



ENERGY STAR® Program Requirements

for Data Center Storage Partner Commitments

1 Following are the terms of the ENERGY STAR Partnership Agreement as it pertains to the manufacture
2 and labeling of ENERGY STAR qualified products. The ENERGY STAR Partner must adhere to the
3 following partner commitments:

4 **Qualifying Products**

- 5 1. Comply with current ENERGY STAR Eligibility Criteria, which define performance requirements and
6 test procedures for Data Center Storage. A list of eligible products and their corresponding Eligibility
7 Criteria can be found at www.energystar.gov/specifications.
- 8 2. **Prior to associating the ENERGY STAR name or mark with any product**, obtain written
9 certification of ENERGY STAR qualification from a Certification Body recognized by EPA for Data
10 Center Storage. As part of this certification process, products must be tested in a laboratory
11 recognized by EPA to perform Data Center Storage testing. A list of EPA-recognized laboratories and
12 certification bodies can be found at www.energystar.gov/testingandverification.

14 **Using the ENERGY STAR Name and Marks**

- 15 3. Comply with current ENERGY STAR Identity Guidelines, which define how the ENERGY STAR name
16 and marks may be used. Partner is responsible for adhering to these guidelines and ensuring that its
17 authorized representatives, such as advertising agencies, dealers, and distributors, are also in
18 compliance. The ENERGY STAR Identity Guidelines are available at www.energystar.gov/logouse.
- 19 4. Use the ENERGY STAR name and marks only in association with qualified products. Partner may not
20 refer to itself as an ENERGY STAR Partner unless at least one product is qualified and offered for
21 sale in the U.S and/or ENERGY STAR partner countries.
- 22 5. Provide clear and consistent labeling of ENERGY STAR qualified Data Center Storage.

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24 Partner shall adhere to the following product-specific commitments regarding use of the ENERGY
25 STAR certification mark on qualified products:

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27 5.1. Partner must use the ENERGY STAR mark in all of the following ways:

28 5.1.1. The ENERGY STAR mark shall be included on the product specification sheet on the
29 Partner's Web site where product information is displayed. This mark shall serve as a
30 hyperlink from the manufacturer's specification sheet to the ENERGY STAR product
31 website for Data Center Storage;

32 5.1.2. The ENERGY STAR mark shall be used to identify qualified storage products and storage
33 product families in electronic and printed marketing collateral materials, including but not
34 limited to user manuals, product guides, and marketing brochures.

35 5.2. If additional information about the ENERGY STAR program(s) or other products provided by the
36 Partner on its Web site, Partner must comply with the *ENERGY STAR Web Linking Policy*, which
37 can be found at www.energystar.gov/partners.

38 **Verifying Ongoing Product Qualification**

- 39 6. Participate in third-party verification testing through a Certification Body recognized by EPA for Data
40 Center Storage, providing full cooperation and timely responses, EPA/DOE may also, at its discretion,

41 conduct tests on products that are referred to as ENERGY STAR qualified. These products may be
42 obtained on the open market, or voluntarily supplied by Partner at the government's request.

43 44 **Providing Information to EPA**

45 7. Provide unit shipment data or other market indicators to EPA annually to assist with creation of
46 ENERGY STAR market penetration estimates, as follows:

47 7.1. Partner must submit the total number of ENERGY STAR qualified Data Center Storage shipped
48 in the calendar year or an equivalent measurement as agreed to in advance by EPA and
49 Partner. Partner shall exclude shipments to organizations that rebrand and resell the shipments
50 (unaffiliated private labelers).

51 7.2. Partner must provide unit shipment data segmented by meaningful product characteristics (e.g.,
52 type, capacity, presence of additional functions) as prescribed by EPA.

53 7.3. Partner must submit unit shipment data for each calendar year to EPA or an EPA-authorized
54 third party, preferably in electronic format, no later than March 1 of the following year.

55 Submitted unit shipment data will be used by EPA only for program evaluation purposes and will be
56 closely controlled. If requested under the Freedom of Information Act (FOIA), EPA will argue that the
57 data is exempt. Any information used will be masked by EPA so as to protect the confidentiality of the
58 Partner;

59 8. Report to EPA any attempts by recognized laboratories or Certification Bodies (CBs) to influence
60 testing or certification results or to engage in discriminatory practices.

61 9. Notify EPA of a change in the designated responsible party or contacts within 30 days using the My
62 ENERGY STAR Account tool (MESA) available at www.energystar.gov/mesa.

63 64 65 **Performance for Special Distinction**

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

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70 ▪ Provide quarterly, written updates to EPA as to the efforts undertaken by Partner to increase
71 availability of ENERGY STAR qualified products, and to promote awareness of ENERGY STAR and
72 its message.
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74 ▪ Consider energy efficiency improvements in company facilities and pursue benchmarking buildings
75 through the ENERGY STAR Buildings program.
- 76
77 ▪ Purchase ENERGY STAR qualified products. Revise the company purchasing or procurement
78 specifications to include ENERGY STAR. Provide procurement officials' contact information to EPA
79 for periodic updates and coordination. Circulate general ENERGY STAR qualified product information
80 to employees for use when purchasing products for their homes.
- 81
82 ▪ Feature the ENERGY STAR mark(s) on Partner website and other promotional materials. If
83 information concerning ENERGY STAR is provided on the Partner website as specified by the
84 ENERGY STAR Web Linking Policy (available in the Partner Resources section of the ENERGY
85 STAR website), EPA may provide links where appropriate to the Partner website.
- 86
87 ▪ Ensure the power management feature is enabled on all ENERGY STAR qualified displays and
88 computers in use in company facilities, particularly upon installation and after service is performed.
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90 ▪ Provide general information about the ENERGY STAR program to employees whose jobs are
91 relevant to the development, marketing, sales, and service of current ENERGY STAR qualified
92 products.

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- Provide a simple plan to EPA outlining specific measures Partner plans to undertake beyond the program requirements listed above. By doing so, EPA may be able to coordinate, and communicate Partner's activities, provide an EPA representative, or include news about the event in the ENERGY STAR newsletter, on the ENERGY STAR website, etc. The plan may be as simple as providing a list of planned activities or milestones of which Partner would like EPA to be aware. For example, activities may include: (1) increasing the availability of ENERGY STAR qualified products by converting the entire product line within two years to meet ENERGY STAR guidelines; (2) demonstrating the economic and environmental benefits of energy efficiency through special in-store displays twice a year; (3) providing information to users (via the website and user's manual) about energy-saving features and operating characteristics of ENERGY STAR qualified products; and (4) building awareness of the ENERGY STAR Partnership and brand identity by collaborating with EPA on one print advertorial and one live press event.
 - Join EPA's SmartWay Transport Partnership to improve the environmental performance of the company's shipping operations. The SmartWay Transport Partnership works with freight carriers, shippers, and other stakeholders in the goods movement industry to reduce fuel consumption, greenhouse gases, and air pollution. For more information on SmartWay, visit www.epa.gov/smartway.
 - Join EPA's Green Power Partnership. EPA's Green Power Partnership encourages organizations to buy green power as a way to reduce the environmental impacts associated with traditional fossil fuel-based electricity use. The partnership includes a diverse set of organizations including Fortune 500 companies, small and medium businesses, government institutions as well as a growing number of colleges and universities. For more information on Green Power, visit www.epa.gov/greenpower.



