ENERGY STAR® Program Requirements Product Specification for Uninterruptible Power Supplies (UPSs)

Eligibility Criteria Draft 1 Version 1.0

Following is the Version 1.0 ENERGY STAR Product Specification for Uninterruptible Power Supplies (UPSs). A product shall meet all of the identified criteria if it is to earn the ENERGY STAR.

1 DEFINITIONS

Unless otherwise specified, all terms used in this document are consistent with the definitions in the International Electrical Commission (IEC) standard IEC 62040-3[1].

For the purpose of this specification the following definitions apply:

Note: The definitions listed below were taken from the Final Draft ENERGY STAR Test Method for UPSs, published in December 2010, with the exception of the input dependence characteristics, which were added to clarify the qualification requirements.

Unless otherwise identified through note boxes, the definitions below were taken from IEC 62040-3/FDIS (Final Draft International Standard), and have been updated to conform with the final IEC 62040-3 Ed. 2.0 standard published in March 2011.

A) Product Types:

1) Uninterruptible Power Supply (UPS): Combination of convertors, switches, and energy storage devices (such as batteries) constituting a power system for maintaining continuity of load power in case of input power failure.[2]

   i) Power conversion mechanism:

      (1) Static UPS: UPS where solid-state power electronic components provide the output voltage.

      (2) Rotary UPS: UPS where one or more electrical rotating machines provide the output voltage.

2) Modular UPS: A UPS in which multiple converters share a common frame, input and output busses, and/or other UPS components. The converters are connected in parallel and can be added to or removed from the UPS to change its rated output power.

3) Multi–mode UPS: A UPS that is able to function within the parameters of more than one set of input dependence characteristics. For example, a UPS that can function as either VFI or VFD. See Section 1.D for input dependence characteristics.

Note: IEC standard 62040-3 does not include a definition of a modular UPS or a multi-mode UPS, so the above definitions were created by EPA based on general discussions with stakeholders to facilitate testing of modular or multi-mode UPSs on par with non-modular or single-mode UPSs. EPA welcomes further input from stakeholders related to the definition of these UPS systems.

1 International Electrotechnical Commission (IEC). IEC standard 62040-3. "Uninterruptible power systems (UPS) - Part 3: Method of specifying the performance and test requirements." Ed. 2.0

2 Input power failure occurs when voltage and frequency are outside rated steady-state and transient tolerance bands or when distortion or interruptions are outside the limits specified for the UPS.

B) Redundancy: Addition of UPS Units in a parallel UPS to enhance the continuity of load power, and classified as follows.

1) N+0: UPS that cannot tolerate any failures while maintaining Normal Mode operation. No redundancy.

2) N + 1: Parallel UPS that can tolerate the failure of one UPS unit or one group of UPS units while maintaining Normal Mode operation.

3) 2N: Parallel UPS that can tolerate the failure of one half of its UPS units while maintaining Normal Mode operation.

Note: The definition of redundancy is based on that of "Redundant System" in IEC standard 62040-3. The remainder of the definitions are intended to help distinguish between different levels of redundancy, and therefore performance, when comparing efficiency results. The efficiency requirements presented later in the document, however, do not differentiate UPSs on the basis of redundancy, as EPA has only eight efficiency results for redundant UPSs (compared to over 300 results for non-redundant UPSs). EPA is therefore of the understanding that most UPSs are N+0 and are only combined in redundant configurations at the time of installation.

EPA welcomes further input from stakeholders on the subject of redundancy as it applies to testing and qualification of UPSs, and the proportion of UPSs that are sold as non-redundant and then combined into redundant systems at the request of customers. This information is valuable in determining the full scope of products labeled under this specification.

C) UPS Operational Modes:

1) Normal Mode: Stable mode of operation that the UPS attains under the following conditions:

i) AC input supply is within required tolerances and supplies the UPS.

ii) The energy storage system remains charged or is under recharge.

iii) The load is within the specified rating of the UPS.

iv) The bypass is available and within specified tolerances (if applicable).

2) Stored Energy Mode: Stable mode of operation that the UPS attains under the following conditions:

i) AC input power is disconnected or is out of required tolerance.

ii) All power is derived from the energy storage system.

iii) The load is within the specified rating of the UPS.

3) Bypass Mode: Mode of operation that the UPS attains when operating the load supplied via the bypass only.

D) UPS Input Dependence Characteristics:

1) Voltage and Frequency Dependent (VFD): Capable of protecting the load from power outage.[3]

2) Voltage Independent (VI): Capable of protecting the load as required for VFD, above, and in addition from:

i) Under-voltage applied continuously to the input

ii) Over-voltage applied continuously to the input[4]

3 The output of the VFD UPS is dependent on changes in AC input voltage and frequency and is not intended to provide additional corrective functions, such as those arising from the use of tapped transformers.

