



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

## Partner Commitments

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

### Qualifying Products

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1. Comply with current ENERGY STAR Eligibility Criteria, which define performance requirements and test procedures for Uninterruptible Power Supplies (UPSs). A list of eligible products and their corresponding Eligibility Criteria can be found at [www.energystar.gov/specifications](http://www.energystar.gov/specifications).
2. **Prior to associating the ENERGY STAR name or mark with any product**, obtain written certification of ENERGY STAR qualification from a Certification Body recognized by EPA for UPSs. As part of this certification process, products must be tested in a laboratory recognized by EPA to perform UPS testing. A list of EPA-recognized laboratories and certification bodies can be found at [www.energystar.gov/testingandverification](http://www.energystar.gov/testingandverification).

### Using the ENERGY STAR Name and Marks

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3. Comply with current ENERGY STAR Identity Guidelines, which define how the ENERGY STAR name and marks may be used. Partner is responsible for adhering to these guidelines and ensuring that its authorized representatives, such as advertising agencies, dealers, and distributors, are also in compliance. The ENERGY STAR Identity Guidelines are available at [www.energystar.gov/logouse](http://www.energystar.gov/logouse).
4. Use the ENERGY STAR name and marks only in association with qualified products. Partner may not refer to itself as an ENERGY STAR Partner unless at least one product is qualified and offered for sale in the U.S and/or ENERGY STAR partner countries.
5. Provide clear and consistent labeling of ENERGY STAR qualified UPSs.
  - 5.1. Partner shall adhere to the product-specific commitments regarding the use of the ENERGY STAR certification mark on qualified products:
    - 5.1.1. Partner must use the ENERGY STAR mark in one of the following ways:
      - 1) Via permanent or temporary label on the top or front of the product. All temporary labeling must be affixed to the product with an adhesive or cling-type application; or
      - 2) Via electronic labeling. Electronic labeling must meet the following requirements:
        - a. The ENERGY STAR mark in cyan, black, or white must appear at system start-up, and must display for a minimum of 5 seconds;
        - b. The ENERGY STAR mark must be at least 10% of the screen by area and must be legible.

EPA will consider alternative proposals for electronic labeling on a case-by-case basis.
    - 5.1.2. Partner must use the ENERGY STAR mark on the manufacturer's Internet site specification sheet where product information is displayed and configurations are provided:
      - 1) This ENERGY STAR mark will also serve as a link from the manufacturer's specification sheet to the ENERGY STAR product website for Uninterruptible Power Supplies.

- 5.1.3. Partner must use the ENERGY STAR mark to identify qualified products in collateral materials, which could include, but not be limited to: user manuals, product guides, marketing brochures, etc.; and
- 5.1.4. Partner must use the ENERGY STAR mark on product packaging for products sold at retail.
- 5.2. If additional information about the ENERGY STAR program or other products is provided by the Partner on its website, Partner must comply with the ENERGY STAR Web Linking Policy, which can be found at [www.energystar.gov/partners](http://www.energystar.gov/partners).

### **Verifying Ongoing Product Qualification**

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6. Participate in third-party verification testing through a Certification Body recognized by EPA for UPSs, providing full cooperation and timely responses, EPA/DOE may also, at its discretion, conduct tests on products that are referred to as ENERGY STAR qualified. These products may be obtained on the open market, or voluntarily supplied by Partner at the government's request.

### **Providing Information to EPA**

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7. Provide unit shipment data or other market indicators to EPA annually to assist with creation of ENERGY STAR market penetration estimates, as follows:
  - 7.1. Partner must submit the total number of ENERGY STAR qualified UPSs shipped in the calendar year or an equivalent measurement as agreed to in advance by EPA and Partner. Partner shall exclude shipments to organizations that rebrand and resell the shipments (unaffiliated private labelers).
  - 7.2. Partner must provide unit shipment data segmented by meaningful product characteristics (e.g., type, capacity, presence of additional functions) as prescribed by EPA.
  - 7.3. Partner must submit unit shipment data for each calendar year to EPA or an EPA-authorized third party, preferably in electronic format, no later than March 1 of the following year.

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

8. Report to EPA any attempts by recognized laboratories or Certification Bodies (CBs) to influence testing or certification results or to engage in discriminatory practices.
9. Notify EPA of a change in the designated responsible party or contacts within 30 days using the My ENERGY STAR Account tool (MESA) available at [www.energystar.gov/mesa](http://www.energystar.gov/mesa).

### **Performance for Special Distinction**

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

- Provide quarterly, written updates to EPA as to the efforts undertaken by Partner to increase availability of ENERGY STAR qualified products, and to promote awareness of ENERGY STAR and its message.
- Consider energy efficiency improvements in company facilities and pursue benchmarking buildings through the ENERGY STAR Buildings program.
- Purchase ENERGY STAR qualified products. Revise the company purchasing or procurement specifications to include ENERGY STAR. Provide procurement officials' contact information to EPA for periodic updates and coordination. Circulate general ENERGY STAR qualified product information to employees for use when purchasing products for their homes.

- Feature the ENERGY STAR mark(s) on Partner website and other promotional materials. If information concerning ENERGY STAR is provided on the Partner website as specified by the ENERGY STAR Web Linking Policy (available in the Partner Resources section of the ENERGY STAR website), EPA may provide links where appropriate to the Partner website.
- Ensure the power management feature is enabled on all ENERGY STAR qualified displays and computers in use in company facilities, particularly upon installation and after service is performed.
- Provide general information about the ENERGY STAR program to employees whose jobs are relevant to the development, marketing, sales, and service of current ENERGY STAR qualified products.
- 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](http://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](http://www.epa.gov/greenpower).