ENERGY STAR® Program Requirements for Data Center Storage

Eligibility Criteria Draft 3 Version 1.0

110 Following is the Draft 3 ENERGY STAR Version 1.0 product specification for Data Center Storage. A
111 product shall meet all of the identified criteria if it is to earn the ENERGY STAR.

12 1 DEFINITIONS

113 A. Product Types:

- 114 1) Storage Product: A fully-functional storage system that supplies data storage services to
115 clients and devices attached directly or through a network. Components and subsystems that
116 are an integral part of the storage product architecture (e.g., to provide internal
117 communications between controllers and disks) are considered to be part of the storage
118 product. In contrast, components that are normally associated with a storage environment at
119 the data center level (e.g., devices required for operation of an external SAN) are not
120 considered to be part of the storage product. A storage product may be composed of
121 integrated storage controllers, storage devices, embedded network elements, software, and
122 other devices. For purposes of this specification, a storage product is a unique configuration
123 of one or more SKUs, sold and marketed to the end user as a Storage Product.
- 124 2) Storage Device: A collective term for disk drives (HDDs), solid state drives (SSDs), tapes
125 cartridges, and any other mechanisms providing non-volatile data storage. This definition is
126 specifically intended to exclude aggregating storage elements such as RAID array
127 subsystems, robotic tape libraries, filers, and file servers. Also excluded are storage devices
128 which are not directly accessible by end-user application programs, and are instead
129 employed as a form of internal cache.
- 130 3) Storage Controller: A device for handling storage request via a processor or sequencer
131 programmed to autonomously process a substantial portion of I/O requests directed to
132 storage devices (e.g., RAID controllers, filers).

133 B. Storage System Connectivity:

- 134 1) Direct-attached Storage (DAS): One or more dedicated storage devices that are physically
135 connected to one or more servers.
- 136 2) Network Attached Storage (NAS): One or more dedicated storage devices that connect to a
137 network and provide file access services to remote computer systems.
- 138 3) Storage Area Network (SAN): A network whose primary purpose is the transfer of data
139 between computer systems and storage devices and among storage devices. A SAN consists
140 of a communication infrastructure, which provides physical connections, and a management
141 layer, which organizes the connections, storage devices, and computer systems so that data
142 transfer is secure and robust.

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

- 145 1) Thin Provisioning: A technology that allocates the physical capacity of a volume or file system
146 as applications write data, rather than reallocating all the physical capacity at the time of
147 provisioning.
- 148 2) Data Deduplication: The replacement of multiple copies of data – at variable levels of
149 granularity – with references to a shared copy in order to save storage space and/or
150 bandwidth.
- 151 3) Compression: The process of encoding data to reduce its size. For the purpose of this
152 specification, only lossless compression (i.e., compression using a technique that preserves
153 the entire content of the original data, and from which the original data can be reconstructed
154 exactly) is recognized.
- 155 4) Delta Snapshots: A type of point-in-time copy that preserves the state of data at an instant in
156 time by storing only those blocks that are different from an already existing full copy of the
157 data.

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

- 161 1) Online Storage: Storage products that are intended to service a mixture of Random and
162 Sequential I/O requests with a short response time. All data stored in Online storage must be
163 accessible in ≤ 80 ms, unless the storage product is in a Deep Idle state. Online storage is
164 typically comprised of one or more HDDs or SSDs and a storage controller, and provides
165 primary data storage to supplement a Computer Server's internal memory.
- 166 2) Near-online Storage: Storage products that are intended to service a mixture of Random and
167 Sequential I/O requests with a short to moderate response time. Near-online storage
168 products offer an asymmetrical response; a portion of data may be accessible in ≤ 80
169 milliseconds, while other data may be accessible in > 80 milliseconds.
- 170 3) Virtual Media Library: Storage products that are intended to service primarily Sequential I/O,
171 with a short response time. The media in a Virtual Media Library (e.g., HDD, optical disk) is
172 not designed to be physically removed from the system. All data stored in the Virtual Media
173 Library must be assessable in ≤ 80 ms, unless the storage product is in a Deep Idle state.
174 Virtual Media Libraries are intended primarily for moderate and long term data storage.
- 175 4) Removable Media Library: Storage products that are intended to service primarily Sequential
176 I/O, with a moderate to long response time. The media (e.g., tape cartridge, optical disk) in a
177 Removable Media Library is designed to be physically removed from the storage product.
178 Removable Media Libraries are intended primarily for long term data archiving.
- 179 5) Adjunct Storage Products: Products which closely support storage devices by adding in real
180 time value or additional control capabilities not present in the storage device(s) itself.
181 Examples include SAN based virtualization controllers, NAS gateways, or other storage
182 services. A key feature of these products is that no end user data is primarily stored on
183 Adjunct Storage products, though data may be held in cache or other working buffers.
- 184 6) Interconnect Element: Devices which provide for interconnection functionality within a storage
185 area network. Examples include SAN Switches, etc.

186 E. Other Data Center Equipment:

¹ The ENERGY STAR storage taxonomy is consistent with the taxonomy developed by the Storage Networking Industry Association Green Storage Initiative as defined in "SNIA Emerald™ Power Efficiency Measurement Specification" Version 1.0 released 23 August 2011. Further detail may be found at www.snia.org/green.

- 187 1) Computer Server: A computer that provides services and manages networked resources for
188 client devices (e.g., desktop computers, notebook computers, thin clients, wireless devices,
189 PDAs, IP telephones, other computer servers and other network devices). Computer servers
190 are sold through enterprise channels for use in data centers and office/corporate
191 environments. Computer servers are primarily accessed via network connections, versus
192 directly-connected user input devices such as a keyboard or mouse. For purposes of this
193 specification, a computer server must meet all of the following criteria:
- 194 i) is marketed and sold as a computer server;
 - 195 ii) is designed for and listed as supporting computer server operating systems (OS) and/or
196 hypervisors, and is targeted to run user-installed enterprise applications;
 - 197 iii) provides support for error-correcting code (ECC) and/or buffered memory (including both
198 buffered DIMMs and buffered on board (BOB) configurations) - systems with greater than
199 50 nodes sharing the same chassis are exempt from this requirement; and
 - 200 iv) is packaged and sold with one or more ac-dc or dc-dc power supplies; and
 - 201 v) is designed such that all processors have access to shared system memory and are
202 independently visible to a single OS or hypervisor.

203 **Note:** The Computer Server definition presented here is from the Draft 2 Version 2.0 ENERGY STAR
204 Computer Server specification. It will be updated in the final Data Center Storage specification to
205 reference any revisions made in the finalized Version 2.0 ENERGY STAR Computer Server specification
206 revision effort.