3) Voltage and Frequency Independent (VFI): Independent of voltage and frequency variations and capable of protecting the load against adverse effects from such variations without depleting the stored energy source.

Note: The above input dependence characteristics are used to classify UPSs for the purpose of meeting efficiency requirements, with more stringent requirements for higher degrees of input dependence. Although input dependence characteristics have been standardized in IEC 62040-3, EPA has noticed considerable variation in what manufacturers consider VFI or VFD, with several manufacturers sharing test results where line-interactive or passive-standby UPSs were listed as meeting the VFI classification. EPA is requesting comment on this apparent misclassification and whether the above definitions for input dependence are sufficient to fully describe the operation of UPSs in various modes.

EPA is also interested in whether VI and VFD UPSs serve different market niches, how heavily customers distinguish between one or the other, and what motives customers would have in selecting one type over the other.

E) UPS Power:

1) Alternating Current (AC): A continuous flow of electric charge that periodically reverses direction.

2) Direct Current (DC): A continuous flow of electric charge that is unidirectional.

F) Other Terms:

1) Bypass: Power path alternative to the AC converter.

a) Maintenance bypass (path): Alternative power path provided to maintain continuity of load power during maintenance activities.

b) Static bypass (electronic bypass): Power path (primary or stand-by) alternative to the indirect AC converter where control is via an electronic power switch, for example transistors, thyristors, triacs or other semiconductor device or devices

G) Reference Test Load: Load or condition in which the output of the UPS delivers the active power (W) for which the UPS is rated.[5]

H) Unit Under Test (UUT): The UPS undergoing the test, configured as though for shipment to the customer, and including any accessories (e.g., filters or transformers) necessary to meet the test setup as specified in section 4 of the ENERGY STAR test method.

2 SCOPE

2.1 Included Products

2.1.1 Products that meet both of the conditions below, with the exception of products listed in Section 2.2.

i. UPSs that meet the definition of Uninterruptible Power Supply (UPS), including Static and Rotary UPS;

ii. UPSs used only in datacenter, office, retail, or home environments.

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4 An output voltage tolerance band narrower than input voltage window shall be defined by the manufacturer. The output of the VI UPS is dependent on AC input frequency and the output voltage shall remain within prescribed voltage limits (provided by additional corrective voltage functions, such as those arising from the use of active and/or passive circuits).

5 This definition permits the UPS output to be backfed into the input AC supply when in test-mode and subject to local regulations.

In at least one other ENERGY STAR product category, EPA has had success in including refurbished products because of their importance to their particular market and the resulting environmental benefits of refurbishment. EPA is exploring the potential of including refurbished UPSs in this specification. Therefore, EPA welcomes comment on the typical processes taken in refurbishing UPS systems, their associated market potential, and the potential impact on product energy performance.

2.2 Excluded Products

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

2.2.2 The following products are not eligible for qualification under this specification:

i. Products that are internal to a computer or another end-use load (e.g., battery-supplemented internal power supplies or battery backup for modems, security systems, etc.).

3 QUALIFICATION CRITERIA

3.1 Significant Digits and Rounding

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

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

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

3.2 Energy Efficiency Requirements for AC-Output UPSs

Note: Due to the absence of data on the typical usage of smaller UPSs in consumer and small-business settings, EPA grouped them together with larger UPSs, using test results collected under IEC 62040-3 and then applying the same loading profile and qualification criteria as in section 3.2.2, below.

Although the same usage profile was used for all UPSs, smaller UPSs used in home and small office/retail settings (output power less than 1.5 kVA) are likely to be used at a much lower proportion of full load, and may even be operated without load (i.e., with the connected computer turned off) for a significant period of time.

EPA seeks comment on whether the loading profile developed for UPSs with output power greater than 1.5 kVA is applicable to UPSs with output power less than or equal to 1.5 kVA and welcomes suggestions regarding other loading profiles, including ones that may incorporate data from the DOE test method for battery chargers (Appendix Y to 10 CFR Part 430), as discussed further in section 4.1, below. EPA is following the DOE test method development for battery chargers and intends to harmonize testing with DOE for products covered both the DOE standard and the ENERGY STAR program.

3.2.1 AC-Output UPSs with Output Power Less than or Equal to 1.5 kVA: Average loading-adjusted efficiency (Eff_{AVG}), as calculated per Equation 1, shall be greater than or equal to the Minimum Average Efficiency Requirement (Eff_{AVG_MIN}), as determined per Table 1.