**Note:** A growing number of large electronics companies have begun asking their top suppliers to measure and reduce their GHG emissions and also set public facing GHG reduction goals. Collaborative initiatives among common industries such as the Electronics Industry Citizens Coalition (EICC) have also developed jointly sponsored supplier training programs or used a common information collection system to gather data from their suppliers. In addition, a handful of ENERGY STAR Partners such as Acer, Asus, Dell, and Philips are also members of the Carbon Disclosure Project's (CDP) Supply Chain initiative, where CDP sends its questionnaire to suppliers on behalf of their customers, asking them to measure and publicly report their direct and indirect GHG emissions.

EPA applauds current industry efforts to engage suppliers on measuring and reducing GHG emissions. EPA encourages more Partners to engage key suppliers to measure and reduce their direct and indirect GHG emissions by developing supplier engagement programs and/or by collaborating with other companies to reach shared suppliers through collective outreach and training efforts. Partners are also encouraged to ask suppliers to report their GHG emissions publicly and set public GHG emissions reduction goals. In order to recognize such efforts, EPA will consider such activity, along with others in this category, for purposes of Manufacturer Partner of the Year.



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

## Eligibility Criteria Version 2.0

Following is the Version 2.0 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

For the purpose of this specification the following definitions apply:

- A) Uninterruptible Power Supply (UPS)<sup>1</sup>: 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.<sup>2</sup>
- 1) Power conversion mechanism:
    - a) Static UPS: UPS where solid-state power electronic components provide the output voltage.
    - b) Rotary UPS: UPS where one or more electrical rotating machines provide the output voltage.
      - i. Rotary UPS (RUPS) without Diesel: A rotary UPS that does not contain an integral diesel engine to supply power to the load during an input power failure.
      - ii. Diesel-coupled rotary UPS (DRUPS): A rotary UPS that contains an integral diesel engine that may be used to supply power to the load during an input power failure.
  - 2) Power Output:
    - a) Alternating Current (Ac)-output UPS: UPS that supplies power with a continuous flow of electric charge that periodically reverses direction.
    - b) Direct Current (Dc)-output UPS: UPS that supplies power with a continuous flow of electric charge that is unidirectional.
      - i. Low-voltage Dc-output UPS/Rectifier: A Dc-output UPS with output voltage less than or equal to 60 V. Includes both individual rectifier units for dc applications and entire Dc-output UPS frames or systems, consisting of rectifier modules, controllers, and any other supporting components.
      - ii. High-voltage Dc-output UPS: A Dc-output UPS with output voltage greater than 60 V.
- Note:* Dc-output UPSs are also known as rectifiers. A rectifier is a product that converts alternating current to direct current to supply a load and an energy storage mechanism. For the purposes of this document, the term “Low-voltage Dc-output UPS/Rectifier” is used because a “rectifier” may also refer to an ac-output UPS subsystem.
- B) Modular UPS: A UPS comprised of two or more single UPS units, sharing one or more common frames and a common energy storage system, whose outputs, in Normal Mode of operation, are connected to a common output bus contained entirely within the frame(s). The total quantity of single UPS units in a modular UPS equals “n + r” where n is the quantity of single UPS units required to

<sup>1</sup> 10 CFR 430, Subpart B, Appendix Y, Section 2.27, with modifications.

<sup>2</sup> 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.

support the load;  $r$  is the quantity of redundant UPS units. Modular UPSs may be used to provide redundancy, to scale capacity or both.

C) 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.

D) UPS Operational Modes:

- 1) Normal Mode: Stable mode of operation that the UPS attains under the following conditions:
  - a) Ac input supply is within required tolerances and supplies the UPS.
  - b) The energy storage system remains charged or is under recharge.
  - c) The load is within the specified rating of the UPS.
  - d) 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:
  - a) Ac input power is disconnected or is out of required tolerance.
  - b) All power is derived from the energy storage system or, in the case of a DRUPS, from the integrated Diesel engine or a combination of both.
  - c) 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.

E) UPS Input Dependency Characteristics:

- 1) Voltage and Frequency Dependent (VFD) UPS<sup>3</sup>: A UPS that produces an ac output where the output voltage and frequency are dependent on the input voltage and frequency.<sup>4</sup>
- 2) Voltage Independent (VI) UPS<sup>5</sup>: Capable of protecting the load as required for VFD, above, and in addition from:
  - a) Under-voltage applied continuously to the input; and
  - b) Over-voltage applied continuously to the input<sup>6</sup>

<sup>3</sup> 10 CFR 430, Subpart B, Appendix Y, Section 2.27.1

<sup>4</sup> This UPS architecture does not provide both over and under-voltage corrective functions like those in voltage independent and voltage and frequency independent systems.

<sup>5</sup> 10 CFR 430, Subpart B, Appendix Y, Section 2.27.3

<sup>6</sup> 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).