- 207 2) Network Equipment: A device whose primary function is to provide data connectivity among
208 an arbitrary combination of devices connected to its several ports. Data connectivity is
209 achieved via the routing of data packets encapsulated according to Internet Protocol, Fibre
210 Channel, InfiniBand or other standard protocol. Examples of network equipment commonly
211 found in data centers are routers and switches.
- 212 3) Power Distribution Unit (PDU): A single- or three-phase power strip designed for data center
213 use. A PDU may include instrumentation for metering power input and output, switched
214 outlets for control of individual receptacles, or other advanced features.
- 215 i) Intelligent Power Distribution Unit (iPDU): A PDU with additional functionality to provide
216 operational measurements of power consumption and environmental temperature.
- 217 4) Blade Storage: A storage device that is designed for use in a blade chassis. A blade storage
218 device is dependent upon shared blade chassis resources (e.g., power supplies, cooling) for
219 operation.

220 **Note:** The Blade System definition from the Version 2.0 ENERGY STAR Computer Server specification
221 has been removed. EPA has added a definition for Blade Storage in its place.

- 222 5) Cache: Temporary storage used to transparently store transitory data and which is not
223 directly addressable by end-user applications. Primarily used for expediting access to or
224 from (typically) slower media.
- 225 F. Capacity: Capacity is reported in units of either binary bytes (1 MiB = 1,048,576 Byte) or decimal
226 bytes (1 MB = 1,000,000 Byte).

- 227 1) Assigned Capacity: The amount of space on a system or data container which has been
228 allotted to be written by an end user or application. (Note: For thin provisioning systems, an
229 assigned capacity number represents a promise that that amount of space will be provided on
230 demand; usable capacity is allocated as the container is written too. For fully-provisioned
231 systems, usable capacity must be committed at the same time the container is allocated.)
- 232 2) Effective Capacity: The amount of data stored on a storage system, plus the amount of
233 unused formatted capacity in the system.
- 234 3) Formatted (Usable) Capacity: The total amount of bytes available to be written after a system
235 or device has been formatted for use (e.g., by an object store, file system or block services
236 manager). Formatted capacity is less than or equal to raw capacity. It does not include areas
237 set aside for system use, spares, RAID parity areas, checksum space, host- or file system-
238 level remapping, "right sizing" of disks, disk labeling and so on. However, formatted capacity
239 may include areas that are normally reserved – such as snapshot set-asides – if these areas
240 may be configured for ordinary data storage.
- 241 4) Free Space: The amount of unused, formatted capacity as reported by the storage product.
- 242 5) Raw (Addressable) Capacity: The sum total amount of addressable capacity of the storage
243 devices in a storage product. The raw capacity of a storage device is commonly understood
244 to be the number of bytes available to be written via SCSI or equivalent protocol. It does not
245 include unaddressable space, ECC (error correcting code) data, remap areas, inter-sector
246 gaps, etc.

247 G. Operational States:

- 248 1) Active State: The state in which a storage product is processing external I/O requests.
- 249 2) Idle State: An operational state in which the Storage Product is capable of completing I/O
250 transactions, but no active I/Os are requested or pending. The system may, however, be
251 servicing self-initiated I/Os from background data protection and cleansing, and other
252 operations not initiated by the user.
- 253 i) Ready Idle: The state in which a storage product is able to respond to arbitrary I/O
254 requests within the MaxTTFD limits for its taxonomy category, but is not receiving
255 external I/O requests. The storage product may perform routine housekeeping tasks
256 during Ready Idle, provided such operations do not compromise the product's ability to
257 meet MaxTTFD requirements.
- 258 ii) Deep Idle: A state in which one or more storage product components or subsystems have
259 been placed into a low-power state for purpose of conserving energy. A storage product
260 in Deep Idle may not be able to respond to I/O requests within the MaxTTFD limits for its
261 taxonomy category, and may need to perform a managed 'wake-up' function in order to
262 return to a Ready Idle or Active State. Deep Idle capability must be a user-selected,
263 optional feature of the Storage Product.

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

- 269 1) Ac-Dc Power Supply: A PSU that converts line-voltage ac input power into one or more dc
270 power outputs.
- 271 2) Dc-dc Power Supply: A PSU that converts line-voltage dc input power to one or more dc
272 power outputs. For purposes of this specification, a dc-dc converter (also known as a voltage
273 regulator) that is internal to a storage product and is used to convert a low voltage dc (e.g., 12
274 V dc) into other dc power outputs for use by storage product components is not considered a
275 dc-dc power supply.

- 276 3) Single-output Power Supply: A PSU that is designed to deliver the majority of its rated output
277 power to one primary dc output. Single-output PSUs may offer one or more standby outputs
278 that remain active whenever connected to an input power source. For purposes of this
279 specification, the total rated power output from all additional PSU outputs that are not primary
280 and standby outputs shall be less than 20 watts. PSUs that offer multiple outputs at the same
281 voltage as the primary output are considered single-output PSUs unless those outputs (1) are
282 generated from separate converters or have separate output rectification stages, or (2) have
283 independent current limits.
- 284 4) Multi-output Power Supply: A PSU that is designed to deliver the majority of its rated output
285 power to more than one primary dc output for the purpose of powering a storage product.
286 Multi-output PSUs may offer one or more standby outputs that remain active whenever
287 connected to an input power source. For purposes of this specification, the total rated power
288 output from all additional PSU outputs that are not primary and standby outputs must be
289 greater than or equal to 20 watts.
- 290 5) Redundant Power Supplies: Two or more PSUs that are configured to maintain uninterrupted
291 output load in the event of failure of one PSU.
- 292 I. Product Family: A group of models/configurations that share a set of common attributes that are
293 variations on a basic design.
- 294 1) Common Product Family Attributes: A set of features common to all models/configurations
295 within a product family that constitute a common basic design. All models/configurations
296 within a product family must share the following:
- 297 i) made by the same manufacturer;
- 298 ii) be from the same model line or machine type;
- 299 iii) utilize the same model of Storage Controller;
- 300 iv) fall under the same taxonomy category;
- 301 v) contain equal or greater amount of cache than the corresponding qualified configuration;
- 302 and
- 303 vi) TBD.

304 **Note:** EPA has received stakeholder feedback stating that variation in cache configuration should be
305 allowed within a product family, with a maximum allowable cache size of 4 SSD storage devices. EPA
306 welcomes stakeholder feedback on this addition. EPA has defined common product family attributes, but
307 welcomes additions to this list to differentiate product families.

- 308 2) Optimal Configuration: A product configuration that lies between the minimum and maximum
309 configurations and is representative of a product with maximum sellable energy efficiency
310 performance for a given workload. This configuration is provided by the manufacturer and
311 can be optimized for the following workload types:
- 312 i) Transaction: A workload optimized for random I/O usage measured in I/O per second per
313 watt;
- 314 ii) Streaming: A workload optimized primarily for sequential I/O usage, measured in MB per
315 second per watt;
- 316 iii) Capacity: A workload optimized for maximum storage as measured by GB per watt.
- 317 3) Maximum Configuration: A product configuration that includes the combination of base
318 components that generates a system which is 5% larger in storage device count than the
319 optimal configuration.

- 320 i) For system with 150 storage device count or higher, the number is rounded up to the
321 nearest drawer boundary.
- 322 ii) Rounding is not applicable to systems with fewer than 150 storage devices.
- 323 4) Minimum Configuration: A product configuration that includes the combination of base
324 components that generates a system which is 20% smaller in storage device count compared
325 to the optimal configuration.
- 326 i) For a system with 150 storage device count or higher, the number is rounded down to the
327 nearest drawer boundary.
- 328 ii) Rounding is not applicable to systems with fewer than 150 storage devices.

