ENERGY STAR Uninterruptible Power Supply
Specification Framework
February 16, 2010

Please send comments to UPS@energystar.gov
no later than Friday, April 02, 2010

Overview

This document describes the key building blocks that form the basis for every ENERGY STAR specification; these items are intended to provide the framework around which the EPA can develop an effective energy efficiency program for Uninterruptible Power Supply (UPS) devices in data center, small office / home office, and home entertainment applications. The principal objectives for this ENERGY STAR specification are threefold:

(1) to provide purchasers with the means to identify the most energy efficient UPS solutions for their specific end-use application,
(2) to provide tools and information to designers and managers looking to improve the efficiency of data center operations, and
(3) to provide uniform efficiency testing conditions and reporting criteria to enable an informed purchase decision and efficiency-oriented comparison of products. EPA will look to harmonize energy efficiency requirements, where appropriate, to minimize the number of competing standards in the marketplace.

The purpose of each building block is provided under the subheadings below, along with EPA's preliminary thoughts on how each may ultimately be incorporated into the Version 1.0 Uninterruptible Power Supply specification. At the end of each section are a series of questions aimed at generating discussion about the proposed approach. Please note that this document is not intended to be a comprehensive review of the ENERGY STAR perspective on UPSs, rather it serves as a starting point for EPA's specification development efforts.

Stakeholders are encouraged to provide feedback on the specific concepts and definitions presented in this document, and are also welcome to submit comments of a more general nature. Communication between EPA and industry stakeholders is critical to the success of the ENERGY STAR program, especially in this early stage of the specification development process. Any and all creative suggestions for improvements to the basic ENERGY STAR approach outlined in this document will be considered for inclusion in subsequent draft and final specifications. ENERGY STAR representatives are available for additional technical discussions with interested parties at any time during the specification development process. Please contact Sarah Medepalli, ICF International, at smedepalli@icfi.com to arrange a meeting.

Building Block #1: Definitions

a. **Purpose:** Establish a set of definitions to explicitly describe which products are covered by the specification and which are not, and to clearly differentiate between Uninterruptible Power Supply and other ENERGY STAR product categories. Provide definitions for operational modes, key components and sub-classes of products, etc. Note that a product may not be qualified as ENERGY STAR under more than one specification.

b. **Initial Approach:** EPA prefers to make use of existing definitions that are generally accepted by industry. In cases where industry accepted definitions are not available or appropriate, EPA will work with stakeholders to develop appropriate definitions.

c. **Preliminary List of Definitions**[1]**:**

a. Uninterruptible Power Supply (UPS):

A device intended to maintain continuity of power to electrical loads in the event of a disruption to expected utility power supply. The ride-through time of a UPS varies from seconds to tens of minutes. UPS designs offer a range of features, from acting as a temporary power source to the load during a power disruption, to conditioning the power reaching the load under normal operation. UPSs contain energy storage mechanisms to supply power to the attached load in the event of full disruption from the utility.

b. System Topology:

1. **Passive Standby:** A UPS device that exists solely to protect the load from power disruptions. The load is primarily powered by utility power without interaction from the UPS. In the event of power disruption or if the power exceeds predetermined tolerances, an inverter engages the energy storage mechanism to provide power to the load, bypassing utility electrical supply.
2. **Line Interactive:** A UPS device that maintains continuity of load power through the use of an inverter or a power interface, while conditioning primary power at the input supply frequency. A Line Interactive UPS provides additional protection to the load by regulating frequency within optimal limits and requires a small trickle current to the battery for charging purposes during normal operation.
3. **Double Conversion:** A UPS device that continuously supplies total load power by regulating utility electricity before it reaches the load. The output voltage and frequency supplied to the load are independent of input voltage and frequency conditions from the utility. Double Conversion UPSs are common in high-reliability applications.

c. Energy Storage Mechanisms:

1. **Electrochemical Battery**: An electrochemical battery is a device which is used to store and discharge electrical energy through the conversion of chemical energy. UPS batteries are designed to be recharged and are sized to the expected load.
2. **Rotary (Flywheel):** A flywheel provides energy storage in the form of a spinning massive disk. When power from the utility is interrupted, the disk transfers momentum to an electrical generator. Ride-through time for rotary systems commonly ranges from ten seconds to one minute.

d. UPS Input Power:

1. **Single-phase**: Single-phase electric power refers to the distribution of alternating current (AC) electric power using a system in which all the voltages of the supply vary in unison. A single-phase UPS is connected between a load and a single-phase AC power source.