- 3) Voltage and Frequency Independent (VFI)<sup>7</sup>: A UPS where the device remains in normal mode producing an ac output voltage and frequency that is independent of input voltage and frequency variations and protects the load against adverse effects from such variations without depleting the stored energy source.
- F) Single-normal-mode UPS: A UPS that functions in Normal Mode within the parameters of only one set of input dependency characteristics. For example, a UPS that functions only as VFI.
- G) Multiple-normal-mode UPS: A UPS that functions in Normal Mode within the parameters of more than one set of input dependency characteristics. For example, a UPS that can function as either VFI or VFD.
- H) Bypass: Power path alternative to the ac converter.
- 1) Maintenance Bypass (path): Alternative power path provided to maintain continuity of load power during maintenance activities.
  - 2) Automatic Bypass: Power path (primary or stand-by) alternative to the indirect ac converter.
    - a) Mechanical Bypass: control is via a switch with mechanically separable contacts.
    - b) Static Bypass (electronic bypass): control is via an electronic power switch, for example transistors, thyristors, triacs or other semiconductor device or devices.
    - c) Hybrid Bypass: control is via switch with mechanically separable contacts in combination with at least one controlled electronic valve device.
- I) Reference Test Load: Load or condition with a power factor of greater than 0.99 in which the output of the UPS delivers the active power ( $W$ ) for which the UPS is rated.<sup>8</sup>
- J) Unit Under Test (UUT):
- 1) For UPSs capable of operating at 115 V and 60 Hz that use National Electrical Manufacturer Association (NEMA) 1-15P or 5-15P plug<sup>9</sup>: The combination of the UPS and battery being tested<sup>10</sup>.
  - 2) For all other UPSs: 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 3 of the ENERGY STAR Test Method.
- K) Power Factor: Ratio of the absolute value of active power  $P$  to the apparent power  $S$ .
- L) Product Family: A group of product models that are (1) made by the same manufacturer, (2) subject to the same ENERGY STAR certification criteria, and (3) of a common basic design. For UPSs, acceptable variations within a product family include:
- 1) Number of installed modules;
  - 2) Redundancy;
  - 3) Type and quantity of input and output filters;
  - 4) Number of rectifier pulses;
  - 5) Energy storage system capacity;

<sup>7</sup> 10 CFR 430, Subpart B, Appendix Y, Section 2.27.2

<sup>8</sup> 10 CFR 430, Subpart B, Appendix Y, Section 2.24

<sup>9</sup> 10 CFR 430, Subpart B, Appendix Y, Section 1, reworded

<sup>10</sup> 10 CFR 430, Subpart B, Appendix Y, Section 2.28, reworded

- 6) For any diesel coupled rotary UPS, the diesel engine's make, model, and capabilities may vary. If sold in the US, the engine of the representative model must meet the requirements in Section 3.5 below; and
- 7) Software or jumper settings that affect rated output power.

M) Abbreviations:

- 1) A: Ampere
- 2) ac: Alternating Current
- 3) dc: Direct Current
- 4) DRUPS: Diesel coupled rotary UPS
- 5) RUPS: Rotary UPS
- 6) THD: Total Harmonic Distortion
- 7) UPS: Uninterruptible Power Supply
- 8) UUT: Unit Under Test
- 9) V: Volt
- 10) VFD: Voltage and Frequency Dependent
- 11) VFI: Voltage and Frequency Independent
- 12) VI: Voltage Independent
- 13) W: Watt
- 14) Wh: Watt-hour

## 2 SCOPE

### 2.1 Included Products

- 2.1.1 Products that meet the definition of an Uninterruptible Power Supply (UPS) as specified herein including Static and Rotary UPSs and Ac-output UPSs and Dc-output UPSs/Rectifiers are eligible for ENERGY STAR certification, with the exception of products listed in Section 2.2. Products eligible for certification under this specification include:
- i. Consumer UPSs intended to protect desktop computers and related peripherals, and/or home entertainment devices such as TVs, set top boxes, DVRs, Blu-ray and DVD players;
  - ii. Commercial UPSs intended to protect small business and branch office information and communication technology equipment such as servers, network switches and routers, and small storage arrays;
  - iii. Data Center UPSs intended to protect large installations of information and communication technology equipment such as enterprise servers, networking equipment, and large storage arrays; and,
  - iv. Telecommunications Dc-output UPSs/Rectifiers intended to protect telecommunication network systems located within a central office or at a remote wireless/cellular site.

### 2.2 Excluded Products

- 2.2.1 Products that are covered under other ENERGY STAR product specifications are not eligible for certification under this specification. The list of specifications currently in effect can be found at [www.energystar.gov/products](http://www.energystar.gov/products).

2.2.2 The following products are not eligible for certification 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.);
- ii. Industrial UPSs specifically designed to protect critical control, manufacturing, or production processes or operations;
- iii. Utility UPSs designed for use as part of electrical transmission and distribution systems (e.g. electrical substation or neighborhood-level UPSs);
- iv. Cable TV (CATV) UPSs designed to power the cable signal distribution system outside plant equipment and connected directly or indirectly to the cable itself. The “cable” may be coaxial cable (metallic wire), fiber-optic, or wireless (e.g., “Wi-Fi”);
- v. UPSs designed to comply with specific UL safety standards for safety-related applications, such as emergency lighting, operations or egress, or medical diagnostic equipment; and,
- vi. UPSs designed for mobile, ship board, marine or airborne applications.
- vii. Hybrid UPSs that can deliver more than 10% of their rated output power through both ac and dc outputs.

