watts. PSUs that offer multiple outputs at the same voltage as the
360 primary output are considered single-output PSUs unless those outputs (1) are generated from
361 separate converters or have separate output rectification stages, or (2) have independent current
362 limits.
- 363 4) Multi-output Power Supply: A PSU that is designed to deliver the majority of its rated output power
364 to more than one primary dc output for the purpose of powering a storage product. Multi-output
365 PSUs may offer one or more standby outputs that remain active whenever connected to an input
366 power source. For purposes of this specification, the total rated power output from all additional
367 PSU outputs that are not primary and standby outputs must be greater than or equal to 20 watts.
- 368 5) Redundant Power Supplies: Two or more PSUs that are configured to maintain uninterrupted
369 output load in the event of failure of one PSU.

370 I. Product Family: [TBD]

371 **Table 1: Product Family Requirements**

Base Component	Same Part Number Required?	Same Technical Specifications Required?	Same Quantity Required?	Notes
TBD	TBD	TBD	TBD	TBD
TBD	TBD	TBD	TBD	TBD

- 372 1) Maximum Configuration: A product configuration that includes the combination of base
373 components that generates the maximum possible power consumption within a product family.
374 [TBD]
- 375 2) Minimum Configuration: A product configuration that includes the combination of base
376 components that generates the least possible power consumption within a product family. [TBD]
- 377 3) Typical Configuration: A product configuration that lies between the minimum and maximum
378 configurations and is representative of a product with high volume sales. [TBD]
- 379 4) Base Configuration: A product configuration that does not qualify for additional power allowances.
380 The base configuration is [TBD].

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

385 J. Other Definitions:

- 386 1) Field-replaceable Unit (FRU): A system component that is designed to be replaced by customers
387 or service personnel in the field, without requiring that the system be returned to a factory or other
388 site for repair.
- 389 2) High-availability (HA): The ability of a system to perform its function continuously (without
390 interruption) for a significantly longer period of time than the reliabilities of its individual
391 components would suggest. High availability is most often achieved through failure tolerance.

- 392 3) Maximum Sustainable Performance: Maximum I/O per second (IOPS) or GiB/s that the UUT is
393 able to deliver under a specified workload. For purposes of this specification, it is suggested that
394 “sustainable” performance is that which ensures the maximum achievable data rate, excludes any
395 transient system caching effects, and can be maintained to within $\pm 5\%$ for the duration of the
396 measurement phase.
- 397 4) Maximum Time to Data (MaxTTD): The maximum time before an entire data object is accessible
398 within the constraints imposed by its storage media. For random-access media, a data object is
399 accessible when any byte may be accessed. For sequential-access media, a data object is
400 accessible when the requested object has begun streaming from a previously inactive drive.
- 401 5) RAS Features: An acronym for reliability, availability, and serviceability features. RAS is
402 sometimes also expanded to RASM, which adds “Manageability” criteria. The three primary
403 components of RAS as related to storage products are defined as follows:
- 404 i) Reliability Features: Features supporting a storage product’s ability to perform its intended
405 function without interruption due to component failures. Technologies applied to increase
406 reliability include: component selection (MTBF), redundancy (both at a micro and macro
407 levels), temperature and/or voltage de-rating, error detection and correction technologies.
- 408 ii) Availability Features: Features that support a storage product’s ability to maximize normal
409 operating time and minimize planned and unplanned down time.
- 410 iii) Serviceability Features: Features that support a storage product’s ability to be serviced (e.g.,
411 hot-plugging).
- 412 iv) Non-disruptive Serviceability: Support for continued availability of data and response times
413 during all FRU and service operations; including break/fix, code patches, software/firmware
414 upgrades, configuration changes, data migrations, and system expansion.
- 415 6) Read/Write:
- 416 i) Random Read: Any I/O load in which consecutively issued read requests do not specify
417 adjacently addressed data. The term random I/O is commonly used to denote any I/O load
418 that is not sequential, whether or not the distribution of data locations is indeed random.
- 419 ii) Random Write: Any I/O load whose consecutively issued write requests do not specify
420 adjacently addressed data. The term random I/O is commonly used to denote any I/O load
421 that is not sequential, whether or not the distribution of data locations is indeed random.
- 422 iii) Sequential Read: An I/O load consisting of consecutively issued read requests to adjacently
423 addressed data.
- 424 iv) Sequential Write: An I/O load consisting of consecutively issued write requests to adjacently
425 addressed data.
- 426 7) Response Time: The time required for the UUT to complete an I/O request.
- 427 8) Single Point of Failure (SPOF): One component or path in a system, the failure of which would
428 make the system inoperable.
- 429 9) Unit Under Test (UUT): The Storage Product being tested.