329 **Note:** EPA has removed the typical configuration definition and replaced it with an Optimal Configuration
330 definition that aligns with the Best Foot Forward concept developed by SNIA. The definitions of maximum
331 and minimum configurations have been revised to reflect the allowable range of a product family for
332 qualification purposes.

333 Based on discussions to date and the data available, the language above is a proposal to create a
334 Product Family structure that is defined by system size and workload configuration for ENERGY STAR
335 qualification. The "Maximum" and "Minimum" in such an approach refer to the maximum and minimum
336 configurations that the manufacturer can sell as ENERGY STAR qualified, which is not necessarily the
337 same as the maximum or minimum of available configuration options for sale by the manufacturer.

338 EPA has discussed this new approach with stakeholders over the months preceding this draft release and
339 has received primarily positive feedback. Qualification of systems will be allowed for systems within the
340 range defined by the minimum and maximum configurations for each optimal configuration submitted for
341 qualification. This definition provides EPA with well-defined boundaries that delineate product families and
342 assure that energy performance within a family is characterized across a range of system sizes. In
343 addition, this approach supports the assembly and disclosure of active mode and ready idle mode test
344 measurement data, which will provide useful information to the product end-user. EPA continues to
345 welcome stakeholder input on the overall approach as well as rounding systems to the nearest drawer
346 boundary.

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

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

- 353 5) Expanded Minimum Configuration (Optional): A manufacturer may submit additional physical
354 data points using configurations which contain a number of Storage Devices less than the
355 required Minimum Configuration defined above if the expanded performing point is within
356 10% of the Optimal Configuration performance (work/watt). The required Minimum
357 Configuration point above can be replaced with this new lower count of Storage Devices.
- 358 i) Performance will be measured using the appropriate relative weighting of workloads
359 defined in Table 6.
- 360 ii) Modeled data may not be used in Expanded Minimum Configuration submissions.
- 361 6) Systems Composed of Combinations of Optimal Configurations: A product family which has
362 demonstrated more than one Optimal Configuration may be sold as ENERGY STAR qualified
363 using a combination of those Optimal Configurations, provided **all** of the following apply:

- 364 i) Combined systems are configured using only those Storage Devices and configuration
365 options which were used in the individual qualified Optional Configurations.
- 366 ii) The combined system contains a defined percent allocation of Storage Devices from the
367 Optimal Configurations.
- 368 iii) The total sum of all percent allocations of Storage Devices drawn from the Optimal
369 Configurations must equal 100%
- 370 iv) The quantity of Storage Devices is adjusted by the percent allocation for the given
371 Optimal Configuration.
- 372 v) After allocation, Storage Devices and Drawers are rounded per the Maximum
373 Configuration and Minimum Configuration rules above.
- 374 vi) When rounding a Drawer, Storage Devices are added (or removed as appropriate) in a
375 ratio similar to the Optimal Configuration allocation percentages.
- 376 vii) Allocation of Optimal Configurations is also used when a Storage Product provides Block
377 I/O capability in addition to NAS capabilities. In this usage, the system wide percentage of
378 defined allocations will include the portion of the system providing NAS functionality.
379 There are no constraints on the size of the NAS portion of the system.
- 380 viii) Multiple transaction or streaming optimizations may be submitted to incorporate different
381 storage device technologies and customer usage needs.

382 **Note:** The above language is designed to allow manufacturers to qualify combinations of Optimal
383 Configurations, as there are relatively few products sold on the market that are fully optimized for a single
384 workload type. More often, combinations of systems are created that can handle two or more workloads.

385 EPA therefore has proposed that manufacturers can submit Optimal Configuration test points and then
386 product combinations of those Optimal Configurations will remain ENERGY STAR qualified, provided they
387 meet all of the criteria above. EPA welcomes stakeholder feedback on the treatment of systems
388 composed of combinations of optimal configurations.

389 The language above states that if multiple Optimal Configurations are qualified, manufacturers may then
390 create systems that utilize X% of drives from one configuration, Y% of drives from another and that $X\% +$
391 $Y\% = 100\%$. Normal drawer rounding would then apply to the combined configuration. This principle also
392 applies to systems combining more than two Optimal Configurations.

393 EPA looks forward to stakeholder feedback on this proposal and to hosting further discussion on this
394 matter.

- 395 7) Capacity Optimization Family Restriction: A product family may not be based solely on
396 Capacity Optimizations. Every product family must include one or more transaction
397 optimized configuration(s) and/or streaming optimized configuration(s). A Capacity
398 Optimization may only be submitted as an addition to one (or more) of the other
399 optimizations.

400 **Note:** EPA welcomes feedback from stakeholders on the above proposal to include a Capacity
401 Optimization option but require that it can only be submitted in addition to a Transaction or Streaming
402 Optimization qualification.

403 J. Other Definitions:

- 404 1) Scale-up Storage Product: A storage product in which additional storage devices can be
405 added to the original controller(s) configuration as capacity needs increase.
- 406 2) Scale-out Storage Product: A storage product in which independent functional nodes contain
407 a set number of storage devices and controllers associated with those devices. All nodes
408 have the ability to work in tandem with additional nodes as customer capacity needs
409 increase.

410 **Note:** EPA has provided definitions for scale-up and scale-out storage products to clarify which of these
411 products are covered in the scope of the specification. EPA welcomes feedback on these definitions.

- 412 3) Field-replaceable Unit (FRU): A unit, or component of a system that is designed to be
413 replaced “in the field;” i.e., without returning the system to a factory or repair depot. Field
414 replaceable units may either be customer-replaceable, or their replacement may require
415 trained service personnel.
- 416 4) High-availability (HA): The ability of a system to perform its function continuously (without
417 interruption) for a significantly longer period of time than the reliabilities of its individual
418 components would suggest. High availability is most often achieved through failure tolerance.
- 419 5) Maximum Sustainable Performance: Maximum I/O per second (IOPS) or GiB/s that the UUT
420 is able to deliver under a specified workload. For purposes of this specification, it is
421 suggested that “sustainable” performance is that which ensures the maximum achievable
422 data rate, excludes any transient system caching effects, and can be maintained to within
423 $\pm 5\%$ for the duration of the measurement phase.
- 424 6) Maximum Time to First Data (MaxTTFD): The maximum time required to start receiving data
425 from a storage system to satisfy a read request for arbitrary data.
- 426 7) RAS Features: An acronym for reliability, availability, and serviceability features. RAS is
427 sometimes also expanded to RASM, which adds “Manageability” criteria. The three primary
428 components of RAS as related to storage products are defined as follows:
- 429 i) Reliability Features: Features supporting a storage product’s ability to perform its
430 intended function without interruption due to component failures. Technologies applied to
431 increase reliability include: component selection (MTBF), redundancy (both at a micro
432 and macro levels), temperature and/or voltage de-rating, error detection and correction
433 technologies.
- 434 ii) Availability Features: Features that support a storage product’s ability to maximize normal
435 operating time and minimize planned and unplanned down time.
- 436 iii) Serviceability Features: Features that support a storage product’s ability to be serviced
437 (e.g., hot-plugging).
- 438 iv) Parity RAID: A collective term used in this specification to refer to any RAID system that
439 achieves better efficiency than RAID 1 (i.e., mirroring).