### 3 CERTIFICATION CRITERIA

#### 3.1 Significant Digits and Rounding

- 3.1.1 Unless otherwise specified, all calculations shall be carried out with actual measured (unrounded) values and only the final result of a calculation shall be rounded.
- 3.1.2 Unless otherwise specified, compliance with specification limits shall be evaluated using exact values without any benefit from rounding.
- 3.1.3 Calculated efficiency values shall be rounded to the third decimal place, as specified in Section 4.3.5 of Appendix Y to Subpart B of 10 CFR 430.
- 3.1.4 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

- 3.2.1 Single-normal-mode UPSs: Average loading-adjusted efficiency ( $Eff_{AVG}$ ), as determined per Appendix Y to Subpart B of 10 CFR 430, or if not applicable, as calculated per Equation 1, shall be greater than or equal to the Minimum Average Efficiency Requirement ( $Eff_{AVG\_MIN}$ ), as determined per Table 2, for the specified rated output power and input dependency characteristic.

##### Equation 1: Calculation of Average Efficiency for Ac-output UPSs and High-voltage Dc-output UPSs

$$Eff_{AVG} = t_{25\%} \times Eff|_{25\%} + t_{50\%} \times Eff|_{50\%} + t_{75\%} \times Eff|_{75\%} + t_{100\%} \times Eff|_{100\%}$$

Where:

- $Eff_{AVG}$  is the average loading-adjusted efficiency,
- $t_{n\%}$  is the proportion of time spent at the particular  $n\%$  of the Reference Test Load, as specified in the loading assumptions in Table 1, and
- $Eff|_{n\%}$  is the efficiency at the particular  $n\%$  of the Reference Test Load, as measured according to the ENERGY STAR Test Method.



**Table 1: Ac-output UPS Loading Assumptions for Calculating Average Efficiency**

| Rated Output Power, <i>P</i> ,<br>in watts (W) | Input<br>Dependency<br>Characteristic | Proportion of Time Spent at Specified<br>Proportion of Reference Test Load,<br><i>t</i> <sub><i>n</i>%</sub> |     |      |      |
|--|---------------------------------------|--|-----|------|------|
|  |                                       | 25%  | 50% | 75%  | 100% |
| <i>P</i> ≤ 1500 W                              | VFD                                   | 0.2  | 0.2 | 0.3  | 0.3  |
|  | VI or VFI                             | 0  | 0.3 | 0.4  | 0.3  |
| 1500 W < <i>P</i> ≤ 10,000 W                   | VFD, VI, or VFI                       | 0  | 0.3 | 0.4  | 0.3  |
| <i>P</i> > 10,000 W                            | VFD, VI, or VFI                       | 0.25   | 0.5 | 0.25 | 0    |

**Table 2: Ac-output UPS Minimum Average Efficiency Requirement**

| Minimum Average Efficiency Requirement ( <i>Eff</i> <sub>AVG_MIN</sub> ), Where:  |  |  |  |
|---|--|--|--|
| <ul style="list-style-type: none"> <li>• <i>P</i> is the Rated Output Power in watts (W),</li> <li>• <i>E</i><sub>MOD</sub> is an allowance of 0.004 for Modular UPSs applicable in the commercial 1500–10,000 W range,</li> <li>• <i>ln</i> is the natural logarithm; and</li> <li>• The requirement shall be rounded to the third decimal place for certification and reporting.</li> </ul> |  |  |  |
| Rated Output Power  | Input Dependency Characteristic        |  |  |
|   | VFD                                    | VI                                     | VFI                                      |
| <i>P</i> ≤ 350 W  | $5.71 \times 10^{-5} \times P + 0.962$ | $5.71 \times 10^{-5} \times P + 0.964$ | $0.011 \times \ln(P) + 0.824$            |
| 350 W < <i>P</i> ≤ 1500 W   | 0.982                                  | 0.984                                  |  |
| 1500 W < <i>P</i> ≤ 10,000 W  | $0.981 - E_{MOD}$                      | $0.980 - E_{MOD}$                      | $0.0145 \times \ln(P) + 0.800 - E_{MOD}$ |
| <i>P</i> > 10,000 W   | 0.970                                  | 0.940                                  | $0.0058 \times \ln(P) + 0.886$           |

3.2.2 Multiple-normal-mode UPSs that Do Not Ship with the Highest Input Dependency Mode Enabled by Default: If the Multiple-normal-mode UPS does not ship with its highest input dependency mode enabled by default, its average loading-adjusted efficiency (*Eff*<sub>AVG</sub>), as determined per Appendix Y to Subpart B of 10 CFR 430, or if not applicable, as calculated per Equation 1, shall be greater than or equal to:

- i. The Minimum Average Efficiency Requirement (*Eff*<sub>AVG\_MIN</sub>), as determined per Table 2, for the rated output power and lowest input dependency mode provided by the UPS.

3.2.3 Multiple-normal-mode UPSs that Ship with the Highest Input Dependency Mode Enabled by Default: If the Multiple-normal-mode UPS does ship with its highest input dependency mode enabled by default, its average loading-adjusted efficiency (*Eff*<sub>AVG</sub>), as calculated per Equation 2, shall be greater than or equal to:

- i. The Minimum Average Efficiency Requirement (*Eff*<sub>AVG\_MIN</sub>), as determined per Table 2 for the rated output power and lowest input dependency mode provided by the UPS.