[1] EPA is interested in feedback on industry standard definitions for all terms identified in this document. Stakeholders are also encouraged to provide additional suggestions or clarifications regarding the proposed definitions.

2. **Three-phase**: Three-phase electric power refers to the distribution of alternating current (AC) electric power using a system in which three overlapping AC cycles are offset by 120 degrees.

e. UPS Operational States:
   1. **Normal State:** The operating state in which the load is continuously supplied by the utility and the UPS device is ready and available to provide backup power in the event of a utility power disruption.
      1. Passive Standby: In normal mode, the load is supplied by the utility power via the transfer switch.
      2. Line Interactive: In normal mode, the load is supplied with conditioned power via a parallel connection of the utility power and the UPS inverter, where the inverter conditions the output voltage.
      3. Double Conversion: In normal mode, the load is continuously supplied by the converter/inverter combination in a double conversion technique (e.g., ac to dc to ac).
   2. **Stored Energy State:** The operating state in which the electric load is actively being supplied by the UPS due a utility power disruption.
      1. Passive Standby: When there is disruption in the utility power supply, the transfer switch switches the load to UPS. The UPS enters stored energy mode of operation where the battery/inverter combination supports the load.
      2. Line Interactive: When the utility power supply voltage is out of UPS preset tolerances, the UPS enters stored energy mode of operation where the battery/inverter combination supports the load.
      3. Double Conversion: When the utility power supply is out of UPS preset tolerances, the UPS enters stored energy mode of operation where the battery/inverter combination supports the load.
   3. **Bypass State:** The operating state in which the UPS is available to be disconnected without disruption to the load. In this state, the load is fully supplied by utility power and the UPS is not available to provide backup power in the event of a utility power disruption.

d. **Questions for Discussion:**
   1. Are there any other sources that the EPA should review for variations of, or additions to, this list of definitions?
   2. Are there alternate versions of the operational state definitions above, that EPA should consider? Are there other operational states specific to UPS that need to be defined in this specification?
   3. EPA is aware of an “eco-mode” in certain Line Interactive and Double Conversion UPS products that trades off power conditioning for higher levels of efficiency. It is EPA’s understanding that “eco-mode” is not often actuated by end-users because of a real or perceived risk that the UPS reliability is diminished. EPA intends at this time to require UPS energy performance to be evaluated without the aid of any “eco-mode” strategies, but would like to request stakeholder feedback on various “eco-modes” to understand if and how they may be referenced in the ENERGY STAR program.
   4. Are standard load conditions (such as 30% or 70%) used in the industry for the evaluation of UPS efficiency? What load conditions are data center operators

most interested in when selecting the most efficient UPS solution for their data center? What load conditions are most applicable to home or small office UPS buyers?

5. EPA is interested in understanding the relationship between various means of UPS power conditioning and energy efficiency. Is there an industry-accepted method to measure and quantify power conditioning? If so, is there a way to "right-size" the amount of power conditioning to match the needs of a particular application in order to maximize energy efficiency?
6. Given the environmental impact of electrochemical battery production and disposal, what environmental programs or best practices should be considered for inclusion in the ENERGY STAR specification?

Building Block #2: Eligible Product Categories

a. Purpose: Identify specific product categories to be covered by the specification based on the agreed upon definitions in Building Block #1. Clearly defined categories are particularly important where requirements may not be appropriate for products that perform distinctly different functions. It is also important to identify product types that are not eligible for ENERGY STAR qualification for reasons such as: use of proprietary technologies; limited availability of data; lack of differentiation with regards to product efficiency; or niche markets.

b. Initial Approach: EPA's intention in developing the Version 1.0 specification is to cover as much of the UPS market as can be reasonably addressed in a timely manner, while maximizing the opportunities for energy savings. To this end, EPA may propose a tiered approach for the specification, concentrating on the greatest opportunities for energy savings in Version 1.0, and expanding the scope in later versions of the specification. Market segments with the greatest opportunity for energy savings and adequate data will likely be targeted in the first specification release, while segments with less opportunity and insufficient data may be included in subsequent specification revisions.

c. Market Segments: EPA intends to explore the following UPS topologies for inclusion in the Version 1.0 specification:

- Passive Standby
- Line Interactive
- Double Conversion

Manufacturers and researchers typically divide the UPS market into segments based on maximum output rating. However, little consensus appears to exist on categorization by output level. UPSs carry ratings ranging from hundreds to millions of Volt-Amperes. At the lower ranges of output ratings, intended applications can include protection of workstation computer equipment and peripherals. The Standby topology, as a low-cost and high-efficiency solution, is common in this market segment. Mid-range applications include server, rack, or localized load protection in data centers or IT equipment rooms. At the highest output ranges, UPSs can serve as centralized solutions for multiple servers or network devices, ranging up to full-facility protection. For both mid- and high-end applications, Line Interactive and Double Conversion topologies are common.