440 **Note:** EPA has moved the parity RAID definition from the COM definition section into the RAS definition
441 section, as parity RAID is not listed as a COM feature in Table 3 below.

- 442 v) Non-disruptive Serviceability: Support for continued availability of data and response
443 times during all FRU and service operations; including break/fix, code patches,
444 software/firmware upgrades, configuration changes, data migrations, and system
445 expansion.

- 446 8) Physical Data: Data generated by testing a Storage Product using the ENERGY STAR Test
447 Method for Data Center Storage.
- 448 9) Modeled Data: Data generated from an algorithmic tool, designed either by the ENERGY
449 STAR Partner or a third party, which generates estimated test results (e.g., power,
450 performance) for a set of Storage Product configuration inputs.

451 **Note:** EPA has defined the difference between physical and modeled data and welcomes stakeholder
452 feedback on these definitions.

- 453 10) Read/Write:
- 454 i) Random Read: Any I/O load in which consecutively issued read requests do not specify
455 adjacently addressed data. The term random I/O is commonly used to denote any I/O
456 load that is not sequential, whether or not the distribution of data locations is indeed
457 random.
- 458 ii) Random Write: Any I/O load whose consecutively issued write requests do not specify
459 adjacently addressed data. The term random I/O is commonly used to denote any I/O
460 load that is not sequential, whether or not the distribution of data locations is indeed
461 random.
- 462 iii) Sequential Read: An I/O load consisting of consecutively issued read requests to
463 adjacently addressed data.
- 464 iv) Sequential Write: An I/O load consisting of consecutively issued write requests to
465 adjacently addressed data.
- 466 11) Response Time: The time required for the UUT to complete an I/O request.
- 467 12) Unit Under Test (UUT): The Storage Product being tested.

468 2 QUALIFYING PRODUCTS

469 2.1 Included Products

- 470 2.1.1 Products that meet all of the following conditions are eligible for ENERGY STAR qualification,
471 with the exception of products listed in Section 2.2:
- 472 i. meet the definition of a Storage Product provided in Section 1 of this document;
- 473 ii. do not fall within the exceptions identified in Section 2.2 of this document;
- 474 iii. are comprised of one or more SKUs and be able to be purchased in a single order from a
475 system vendor;
- 476 iv. are characterized within the Online 2, 3, or 4 Storage Taxonomy categories² with the
477 following additional criteria;
- 478 a) contain a RAID capable storage controller within the storage device;
- 479 b) support Block I/O storage functions either entirely or as an additional capability, with the
480 exception of object based storage; and
- 481 c) implement scale-up storage product architecture.

² As defined in the “SNIA Emerald™ Power Efficiency Measurement Specification,” Version 1.0 (23 August 2011).

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Note: EPA has clarified that all products submitted for qualification must include a RAID capable controller within the storage device.

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EPA received feedback from stakeholders and has added block I/O capable NAS systems to the scope of Version 1.0, to be qualified in the same manner as the other products covered in the scope. EPA looks to include additional testing for the NAS features of these hybrid NAS-SAN systems in a future revision when an applicable NAS Active State energy efficiency test method becomes available.

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2.2 Excluded Products

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

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

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i. Personal / Portable Data Storage Products;

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ii. Computer Servers;

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iii. Blade Storage Products;

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iv. Direct Attached Storage Products

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

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vi. Object Storage Products;

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

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

502

503

ix. Scale-out Storage Products.

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Note: EPA proposes to exclude the following products from the scope of Version 1.0: Blade Storage Products, “just a bunch of disks” (JBOD) Storage Products, Object Storage Products, and Network Attached Storage Products which cannot perform block I/O. EPA currently lacks test methods to assess the active performance of these systems with the inclusion of energy efficiency metrics. EPA welcomes stakeholder feedback on these exclusions from Version 1.0.

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Additionally EPA recognizes that scale-out storage products represent an important segment of the data center storage market, but lacks the necessary information to move forward on including these products in the Version 1.0 specification at this time. Stakeholders are encouraged to provide feedback to EPA to answer the following questions so that these systems can be considered for the next draft:

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- Definition of a node for scale-out systems. The definition of node varies greatly between different manufacturers and product lines, and must be clear and understood. Some vendors consider nodes on a rack level, while others consider nodes on a drawer / controller level.

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- Expected common behaviors of Scale-out storage products as additional nodes are added. The EPA is concerned that by the nature of Scale Out systems, Optimal Configuration points may result in very large, and hence costly, systems being demonstrated. The EPA is interested in data-derived approaches which can help mitigate this potential testing burden.

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EPA believes that this issue must be resolved prior to the release of Draft 4, as the Agency anticipates that Draft 4 will be the last substantial draft of the Version 1.0 development process.

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522 **3 QUALIFICATION CRITERIA**

523 **3.1 Significant Digits and Rounding**

524 3.1.1 All calculations shall be carried out with directly measured (unrounded) values.

525 3.1.2 Unless otherwise specified, compliance with specification limits shall be evaluated using
526 directly measured or calculated values without any benefit from rounding.

527 3.1.3 Directly measured or calculated values that are submitted for reporting on the ENERGY STAR
528 website shall be rounded to the nearest significant digit as expressed in the corresponding
529 specification limit.

530 **3.2 Power Supply Requirements**

531 **Note:** EPA has not received additional data on PSU efficiency in the storage industry, or loading patterns
532 on storage PSUs. Therefore the current draft proposes to retain levels consistent with CSCI Silver for all
533 power supplies. EPA continues to welcome any data stakeholders can provide on the issue of PSU
534 efficiency.

535 EPA has received stakeholder feedback suggesting the removal of the 10% load point for redundant
536 capable PSUs to focus on higher efficiencies in the 20-100% load range of operation. Stakeholders noted
537 that storage products are unlikely to operate at 10% load even when fully idle and that removing the 10%
538 load requirement would allow PSU designers to improve PSU efficiency in the more expected loading
539 range >20%. EPA is considering removing the 10% load requirement and increasing the efficiency of the
540 20%, 50%, and 100% load requirements for redundant capable IPS by 1-2% each to compensate. EPA
541 welcomes stakeholder data to help determine which approach is more appropriate for typical storage
542 product power usage.

543 3.2.1 Power Supply Units (PSUs): PSUs used in Data Center Storage products eligible under this
544 specification shall meet the following requirements when tested using the *EPRI Generalized*
545 *Internal Power Supply Efficiency Test Protocol, Rev. 6.5* (available at
546 www.efficientpowersupplies.org).

547 i. Efficiency: A Data Center Storage product PSU shall meet efficiency requirements as
548 specified in Table 1.