**Equation 2: Calculation of Average Efficiency for Multiple-normal-mode Ac-output UPSs**

$$Eff_{AVG} = 0.75 \times Eff_{LOW} + 0.25 \times Eff_{HIGH}$$

Where:

- *Eff*<sub>AVG</sub> is the average loading-adjusted efficiency,
- *Eff*<sub>LOW</sub> is the average loading-adjusted efficiency in the lowest input dependency mode (i.e., VFI or VI), as determined per Appendix Y to Subpart B of 10 CFR 430, or if not applicable, as calculated per Equation 1, and
- *Eff*<sub>HIGH</sub> is the average loading-adjusted efficiency in the highest input dependency mode (i.e., VFD), as

determined per Appendix Y to Subpart B of 10 CFR 430, or if not applicable, as calculated per Equation 1.

### 3.3 Energy Efficiency Requirements for Dc-output UPSs/Rectifiers

- 3.3.1 High-voltage Dc-output UPSs: Average loading-adjusted efficiency ( $Eff_{AVG}$ ) for High-voltage Dc-output UPSs/Rectifiers, as calculated per Equation 1, shall be greater than or equal to the Minimum Average Efficiency Requirement ( $Eff_{AVG\_MIN}$ ), in Table 3, subject to the following requirement.
- i. High-voltage Dc-output UPSs shall be treated as VFI when referencing Table 1.
- 3.3.2 Low-voltage Dc-output UPSs/Rectifiers: Average loading-adjusted efficiency ( $Eff_{AVG}$ ) for Low-voltage Dc-output UPSs/Rectifiers, as calculated per Equation 3 shall be greater than or equal to the Minimum Average Efficiency Requirement ( $Eff_{AVG\_MIN}$ ), in Table 3. This requirement shall apply to complete systems and/or individual modules. Manufacturers can qualify either, subject to the following requirements:
- i. Complete systems that are also modular shall be certified as Modular UPS Product Families with a particular model of module installed,
  - ii. Certification of individual modules will have no bearing on the certification of modular systems unless the entire systems are also certified as specified above.

#### Equation 3: Calculation of Average Efficiency for Low-voltage Dc-output UPSs

$$Eff_{AVG} = \frac{Eff|_{30\%} + Eff|_{40\%} + Eff|_{50\%} + Eff|_{60\%} + Eff|_{70\%} + Eff|_{80\%}}{6}$$

**Table 3: High Voltage Dc-output UPS and Low-voltage Dc-output UPS/Rectifier Minimum Average Efficiency Requirement**

| Minimum Average Efficiency Requirement ( $Eff_{AVG\_MIN}$ ) |
|---|
| 0.955   |

### 3.4 Power Factor Requirements

- 3.4.1 The measured input power factor at 100 percent of the Reference Test Load shall meet the minimum level specified in Table 4 for all VFI and VI Normal Modes required for certification.

**Table 4: UPS Minimum Input Power Factor Requirement**

| Minimum Power Factor Requirement |
|----------------------------------|
| 0.90                             |

### 3.5 Diesel Coupled Rotary UPS Emissions Requirements

- 3.5.1 Diesel coupled rotary UPS systems intended for sale in the US must demonstrate that their diesel engines are in compliance with Clean Air Act regulations, 40 CFR part 60 subpart IIII. Compliance shall be demonstrated via presentation of a certificate of conformity with this regulation at the time of certification.
- i. Systems intended for sale outside the US are not subject to this requirement.
  - ii. Only the representative model(s) for testing, as specified in Section 4.2, shall demonstrate compliance with Clean Air Act regulations.

## 4 TESTING

### 4.1 Test Methods

- 4.1.1 When testing UPSs, the test methods identified in Table 5 shall be used to determine ENERGY STAR certification.

**Table 5: Test Methods for ENERGY STAR Certification**

| Product Type   | Test Method  |
|--|--|
| UPSs capable of operating at 115 V and 60 Hz that use NEMA 1-15P or 5-15P plug | Uniform Test Method for Measuring the Energy Consumption of Battery Chargers incorporated in Appendix Y to Subpart B of 10 CFR 430, Section 4: Testing Requirements for Uninterruptible Power Supplies |
| All other UPSs   | ENERGY STAR Test Method for Uninterruptible Power Supplies, Rev. Dec-2017  |

### 4.2 Number of Units Required for Testing

- 4.2.1 Representative Models shall be selected for testing by either the sampling requirements defined in 10 CFR 429.25, which references 10 CFR 429.11, or the following requirements:

- i. For certification 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 certification of a Modular UPS Product Family where models vary by number of installed modules or Product Family where models vary by software or jumper settings that affect rated output power, the manufacturer shall select the maximum and minimum configurations to serve as Representative Models—i.e., the system shall meet the eligibility criteria in both its maximum and minimum non-redundant configurations. If the maximum and minimum configuration Representative Models meet the ENERGY STAR certification criteria at their respective output power levels, all intermediate configuration models within a Modular or software- or jumper-set UPS Product Family may be certified to ENERGY STAR.
- iii. For certification of a UPS Product Family where the models are related by a characteristic other than the number of installed modules or software or jumper settings, the highest energy using configuration within the Product Family shall be considered the Representative Model with the exception of energy storage system variations—the manufacturer may select any energy storage system for the test, within the requirements of the ENERGY STAR Test Method. Other products within a Product Family do not have to be tested for certification, but they are expected to meet relevant ENERGY STAR certification criteria and may be subject to verification testing sometime after initial certification.

- 4.2.2 A single unit of each Representative Model shall be selected for testing.

- 4.2.3 All tested units shall meet ENERGY STAR certification criteria.