Equation 1: Calculation of Average Efficiency for AC-Output UPSs with Output Power Less than or Equal to 1.5 kVA

$$Eff_{AVG} = 0.25 \times Eff|_{25\%} + 0.5 \times Eff|_{50\%} + 0.25 \times Eff|_{75\%}$$

Where:

- *Eff_{AVG} is the average loading-adjusted efficiency,*
- *$Eff|_{n\%}$ is the efficiency at the specified n% of the reference test load, as measured according to the test method.*

3.2.2 AC-Output UPSs with Output Power Greater than 1.5 kVA: Average loading-adjusted efficiency (Eff_{AVG}), as calculated per Equation 2, shall be greater than or equal to the Minimum Average Efficiency Requirement (Eff_{AVG_MIN}), as determined per Table 1.

Equation 2: Calculation of Average Efficiency for AC-Output UPSs with Output Power Greater than 1.5 kVA

$$Eff_{AVG} = 0.25 \times Eff|_{25\%} + 0.5 \times Eff|_{50\%} + 0.25 \times Eff|_{75\%}$$

Where:

- *Eff_{AVG} is the average loading-adjusted efficiency,*
- *$Eff|_{n\%}$ is the efficiency at the specified n% of the reference test load, as measured according to the test method.*

Note: The loading profile embedded in the equation above was suggested by a stakeholder as being typical of data center operation. This loading profile takes into account current data center trends as explained below:

- 25% at 25% load: accounts for delayed datacenter build-out/over-provisioning,
- 50% at 50% load: accounts for the prevalence of 2N redundant operation,
- 25% at 75% load: accounts for the growing popularity of virtualization and UPS modularity/N+1 redundancy.

EPA welcomes comment on the representativeness of the above loading profile and suggestions for any alternative weighting schemes or other proposals.

Table 1: Minimum Average Efficiency Requirement

Input Dependence, as Specified in the ENERGY STAR Test Method	Minimum Average Efficiency Requirement ($Eff_{AVG\ MIN}$), Where: • P is the Apparent Power in kilovolt-amperes (kVA), and • ln is the natural logarithm.
VFI	$0.0099 \times \ln(P) + 0.81$
VI	0.97
VFD	0.98

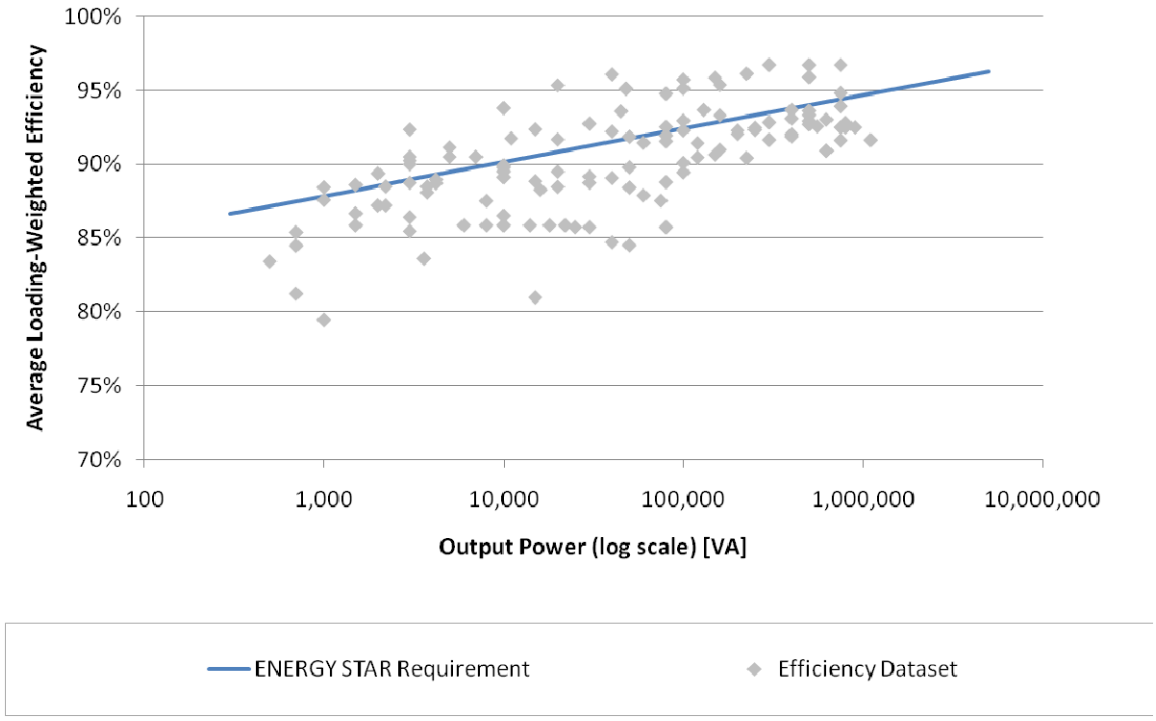
Note: EPA is interested in comments and proposals on the best way to capture the capabilities of UPSs that can operate in more than one input mode (e.g., either VFI or VFD, depending on the input conditions),