549 **Table 1: Efficiency Requirements for PSUs**

PSU Type	Rated Output Power	10% Load	20% Load	50% Load	100% Load
Non-Redundant Capable PSU	All Output Levels	n/a	85%	88%	85%
Redundant Capable PSU	All Output Levels	75%	85%	89%	85%

550

551 ii. Power Factor: A Data Center Storage product PSU shall meet power factor requirements as
552 specified in Table 2.

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Table 2: Power Factor Requirements for PSUs

PSU Type	Rated Output Power	10% Load	20% Load	50% Load	100% Load
Non-Redundant Capable PSU	All Output Levels	n/a	0.80	0.90	0.95
Redundant Capable PSU	≤ 500 watts	n/a	0.80	0.90	0.95
	500 watts < Output ≤ 1000 watts	0.65	0.80	0.90	0.95
	> 1000 Watts	0.65	0.80	0.90	0.95

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- iii. Efficiency and Power Factor in Embedded Equipment: Embedded PSUs that power primary components of the Data Center Storage product, including controllers and drawers, must meet the requirements in Table 1 and Table 2. Embedded PSUs that do not power primary components of the Data Center Storage product are not subject to PSU requirements.

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Note: Stakeholders raised the concern that the power supplies in 3rd party products are neither chosen by the Data Center Storage manufacturer nor subject to their modification. EPA proposes to remove the efficiency and power requirements for all PSUs that are not embedded in or otherwise powering the controllers or drawers of the system.

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Additionally, after discussions with stakeholders, EPA has decided not to include a requirement that all equipment in a storage system that falls under the scope of another applicable ENERGY STAR specification (e.g. computers, servers, networking equipment) also be ENERGY STAR qualified. Stakeholder concerns over third party vendor modification, complication associated with such products, as well as the small energy usage of these products compared to the total Data Center Storage product energy usage, do not support including this requirement in Version 1.0.

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3.3 Active and Idle State Efficiency Criteria

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Note: EPA has chosen not to pursue efficiency levels for Idle State energy consumption in Version 1.0 but will examine both Active and Idle levels in future versions of the specification.

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EPA has done so pending the development of an unbiased data set for use in the Version 2.0 specification development cycle. The amount of data that EPA currently has may allow for setting of a single Idle threshold, but system configurations have such different energy consumption profiles that this single threshold would inevitably favor one configuration at the expense of the other two, skewing the ENERGY STAR products list and leading to a data set that does not represent the full range of storage system capabilities that customers require. Additionally, systems that perform well in Idle may or may not perform well in Active State, creating another potential source of bias in the products qualified for ENERGY STAR and complicating level setting in Version 2.0.

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EPA's approach to Active and Idle State information reporting requirements will encourage further testing for energy efficiency of Data Center Storage products. Data generated through this testing will allow EPA to set efficiency levels for Active and Idle State energy consumption in future versions of the specification. Reposting of this information will assist manufacturers in differentiating their products via energy efficiency by associating measured efficiency data with the hardware and software characteristics of each system.

585 **3.4 Power Management Requirements**

586 3.4.1 Power Modeling Presale tool: For Online 4 systems that qualify using modeled data, a power
587 modeling tool characterizing the Data Center Storage product must be made available to
588 manufacturer qualified purchasers of the product. The power modeler must provide an
589 estimated power usage of a deployed configuration based on user-selected configuration
590 characteristics.

591 **Note:** EPA is proposing to remove the warranty requirement for power modeling presale tools in Draft 1
592 and require their availability only for Online 4 systems that qualify using modeled data. EPA is aware of
593 stakeholder concerns about the availability of the power modeling presale tool to the public and welcomes
594 stakeholder feedback on appropriate language to limit availability to potential customers of their storage
595 systems.
596 Additional data center power management techniques are covered in the energy efficiency feature
597 requirements below.

598 **3.5 Energy Efficiency Feature Requirements**

599 3.5.1 To qualify for ENERGY STAR, a Data Center Storage product must contain the following
600 features, implemented as specified:

- 601 i. *Parity RAID*: A storage product must offer a form of Parity RAID.
602 ii. *Adaptive Cooling*: A storage product must utilize adaptive cooling technologies that reduce
603 the energy consumed by the cooling technology in proportion to ambient air temperature
604 conditions in proximity to the Data Center Storage product and the current cooling needs to
605 the Storage System. (e.g., reduction of variable speed fan or blower speeds at lower ambient
606 air temperature).

607 3.5.2 A Storage product shall make available for purchase to the end user configurable / selectable
608 features listed in Table 3 in quantities greater than or equal to those listed in Table 4.
609

610 **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

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

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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	2
Online 4	3

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Note: Based on stakeholder feedback from Draft 2 and internal discussions, EPA is proposing to require that a certain number of COMs are made available for purchase, with this number defined by the Online category of the product. EPA welcomes stakeholder feedback on the proposed levels set in Table 4.

EPA has removed “Deep Sleep Mode” and “Allow for unallocated storage elements to be placed in a power down state” from this list as there is currently no way to validate that these features exist during testing. EPA is open to including additional features in Table 3 in future versions as validation tests are made available.

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3.6 Information Reporting Requirements

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3.6.1 Active and Idle State Efficiency Disclosure: To qualify for ENERGY STAR, a Data Center Storage product or family must be tested in accordance to the requirements defined in Table 5.

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Table 5: Public Disclosure Requirements for Active and Idle State Efficiency

Workload Test	Transaction Optimization	Streaming Optimization	Capacity Optimization
Mixed Workload 1	Required	Optional	Optional
Mixed Workload 2	Required	Optional	Optional
Random Read	Required	Optional	Optional
Random Write	Required	Optional	Optional
Sequential Read	Optional	Required	Optional
Sequential Write	Optional	Required	Optional
Ready Idle	Required	Required	Required

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Note: This approach mirrors the proposed approach to active power measurement in the ENERGY STAR Computer Server Version 2.0 development process and requires that a Data Center Storage product is evaluated using a predetermined Active and Idle State testing methodology, with results to be publically disclosed via the ENERGY STAR program as part of the Power and Performance Datasheet (PPDS).

632 In place of an Idle Efficiency requirement for all Storage Products, EPA has introduced the Capacity
 633 Optimized Efficiency measurement requirements in this section. This additional optimization option allows
 634 stakeholders to show performance of qualified systems when optimized for Idle State.

635 3.6.2 The weighted percentages shown in Table 6 shall be used to calculate the appropriate optimal
 636 configuration point for a given system.
 637

638 **Table 6: Workload Weighting Requirements**

Workload Test	Transaction Optimization	Streaming Optimization	Capacity Optimization
Mixed Workload 1	70%	0%	10%
Mixed Workload 2	0%	0%	0%
Random Read	10%	0%	0%
Random Write	10%	0%	0%
Sequential Read	0%	50%	10%
Sequential Write	0%	20%	10%
Ready Idle	10%	30%	70%

639
 640 **Note:** Table 6 has been established to assure a level of commonality in different manufacturers'
 641 approaches to defining the Optimal Configuration. It is the EPA's intention to recognize the three primary
 642 values of Storage Systems:

- 643 1) Ability to receive data for storage;
- 644 2) Ability to retain received data over a period of time;
- 645 3) Ability to retrieve received data as requested.