## 5 EFFECTIVE DATE

- 5.1.1 Effective Date: The Version 2.0 ENERGY STAR UPS specification shall take effect on **January 1, 2019**. To qualify for ENERGY STAR, a product model shall meet the ENERGY STAR specification in effect on its date of manufacture. The date of manufacture is specific to each unit and is the date on which a unit is considered to be completely assembled.
- 5.1.2 Future Specification Revisions: EPA reserves the right to change this specification should technological and/or market changes affect its usefulness to consumers, industry, or the environment. In keeping with current policy, revisions to the specification are arrived at through stakeholder discussions. In the event of a specification revision, please note that the ENERGY STAR certification is not automatically granted for the life of a product model.

## 6 CONSIDERATIONS FOR FUTURE REVISIONS

- 6.1.1 Communications Criteria: EPA will continue to monitor the market and consider use-cases for UPS connected capabilities, such as demand response, that can save energy or help balance grid loads. If a U.S. market for grid-connected demand response capable UPSs starts to develop, EPA may reconsider including optional connected functionality criteria.



# ENERGY STAR<sup>®</sup> Program Requirements Product Specification for Uninterruptible Power Supplies (UPSs)

## Test Method Rev. Dec-2017

### 1 OVERVIEW

The following test method shall be used for determining product compliance with requirements in the ENERGY STAR Eligibility Criteria for Uninterruptible Power Supplies (UPSs).

### 2 APPLICABILITY

The following test method is applicable to all products eligible for qualification under ENERGY STAR Eligibility Criteria for UPSs, including:

| Product Type   | Test Method  |
|--|--|
| UPSs capable of operating at 115 V and 60 Hz that use NEMA 1-15P or 5-15P plug | Uniform Test Method for Measuring the Energy Consumption of Battery Chargers incorporated in Appendix Y to Subpart B of 10 CFR 430, Section 4: Testing Requirements for Uninterruptible Power Supplies |
| All other UPSs   | ENERGY STAR Test Method for Uninterruptible Power Supplies, Rev. Dec-2017.   |

### 3 TEST SETUP

- A) Test Setup and Instrumentation: Unless otherwise specified within this Test Method, the test setup and instrumentation for all portions of this method shall be in accordance with the following:
- 1) For Ac-output UPSs, International Electrotechnical Commission (IEC) standard:
    - a) IEC 62040-3:2011, Ed. 2.0, *Uninterruptible power systems (UPS) - Part 3: Method of specifying the performance and test requirements*, Section J.2.
  - 2) For High-voltage Dc-output Datacenter UPSs (output voltage greater than 60 V), International Electrotechnical Commission (IEC) standard:
    - a) IEC 62040-5-3:2016; *Uninterruptible power systems (UPS) – Part 5-3: DC output UPS – Performance and test requirements*, Annex F.
  - 3) For Low-voltage Dc-output UPSs/Rectifiers (output voltage less than or equal to 60 V), Alliance for Telecommunications Industry Solutions (ATIS) standards:
    - a) ATIS-0600015.2013, *Energy Efficiency for Telecommunication Equipment: Methodology for Measurement and Reporting – General Requirements*; and
    - b) ATIS-0600015.04.2010, *Energy Efficiency for Telecommunication Equipment: Methodology for Measurement and Reporting DC Power Plant – Rectifier Requirements*.

Note:

The requirement in Section 5.4 of ATIS-0600015.2013, which states “DC power sources used to provide power to the equipment under test shall be capable of

providing a minimum of 1.5 times the power rating of the equipment under test," is optional for ENERGY STAR testing.

The requirement in Section 6.2 of ATIS-0600015.04.2010, which states the Unit Under Test (UUT) shall be evaluated with "a power source with a rating of at least 2X the maximum input power rating of the rectifier," is optional for ENERGY STAR testing.

- B) The UUT shall be tested in "as-shipped" configuration, with the following exceptions:
- 1) Any dc output port(s) of the UUT that provide less than 90% of the rated output power must remain unloaded during testing, unless that would result in all ports unloaded.
  - 2) Any feature unrelated to maintaining the energy storage system at full charge or delivery of load power (e.g., LCD display) shall be switched off. If it is not possible to switch such features off, they shall be set to their lowest power-consuming mode during the test.
  - 3) If the UPS takes any physically separate connectors or cables not required for maintaining the energy storage system at full charge or delivery of load power but associated with other features (such as serial or USB connections, Ethernet, etc.), these connectors or cables shall be left disconnected during the test.
  - 4) Any manual on-off switches specifically associated with maintaining the energy storage system at full charge or delivery of load power shall be switched on for the duration of the test.
- C) Ac-input Power: The UUT shall be connected to the first (highest) rated voltage and rated frequency combination specified in Table 1, top to bottom. If two frequencies are provided in a given row, the manufacturer may specify which frequency shall be used for testing.

**Table 1: Input Supply Requirements**

| Voltage and Precedence | Frequency   |
|------------------------|-------------|
| 1. 600Δ V ac           | 60 Hz       |
| 2. 600Y/346 V ac       | 60 Hz       |
| 3. 480Δ V ac           | 60 Hz       |
| 4. 480Y/277 V ac       | 60 Hz       |
| 5. 415Δ V ac           | 60 Hz       |
| 6. 415Y/240 V ac       | 60 Hz       |
| 7. 400Δ V ac           | 50 Hz       |
| 8. 400Y/230 V ac       | 50 Hz       |
| 9. 380Y/220 V Ac       | 50 or 60 Hz |
| 10. 230 V ac           | 50 or 60 Hz |
| 11. 208Δ V ac          | 60 Hz       |
| 12. 208Y/120 V ac      | 60 Hz       |
| 13. 200 V ac           | 50 or 60 Hz |
| 14. 120 V ac           | 60 Hz       |
| 15. 115 V ac           | 50 or 60 Hz |
| 16. 100 V ac           | 50 or 60 Hz |