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

436 **2. Qualifying Products**

437 **2.1. Included Products**

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

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

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

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

464 **2.2. Excluded Products**

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

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

- 470 1) Personal / Portable Data Storage Products
- 471 2) Computer Servers
- 472 3) Computers (Laptop, Desktop, Small Workstation, Thin-client, Game Console)
- 473 4) Data Center Network Equipment

474 **3. Energy Efficiency Criteria**

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

477 **3.1. PSU Efficiency Criteria**

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

480 **Table 2: Efficiency Requirements for PSUs**

PSU Type	Rated Output Power	10% Load	20% Load	50% Load	100% Load
TBD	TBD	TBD	TBD	TBD	TBD

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

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

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

497 **3.2. PSU Power Factor Criteria**

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

503 **Table 3: Power Factor Requirements for PSUs**

PSU Type	Rated Output Power	10% Load	20% Load	50% Load	100% Load
TBD	TBD	TBD	TBD	TBD	TBD

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

511 **3.3. Active State Efficiency Criteria**

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

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

519 **3.4. Idle State Efficiency Criteria**

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

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

525 **3.5. Power Management Requirements**

- 526 1) **Power Management Function:** To qualify for ENERGY STAR, a storage product must offer the
527 following power management features: [TBD]
- 528 2) **Power Management Disclosure:** To qualify for ENERGY STAR, all power management features
529 offered by the storage product must be itemized on the Power and Performance Data Sheet,
530 along with an indication of which features are enabled by default.

531 **3.6. Additional Requirements**

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

538 **4. Standard Information Reporting Requirements**

539 **4.1. Power and Performance Data Sheet (PPDS)**

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

542 **Note:** An example PPDS for the ENERGY STAR Computer Servers program is available on the ENERGY
543 STAR Product Development Web page at www.energystar.gov/NewSpecs under the link for Data Center
544 Storage. Stakeholders are encouraged to review the example data sheet and send comments regarding
545 data fields that should be included in a PPDS for data center storage products. EPA plans to distribute a
546 first draft of the storage PPDS for stakeholder review along with the next draft of the data center storage
547 product specification in the coming months.

548 Partners are encouraged to provide one data sheet for each ENERGY STAR qualified storage product,
549 though EPA will also accept a data sheet for each qualified storage product family. A product family PPDS
550 must include data for Maximum, Minimum and Typical configurations as defined in Section 1 of this
551 document. Whenever possible, Partners must also provide a hyperlink to a more detailed power calculator
552 on their Web site that purchasers can use to understand power and performance data for specific products
553 within the product family.

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

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

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

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

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

576 **5. Standard Performance Data Measurement and Output Requirements**

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

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

- 586 1) Implementation: To qualify for ENERGY STAR:

- 587 i) a storage product must make energy performance data available to end users via either
588 embedded components or add-in devices that are packaged with the storage product (e.g., a
589 service processor, embedded power or thermal meter or other out-of-band technology); and
- 590 ii) when an open and universally available data collection and reporting standard becomes
591 available, manufacturers shall incorporate the universal standard into their systems.
- 592 2) Measurement Accuracy: To qualify for ENERGY STAR:
- 593 i) input power measurements must be reported with accuracy of less than or equal to 5% of the
594 actual value for measurements greater than 200 W, through the full range of operation. For
595 measurements less than or equal to 200 W, the accuracy must be less than or equal to 10 W
596 times the number of installed PSUs; and

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

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

603 3) Sampling Requirements: To qualify for ENERGY STAR:

- 604 i) input power measurements must be collected at a rate of greater than or equal to one
605 measurement per second. A rolling average, encompassing a period of no more than 30
606 seconds, must be reported at a frequency of greater than or equal to one per second; and
- 607 ii) inlet air temperature measurements must be collected and reported at a rate of greater than or
608 equal to one measurement every 10 seconds.

609 6. Testing

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

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

628 **7. Product Qualification**

629 **7.1. Storage Product Qualification Requirements**

630 The party that ultimately sells an ENERGY STAR qualified storage product to an end-user is responsible
631 for ensuring that the product meets all applicable ENERGY STAR qualification criteria.

632 The following requirements apply to storage products that are sold to end-users through indirect, 3rd-party
633 sales channels: [TBD]

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

639 **7.2. Product Family Qualification Requirements**

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

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

- 647 1. Individual storage products are built on the same platform and are identical in every respect to
648 the tested, representative storage product except for [TBD]; or
- 649 2. Individual products meet the requirements of a product family, as defined in Section 1 of this
650 document. In this case, partners must test and submit power data on [TBD].

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

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

659 **8. Effective Date**

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

662 Qualifying and Marking Products under the Version 1.0 Specification: The effective date for this
663 specification is [TBD]. All products with a date of manufacture on or after this effective date must meet
664 applicable Version 1.0 requirements in order to qualify for ENERGY STAR. The date of manufacture is
665 specific to each unit and is the date (e.g., month and year) on which a unit is considered to be completely
666 assembled.

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Note: EPA will likely distribute two or more drafts of the storage specification before publishing the final specification. Subsequent drafts will include revisions based on stakeholder comments on Draft 1, plus additional content to define energy efficiency requirements based on the results of ongoing data collection and analysis. Since data center storage is a new program, eligible storage products will be able to qualify for ENERGY STAR immediately upon finalization of this specification.

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

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9. Future Specification Revisions

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EPA reserves the right to revise this specification should technological and/or market changes affect its usefulness to consumers, industry, or the environment. In keeping with current policy, revisions to the specification are arrived at through industry discussions. To carry the ENERGY STAR mark, a product model must meet the ENERGY STAR program requirements that are in effect on the date of manufacture of the product.