646 The above table includes a percentage weighting of the seven workloads with the intent that they will
 647 provide a reasonable representation of each Optimization category. The EPA welcomes feedback on the
 648 allocation of workloads, both in terms of weighting and workload inclusion. The above numbers are
 649 believed to be reasonable assumptions of workload weightings.

650 3.6.3 Testing Data Requirements for Online 2 and Online 3 Storage Products: The following testing
 651 data is required for each configuration submitted for qualification as ENERGY STAR.

- 652 i. Physical data for all 7 measurements listed in Table 6 shall be submitted for all of the
 653 following system sizes:
 654 (a) Manufacturer determined Optimal Configuration point;
 655 (b) A manufacturer chosen point at least 40% smaller in storage device count compared
 656 to the optimal configuration, rounded down to the nearest drawer boundary; and
 657 (c) A manufacturer chosen point at least 15% larger in storage device count compared to
 658 the optimal configuration, rounded down to the nearest drawer boundary;
 659
- 660 ii. Modeled data for all 7 measurements listed in Table 6 may optionally be submitted for all
 661 system sizes listed above, as well as any other system sizes the manufacturer wishes to
 662 provide.

663 3.6.4 Testing Data Requirements for Online 4 Storage Products: The following testing data is
 664 required for each configuration submitted for qualification as ENERGY STAR.

- 665 i. Physical data for all 7 measurements listed in Table 6 shall be submitted for the following
666 system size:
667 (a) Manufacturer determined Optimal Configuration point.
- 668 ii. Modeled data for all 7 measurements listed in Table 6 shall be submitted for all of the
669 following system sizes;
670 (a) Manufacturer determined Optimal Configuration point;
671 (b) At least 6 manufacturer chosen points smaller in storage device count compared to
672 the optimal configuration, with the smallest point being at least 40% smaller in
673 storage device count; and
674 (c) At least 6 manufacturer chosen points larger in storage device count compared to the
675 optimal configuration, with the largest point being at least 15% larger in storage
676 device count.
- 677
678 iii. Additional modeled data for all 7 measurements listed in Table 6 may optionally be submitted
679 for other system sizes that the manufacturer wishes to provide.
- 680 iv. If accurate modeled data for an Online 4 Storage Product submission cannot be provided,
681 stakeholders may use the full testing requirements for Online 2 and Online 3 in lieu of the
682 Online 4 testing requirements.

683 **Note:** EPA welcomes feedback on the proposed testing requirements, and the option to submit modeled
684 data in lieu of two additional physical data points for qualification in Online 4 systems where system size
685 and testing burden were raised as concerns. EPA would like to clarify that only the physical data from the
686 optimal configuration points will be made publically available in Version 1.0.

687

688 **Note:** As part of the ENERGY STAR Uninterruptible Power Supply (UPS) specification development
689 effort, EPA has initiated development of an improved approach to the PPDS process that is being
690 proposed for application in the ENERGY STAR Storage program. Under this approach, data will be
691 maintained in a centralized database instead of individual forms, with a consumer-facing “widget”
692 available for embedding on websites. It is anticipated that such a system would also have the benefit of
693 tying data from qualification directly into the online PPDS, reducing the level of effort for ENERGY STAR
694 partners. EPA will make this tool available to ENERGY STAR Storage partners as well. EPA expects this
695 tool to offer significant benefit to partners and will share information on the status of this development
696 effort and use of the tool as the Agency works with stakeholder to complete this spec development effort.

697 Information about this approach will be provided in conjunction with further drafts of the Version 1.0 Data
698 Center Storage specification.

699 3.6.5 Data for a standardized Power and Performance Data Sheet (PPDS) shall be submitted for
700 each ENERGY STAR qualified Storage Product or Storage Product Family.

- 701 i. Partners are encouraged to provide one set of data for each ENERGY STAR qualified
702 product configuration, though provision of a data set for each qualified product family is also
703 acceptable.
- 704 ii. Whenever possible, Partners must also provide a hyperlink to a more detailed power
705 calculator on their Web site that purchasers can use to understand power and performance
706 data for specific configurations within the product family.

707 3.6.6 Templates for the PPDS will be located on the ENERGY STAR Web page for Data Center
708 Storage at www.energystar.gov/products once the specification is finalized. The PPDS
709 contains the following information:

- 710 i. Product model name, model number, and SKU or other configuration identification number;
- 711 ii. A list of important product characteristics, including;
- 712 (a) System configuration;
- 713 (b) Controller details;
- 714 (c) Software configuration;
- 715 (d) Controller power supply information;
- 716 (e) Storage media drawer power supply information;
- 717 (f) Storage media used per optimization points
- 718 (g) Input power and environmental characteristics during testing;
- 719 (h) System power optimization capabilities;
- 720 (i) Inlet air temperature and Power Consumption reporting capabilities.

721 **Note:** EPA welcomes stakeholder feedback on additional characteristics that will best inform buyers and
722 thus should be included to finalize the product characteristics list above.

- 723 iii. A list of qualified system configurations, including maximum, minimum and optimal
724 configurations of qualified product families;
- 725 iv. Power consumption and performance data, along with guaranteed accuracy levels for all
726 power and temperature measurements, disclosure of the time period used for data averaging,
727 and a hyperlink to a detailed power calculator, as available;
- 728 v. A list of power management and other power saving features available and enabled by
729 default;
- 730 vi. Information on product power measurement and reporting capabilities;
- 731 vii. A list of selected data from the ASHRAE Thermal Report; and
- 732 viii. For product families, a list of qualified storage products within the family.

733 3.7 Storage Device Replacement Requirements

734 3.7.1 Replacement of Rotational Storage Devices in As-Shipped Configurations: In order to reduce
735 testing burden, manufacturers may replace storage devices that were used during qualification
736 with rotational storage devices that have similar energy efficiency performance compared to
737 the device being replaced after qualification. Manufacturers must submit specification sheets
738 from the storage device vendors for the original and replacement devices to validate the
739 following:

- 740 i. No change in **any** of the following categories:
- 741 (a) Form factor
- 742 (b) Interface type, quantity, and transfer speed
- 743 (c) Cache Size
- 744 (d) Data capabilities (e.g. Self-encryption)
- 745 (e) Power Management related features and capabilities (e.g. Power Down modes)
- 746 (f) Rotational Speed
- 747 ii. Performance within +/- 5% in **all** of the following categories:
- 748 (a) Average Seek Time
- 749 (b) Sustained Transfer Rate
- 750 (c) Average Latency
- 751 (d) Reported average power consumption in like modes of operation
- 752

- 753 ii) Capacity equal or greater than the storage device being replaced.
- 754 3.7.2 Replacement of Non-Rotational Storage Devices in As-Shipped Configurations: Non-rotational
755 Storage Devices (e.g. SSDs) may be replaced subject to the following:
- 756 i. No change in **any** of the following:
- 757 (a) Form factor
- 758 (b) Interface type, quantity, and transfer speed
- 759 (c) Data capabilities (e.g. Self-encryption)
- 760 (d) Power Management related features and capabilities (e.g. Power Down modes)
- 761
- 762 ii) Capacity equal or greater than the storage device being replaced.
- 763 ii. Performance Improvement Cap: Replacement of a storage device in a storage product that
764 leads to a change of greater than 20% of the overall system performance as defined by Table
765 6 (with the exception of the Ready Idle metric) will require testing of a new optimized
766 configuration for inclusion in the product family definition.