One possible proposal is to utilize the ITI-CBEMA curve to determine how to test these products:

- If the unit can switch input modes within the boundaries of the ITI-CBEMA curve, then it may be tested in its highest efficiency mode and should be compared to the minimum average efficiency requirement for that mode, as listed above. EPA may then report this product's efficiency on its Qualified Products list and on the PPDS document as the result of testing the product at its highest efficiency.
- If the unit cannot switch input modes within the boundaries of the ITI-CBEMA curve, then it must be tested in its highest load protection mode and should be compared to the minimum average efficiency requirement for that mode, as listed above. EPA may then report this product's efficiency on its Qualified Product list and on the PPDS document as the result of testing the product in its highest load protection mode.

It is EPA's understanding that a product that is capable of operating in more than one of the modes listed in Table 1 above will be most energy efficient in VFD, followed by VI and then VFI. It will offer the best protection to the load in VFI, followed by VI and then VFD, though some manufacturers have commented that given sufficiently rapid transfer to a VFI mode, a VFD or VI mode offer comparable levels of protection.

Note: The above qualification requirement (Table 1) was developed after analyzing the test results obtained during Phases 1 and 2 of data assembly in the winter of 2011, and corresponds to a simplified best-fit line separating the top performers in each input dependence category over the full range of output power, as illustrated in the below figure for units tested in VFI mode.



3.3 Energy Efficiency Requirements for DC-Output UPSs

3.3.1 DC-Output UPSs:

Note: Despite the growing market and previous positive stakeholder feedback, EPA has insufficient and incomplete efficiency data for DC-Output UPSs. EPA continues to investigate the inclusion of DC output UPSs and encourages stakeholders to share DC-Output UPS data which will help promote savings enabled by these systems.

3.4 Power Factor Requirements

3.4.1 (TBD)

Note: EPA is in the process of analyzing the available range of input power factor over the full range of rated UPS output power and welcomes stakeholder comment on potential power factor requirements.

3.5 Standard Information Reporting Requirements

Note: EPA is interested in facilitating the efficient design and operation of data centers. As such, EPA is in the process of creating standard information reporting requirements via a UPS Power and Performance Data Sheet for all ENERGY STAR qualified UPS products. EPA believes that data center operators would benefit from having access to real-time or periodic system performance data when UPS devices are in use.

In order to understand real-time reporting capabilities, EPA has reached out to interested stakeholders—manufacturers as well as end users—on the topic of data measurements and output requirements. EPA would like to stimulate further discussion on:

1. The general requirements needed to integrate UPSs into monitoring systems; and

2. The topic of basic and robust reporting capabilities.

Based on stakeholder feedback, real-time UPS data measurement and output requirements are customer driven. Therefore, EPA is interested in distinguishing the fundamental differences between various real-time reporting/metering mechanisms that customers are requesting from UPS manufacturers as well as their associated costs.

3.5.1 A standardized Power and Performance Data Sheet (PPDS) shall be completed for each ENERGY STAR qualified Uninterruptible Power Supply and posted with other product configuration information on the Partner's website. Partners are encouraged to provide one data sheet per qualified configuration.

3.5.2 If one PPDS is used to represent a Product Family, Partners are encouraged to provide a link to a more detailed power calculator where information on the power consumption of specific system configurations can be found.

Note: The PPDS for UPS products is still under development and a draft form will be released for review and comment. The text contained below represents EPA's initial formulation of information that would be presented in the PPDS.

3.5.3 Templates for the PPDS can be found on the ENERGY STAR Web page for Uninterruptible Power Supplies at www.energystar.gov/products. Partners are encouraged to use the template provided by EPA, but may also create their own template provided that it has been approved by EPA and contains the following information, at a minimum:

i. Model name/number;

ii. SKU and/or configuration ID;

iii. System characteristics (e.g., form factor, max rated load, power specifications);

iv. Compatible energy storage technologies;

v. Efficiency and power-factor curves over the rated load range;

vi. Output power characteristics, including input dependence and output waveform;

vii. Thermal characteristics and cooling requirements;

viii. Expected lifetime;

ix. Available / enabled power saving features (e.g., Energy saver modes, such as Eco-Mode); and

x. Information on the power measurement and real-time reporting capabilities of the device, including guaranteed accuracy levels for power and temperature measurements, and the time period used for data averaging (see section 3.6).