- 1) UUTs that are not compatible with any of the combinations listed in Table 1 shall be connected to the highest rated voltage and frequency combination. The test voltage and frequency used for the test shall be reported.
- D) Ac-output Power: For Ac-output UPSs, the output voltage and frequency of the UUT shall have the same characteristics as the input voltage, specified in Table 1, above, and Section J.2 of IEC standard 62040-3, Ed. 2.0.
- 1) UUTs that have an output voltage different from the input voltage shall be tested at the highest compatible output voltage. The voltage and frequency used for the test shall be reported.
- E) Dc-output Power: For Dc-output UPSs/Rectifiers, the output voltage of the UUT shall be the first applicable voltage specified in Table 2, from top to bottom. The voltage used for the test shall be reported.

**Table 2: Dc-output Power Requirements and Precedence**

| Nominal Voltage and Precedence | Voltage for Test <sup>1</sup> | Voltage Tolerance |
|--------------------------------|-------------------------------|-------------------|
| 1. 380 V dc                    | 418 V dc                      | +/- 1 %           |
| 2. 48 V dc                     | 53 V dc                       | +/- 1 %           |
| 3. 60 V dc                     | 66 V dc                       | +/- 1 %           |
| 4. 24 V dc                     | 26 V dc                       | +/- 1 %           |
| 5. USB Type C                  | 20 V dc                       | +/- 1 %           |
| 6. 575 V dc                    | 595 V dc                      | +/- 1 %           |

- F) Measurement Accuracy:
- 1) Power measurements with a value greater than or equal to 2 W shall be made with an uncertainty of less than or equal to 0.5% at the 95% confidence level.
  - 2) Power measurements with a value less than 2 W shall be made with an uncertainty of less than or equal to 0.01 W at the 95% confidence level.
  - 3) Output power measurement shall be taken as close to the output of the UUT as is feasible to ensure compliance with accuracy requirements specified in the referenced test methods.
- G) Relative Humidity: Relative humidity shall be within the range specified by the manufacturer.

## 4 TEST CONDUCT

### 4.1 UPS Operating Mode Conditions

If the UUT can operate in two or more distinct normal modes, conduct all parts of the test and report all parameters listed in the test reporting template in:

- The lowest input dependency, and
- The highest input dependency, as specified in the ENERGY STAR Eligibility Criteria for UPSs.

<sup>1</sup> Expected voltage for a fully charged battery

If applicable, the UUT shall be tested in the highest efficiency sub-mode of each tested normal mode.

## **4.2 ENERGY STAR Guidance for Implementation of IEC 62040-3, Ed. 2.0<sup>2</sup>**

- A) The reference test load defined in IEC 62040-3, Ed. 2.0 Section 3.3.5 shall be a resistive test load.
- B) Modular UPSs with output power that varies depending on the number of modules installed shall be tested twice, at both the vendor-specified minimum and maximum non-redundant (i.e., N+0) configurations.
  - 1) For Low-voltage Dc-output UPSs/Rectifiers, this test method shall take precedence over the requirements specified in Section 5.10 of the ATIS -0600015.2013 standard.<sup>3</sup>
- C) Modular UPSs shall be tested with redundant components (e.g., fans, controllers, etc.) for the vacant module slots functioning according to the UUT's as-shipped default behavior.
- D) Back-feeding the source may be used in place of a test load during testing of UPS systems larger than 100 kW output, provided that an output power factor greater than 0.99 is maintained at all times.
- E) Energy Storage System: The UPS shall not be modified or adjusted to disable energy storage charging features, with the following exceptions.
  - 1) If the energy storage system is able to be disconnected by physical means or by using default controls while maintaining normal operation, and the user manual or other publicly available documents do not advise against disconnecting it, the UPS shall be tested with the energy storage system disconnected.<sup>4</sup>
  - 2) The UPS may be adjusted to disable any alarms, indications, or default detection mechanisms that may result from disconnecting the energy storage system, as long as the controls necessary to do so are natively present on the UPS or are included in end-user software.
  - 3) If unable to disconnect the energy storage system as instructed in Sections 4.2.E)1) and 4.2.E)2), the energy storage system shall store maximum energy and the transfer of energy to and from the energy storage system shall be minimized during the test.
    - a) For battery-operated UPSs, to ensure the battery is fully charged, perform the following steps:
      - i. For UPSs that have an indicator to show that the battery is fully charged, continue charging for an additional 5 hours after the fully charged indication is present.
      - ii. If there is no state of charge indicator, but the manufacturer's instructions provide a time estimate for when charging this battery or this capacity of battery should be complete, continue charging for an additional 5 hours after the manufacturer's estimate.
      - iii. If there is no indicator and no time estimate in the instructions, but the charging current is stated on the UPS or in the instructions, terminate charging 1 hour after the calculated test duration or, if none of the above applies, the duration shall be 24 hours.
    - b) For battery-operated UPSs, if the UPS is shipped with a battery, that battery shall be used for testing. Otherwise, the manufacturer may select a battery for testing. Details regarding the selected battery shall be included in publicly available documents and documented in the test reporting template. These batteries are not required to ship with the UPS.

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<sup>2</sup> This guidance also applies to Dc-output UPSs.