767 **Note:** EPA welcomes stakeholder feedback on additional variables that should be considered when
768 comparing performance and energy efficiency of both rotational and non-rotational storage devices on a
769 device level. The above requirements are intended to reduce re-testing burden by defining an allowable
770 level of Storage Device modification that may be made within product families. Modifications that fall
771 outside these bounds will require that a new system be tested. Once tested, the new system may be used
772 to expand the existing product family.

773 3.8 Standard Performance Data Measurement and Output Requirements

774 **Note:** The requirements in this section are similar to those in the Draft 1 Version 2.0 ENERGY STAR
775 Computer Servers specification and largely maintained from the Draft 1 Data Center Storage
776 specification.

777 EPA received limited, but substantive, feedback from stakeholders regarding the complexities of, and
778 alternatives to, requirements for integrated inlet air temperature measurements. EPA plans to hold further
779 discussions with stakeholders on this topic in order to finalize requirements.

780 After discussion with stakeholders, the sampling requirement for input power measurements has also
781 been altered to take 1 or more measurements per 10 second interval. EPA welcomes further stakeholder
782 input on all of the above modifications to the specification.

783 3.8.1 Data Elements: All Data Center Storage products shall be capable of measuring and reporting the
784 following data elements:

- 785 i. Input Power, in watts. Input power measurements must be reported with accuracy of less
786 than or equal to 5% of the actual value for measurements greater than 200 W, through the
787 full range of operation. For measurements less than or equal to 200 W, the accuracy must
788 be less than or equal to 10 W times the number of installed PSUs; and
- 789 ii. Inlet Air Temperature (optional), in degrees Celsius, with accuracy of $\pm 2^{\circ}\text{C}$.

790 **Note:** Based on discussions with stakeholders, EPA is proposing to make the inlet air temperature
791 measurement requirements optional for Version 1.0, with the expectation of requiring the measurements
792 in Version 2.0. The ability to measure air inlet temperature will be reported in the PPDS. EPA welcomes
793 feedback on this approach.

794 3.8.2 Reporting Implementation:

- 795 i. Data shall be made available in a published or user-accessible format that is readable by
796 third-party, non-proprietary management systems;
- 797 ii. Data shall be made available to end users and third-party management systems over a
798 standard network connection;
- 799 iii. Data shall be made available via embedded components or add-in devices that are
800 packaged with the Data Center Storage product (e.g., a service processor, embedded
801 power or thermal meter or other out-of-band technology, iPDU, or pre-installed OS);

802 **Note:** EPA is requiring the collection of input power using any embedded or add-in solution for Version
803 1.0. Additionally EPA encourages the collection of air inlet temperature using similar techniques. EPA
804 intends to require that these reporting abilities be conducted by embedded components within the storage
805 device, and not through add-in devices for Version 2.0.

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

808 3.8.3 Sampling Requirements:

- 809 i. *Input power:* Input power and processor utilization measurements must be collected at a
810 rate of ≥ 1 measurement every 10 seconds. A rolling average, encompassing a period of
811 no more than 30 seconds, must be reported at a frequency of greater than or equal to once
812 every 10 seconds.
- 813 ii. *Inlet air temperature (optional):* Inlet air temperature measurements must be collected at a
814 rate of ≥ 1 measurement every 10 seconds.

815 3.8.4 Documentation Requirements: The following information shall be included on the Power and
816 Performance Data Sheet:

- 817 i. Guaranteed accuracy levels for power and temperature measurements, and
818 ii. The time period used for data averaging.

820 3.8.5 Section 3.7 may be satisfied in Version 1.0 using iPDUs. In order to satisfy the Data Elements
821 requirement, an iPDU must:

- 822 i. Meet all requirements for accuracy, sampling, and data reporting;
823 ii. Be made available for sale and delivery with qualified ENERGY STAR Storage Products.
824

825 **Note:** EPA will allow manufactures to utilize iPDUs to meet the Version 1.0 Standard Performance Data
826 Measurement and Output Requirements. Due to the N to 1 relationship of Storage Products to iPDUs,
827 the EPA is not requiring all Storage Products include an iPDU but does anticipate delivery of qualified
828 Storage Products will include a sufficient number of iPDUs to provide whole system coverage. EPA
829 intends to eliminate the iPDU option in Version 2.0 and require that all Storage Products qualified by the
830 program meet these requirements as a capability integral to the Storage Product.

831 **4 TESTING**

832 **4.1 Test Methods**

833 4.1.1 Test methods identified in Table 7 shall be used for purposes of evaluating idle and active
834 Storage product energy efficiency.

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

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

836 **Note:** The reference in this table is revised to point to the ENERGY STAR Test Method. This document, a
837 draft of which is distributed with this Draft 3 Specification, references the SNIA Emerald Power Efficiency
838 Measurement Specification, Version 1.0 (23 August 2011).

839 EPA is aware of developments in the industry towards revising the SNIA Emerald Power Efficiency
840 Measurement Specification to effectively evaluate Active State efficiency measurements using
841 Heterogeneous Storage Devices. EPA looks forward to continued progress on these efforts and hopes to
842 implement revisions prior to finalization of Version 1.0.

843 **4.2 Number of Units Required for Testing**

844 4.2.1 Representative Models shall be selected for testing per the following requirements:

- 845 i. For qualification of an individual product model, a product configuration equivalent to that
846 which is intended to be marketed and labeled as ENERGY STAR is considered the
847 Representative Model;
- 848 ii. For qualification of a product family one or more Optimization Configurations shall be tested
849 and submitted. Within the range defined by the Maximum Configuration, Minimum
850 Configuration, and Optimal Configuration, manufacturers continue to be held accountable for
851 any efficiency claims made about their products, including those not tested or for which data
852 was not reported;

853 **5 EFFECTIVE DATE**

854 5.1.1 Effective Date: The Version 1.0 ENERGY STAR Data Center Storage specification shall take
855 effect on the dates specified in Table 8. To qualify for ENERGY STAR, a product model shall
856 meet the ENERGY STAR specification in effect on its date of manufacture. The date of
857 manufacture is specific to each unit and is the date on which a unit is considered to be
858 completely assembled.

859 5.1.2 Future Specification Revisions: EPA reserves the right to change this specification should
860 technological and/or market changes affect its usefulness to consumers, industry, or the
861 environment. In keeping with current policy, revisions to the specification are arrived at through
862 stakeholder discussions. In the event of a specification revision, please note that the ENERGY
863 STAR qualification is not automatically granted for the life of a product model.

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Table 8: Specification Effective Date

Effective Date
January 2013

866
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Note: EPA is proceeding with a goal to complete development of the Version 1.0 Data Center Storage program by **October 2012**. As a reminder, the Data Center Storage program would have a slightly delayed effective date to enable CB and lab certification for testing storage products. Therefore, EPA will chose an effective date in January 2013, approximately 3 months following finalization.

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6 CONSIDERATIONS FOR FUTURE REVISIONS

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

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TBD