Note: EPA is aware of the development of an International Electrotechnical Commission (IEC) lifecycle carbon assessment (LCA) standard (IEC 62040-4), the goal of which is to promote the reduction of environmental impact during the UPS unit life cycle. EPA supports this effort and would like to facilitate further discussion of the relevant reporting aspects beneficial for inclusion in an ENERGY STAR PPDS.

3.5.4 EPA may periodically revise this template, as necessary, and will notify Partners of the revision process. Partners should always use the most recent version of the data sheet posted to the ENERGY STAR Web site.

Note: EPA recognizes there are existing programs in place to facilitate battery recycling and would like to use its broad influence with consumers of all sizes to draw attention to these programs. One possible way to do so would be through the creation of web-based tips or links to resources explaining what consumers can do to recycle their batteries. EPA seeks information from manufacturers on what programs currently exist and could be brought to consumers' attention to facilitate recycling.

EPA would also like to support the sharing of best practices in data center operation. It seeks information on (1) the adaptability and use of hot-swappable or easily removable battery systems and (2) the potential for designing UPSs that enable placement of batteries in the cooled data center areas while separating power consuming electronics outside in a utility room where they can take advantage of free-air cooling.

Finally, EPA welcomes stakeholder feedback on the thermal requirements of UPS power electronics.

3.6 Data Measurement and Output Requirements

3.6.1 Data Elements: UPSs with output power greater than 1.5 kVA shall be capable of measuring and reporting the following data elements:

i. (TBD)

3.6.2 Reporting Implementation:

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

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

iii. Data shall be made available via embedded components or add-in devices that are packaged with the UPS.

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

Note: EPA wishes to promote consistency in the real-time power information reported by UPSs, and welcomes comments on standard data elements and protocols for this information.

3.6.3 Sampling Requirements: Data shall be averaged on either a rolling basis or over a manufacturer specified time period. A default rolling average or time period of 30 seconds is recommended.

4 TESTING

4.1 Test Methods

4.1.1 When testing UPSs, the test methods identified in Table 2 shall be used to determine ENERGY STAR qualification.

Table 2: Test Methods for ENERGY STAR Qualification

Product Type	Test Method
UPSs with Output Power Less than or Equal to 1.5 kVA	"Uniform Test Method for Measuring the Energy Consumption of Battery Chargers," in Appendix Y to Subpart B of 10 CFR Part 430.
All UPSs	ENERGY STAR Test Method for Uninterruptible Power Supplies, Rev. XX-2011
All UPSs	International Electrotechnical Commission (IEC) Standard 62040-3: Method of Specifying the Performance and Test Requirements. Ed. 2.0.

Note: In its Preliminary Analysis of Energy Conservation Standards for Battery Chargers and External Power Supplies, the U.S. Department of Energy (DOE) indicated that it was considering covering consumer UPSs under its definition of battery chargers. Although DOE continues to develop its approach, consumer UPSs may potentially be required to meet minimum standards when tested in accordance with DOE's test method.

EPA therefore welcomes comment on whether consumer UPSs (considered as UPSs with output power less than or equal to 1.5 kVA) should be tested and qualified for ENERGY STAR using only the DOE test method (which does not measure efficiency in normal mode), or whether they should also be subject to additional testing using the ENERGY STAR test method (which does measure efficiency in normal mode), as indicated in Table 2, above.

4.2 Number of Units Required for Testing

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

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

ii. For qualification of a Modular UPS, both the maximum and minimum configurations that are intended to be marketed and labeled as ENERGY STAR are considered Representative Models.

Note: According to the above requirement, intermediate configurations of a modular UPS would qualify if the minimum and maximum configurations meet the requirements of this specification. EPA welcomes comments on the treatment of modular UPSs and other product family concepts.

5 EFFECTIVE DATE

5.1.1 Effective Date: The Version 1.0 ENERGY STAR UPS specification shall take effect on the dates specified in Table 3. To qualify for ENERGY STAR, a product model shall meet the ENERGY STAR specification in effect on its date of manufacture. The date of manufacture is specific to each unit and is the date (e.g., month and year) on which a unit is considered to be completely assembled.

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

Table 3: Specification Effective Dates

Effective Date
September 1, 2011