<sup>3</sup> The ATIS-0600015.2013 specifies that modular Dc-Output UPSs/Rectifiers may be tested on a per-module basis.

<sup>4</sup> The ATIS standard does not specify the disconnection of the energy storage system. Therefore, all UPSs, including Dc-output UPSs/Rectifiers, shall follow this provision.



## 5 TEST PROCEDURES FOR ALL PRODUCTS

- A) Required Calculations: Equations 1 and 2 shall be used when calculating the UUT's average power and efficiency:

### Equation 1: Calculation of Average Power

$$P_{AVG} = \frac{E_{TOT}}{t}$$

Where:

- $P_{AVG}$  is the average power in watts.
- $E_{TOT}$  is the total energy in watt-hours.
- $t$  is the length of the measurement in hours.

### Equation 2: Calculation of Efficiency

$$Eff = \frac{P_{AVG\_OUT}}{P_{AVG\_IN}}$$

Where:

- $Eff$  is the UPS efficiency.
- $P_{AVG\_OUT}$  is the average output power in watts.
- $P_{AVG\_IN}$  is the average input power in watts.

- B) Steady-state: The UPS and load shall have been operated for a sufficient length of time to reach thermal stability. Allow the UUT to stabilize for 125% of the manufacturer-specified stabilization time, as instructed in Appendix J of IEC 62040-3, Ed. 2.0. During the final 20 minutes of the stabilization period, at the 100% loading point, perform the following steady-state check, in which the difference between the two efficiency calculations shall be less than one percent:
- 1) Simultaneously measure the UUT's accumulated input and output energy in watt-hours (Wh) for at least 5 minutes.
  - 2) Calculate the UUT's average input and output power in watts (W) using Equation 1.
  - 3) Calculate the UUT's efficiency,  $Eff_1$ , using Equation 2.
  - 4) Wait a minimum of 10 minutes.
  - 5) Repeat steps 1 to 3 to calculate another efficiency value,  $Eff_2$ .
  - 6) Equation 3 shall be used to determine if the UUT is at steady-state. If the percent difference of  $Eff_1$  and  $Eff_2$ , as described in Equation 3, is less than one percent, the UUT is at steady-state.

### Equation 3: Calculation of Efficiency Variation for Determination of Steady-state

$$\text{Percent Difference} = \frac{|Eff_1 - Eff_2|}{\text{Average}(Eff_1, Eff_2)}$$

- 7) If the percent difference is greater than or equal to one percent, the UUT is not at steady-state. Repeat steps 4 to 6 until the UUT is at steady-state. Record the appropriate values in the test reporting template.
- C) Efficiency Measurements: Input and output power measurements for efficiency calculations shall be performed on the UUT according to Section J.3 of IEC standard 62040-3, Ed. 2.0, with the following exceptions.

- 1) Test the UUT at the following reference test load conditions, in the specified order:
  - a) Ac-output UPSs and high-voltage Dc-output UPSs: 100%, 75%, 50%, 25%, and 0% of the rated output power.
  - b) Low-voltage Dc-output UPSs/Rectifiers: 80%, 70%, 60%, 50%, 40%, 30%, 0% of the rated output power.

*Note:* For the 0% loading condition (i.e., the test load disconnected, but output inverter operational for Ac-output UPS), measure only at the input to the UUT.
- 2) The test shall be performed at each of the reference test loads by simultaneously measuring the UUT's total input and output energy in Wh over a 15 minute test period. The total energy accumulation rate shall be at least 1 Hz. Calculate the UUT's average input power and output power for the period using Equation 1, and the UUT's efficiency using Equation 2.
- 3) Measure and record all the applicable parameters listed in the test reporting template for each Ac-output/Dc-output UPS test performed. For Ac-output UPSs, also record the input dependency characteristic (AAA) in the tested modes, as specified in Section 5.3.4 of IEC standard 62040-3, Ed. 2.0.
- D) Input Power Factor Measurements: Measure and report the input power factor of the UUT per Section 6.4.1.5 of IEC standard 62040-3, Ed. 2.0, for each mode at 100% of the reference test load.<sup>5</sup>

## 6 REFERENCES

- A) 10 CFR 430 Subpart B Appendix Y, *Uniform Test Method for Measuring the Energy Consumption of Battery Chargers*
- B) ATIS-0600015.04.2010, *Energy Efficiency for Telecommunication Equipment: Methodology for Measurement and Reporting DC Power Plant – Rectifier Requirements*. January 1, 2010.
- C) ATIS-0600015.2013, *Energy Efficiency for Telecommunication Equipment: Methodology for Measurement and Reporting – General Requirements*. May 6, 2013.
- D) IEC 62040-3:2011, Ed. 2.0, *Uninterruptible power systems (UPS) - Part 3: Method of specifying the performance and test requirements*, Section J.2. March 14, 2011.
- E) IEC 62040-5-3: 2016, Ed. 1, *Uninterruptible power systems (UPS) - Part 5-3: DC output UPS - Performance and test requirements*, Annex F. October 26, 2016.
- F) DOE Appendix Y to Subpart B of 10 CFR 430, Section 4: Testing Requirements for Uninterruptible Power Supplies.

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<sup>5</sup> Neither the ATIS-0600015.2013 nor the ATIS-0600015.04.2010 standard specifies requirements for testing input power factor; therefore, the provisions contained in section 6.4.1.5 of IEC standard 62040-3 shall be used for testing the input power factor of Dc-output UPSs/Rectifiers.