According to a study done by EPRI[2], the data center/IT market accounts for about two-thirds of UPS units installed in the United States.

d. Questions for Discussion:

1. Aside from output rating, what are some other means of segmenting the UPS market? Would market segmentation by input power phase (single- versus three-phase) more effectively classify devices according to end-use application?
2. Given the wide variations in topology, base technology, and load range for UPS devices, which portions of the market provide the biggest opportunity for energy savings?
3. Are there any upcoming technologies or product types in development which are not included in this document and should be considered for inclusion in this ENERGY STAR specification?

Building Block #3: Energy Efficiency Criteria and Test Procedures

a. **Purpose:** Once it is determined which products will be included in the ENERGY STAR specification, the next step is to identify metrics for energy efficiency performance. Metrics may address the efficiency of key components, operational states, and/or whole-system energy efficiency. Efficiency metrics must be supported by generally accepted test procedures. Further, while one efficiency metric across a broad range of products is preferable, EPA will evaluate the need to develop unique requirements for segments of the market if it can be shown that key product functions or purposes require additional energy.

Efficiency metric(s) will ultimately be used to determine ENERGY STAR qualification. The ENERGY STAR program strives to set requirements such that 25% of the products available in the market at the time the specification becomes effective will be able to qualify.

Notes on Value Added Resellers (VAR):
In some cases, UPSs may be shipped from the Original Equipment Manufacturer (OEM) to a VAR that then configures the device for sale to the end user. EPA will further evaluate the role of VARs during the development of the specification. Based on feedback received and EPA assessments, guidelines may be established to define partnership and testing requirements for the VAR sales channel.

Initial Approach: EPA intends to adopt or refine existing test procedures to evaluate the efficiency and power factor over a product's rated load range. EPA recognizes that UPS efficiencies vary based on actual load requirements and UPS configuration (e.g., 2n, 2n+1). Efficient operation at part-load conditions is important to ENERGY STAR because efficiencies typically decrease dramatically at low loads. EPA believes that the typical UPS device spends the majority its time in Normal State, with utility power within accepted tolerances, and that performance in this state is most representative of overall UPS energy efficiency.

EPA will evaluate industry-standard UPS efficiency test procedures for adoption by ENERGY STAR. If no suitable procedure exists, EPA will work with stakeholders to

[2] http://www.scribd.com/doc/13404331/High-Performance-Buildings-Data-Centers-Uninterruptible-Power-Supplies-UPS

develop one. Once a test procedure has been identified, EPA will begin an effort to collect and analyze test data from product tests performed by manufacturers. This data collection is critical to the success of the program, since the test data will be used to inform the development of the final ENERGY STAR performance criteria.

b. **Existing Test Procedures for Reference:**

- IEC 62040-3 – Uninterruptible power systems (UPS) – Part 3: Method of specifying the performance and test requirements – Originally established in 1999, this international standard describes standard UPS topology categories and test conditions.
- NEMA – Uninterruptible Power Systems (UPS) – Specification and Performance Verification – This standard adopts standard IEC 62040-3 in its entirety and adds performance verification and safety criteria for various battery types.
- CSA C813.1.01 – Performance Test Method for Uninterruptible Power Supplies – This standard specifies a test method for measuring the electrical characteristics of UPS devices. The standard addresses energy efficiency and total harmonic distortion (THD) of UPS current and voltage output.
- EPRI / CEC Public Interest Energy Research (PIER) Program – Guidelines for Manufacturers' Testing to Benchmark Data Center UPS Efficiency – This guideline provides instructions for measurement and reporting of data center UPS efficiency under various linear and nonlinear loading conditions. This guideline refers to the IEC 62040-3 test method.

In all of the above test procedures, UPS efficiency, current and voltage Total Harmonic Distortion (THD) are calculated based on the input and output current, voltage and power of the UPS.

c. **Questions for Discussion:**

1. Which operational states (e.g., stored energy, normal, bypass) should EPA address in the specification? In which states(s) might the highest energy savings be achieved?
2. For various types or classes of UPS, what is the typical breakdown of energy consumption across operational states and how often is the UPS expected to operate in each state?
3. Research indicates that UPSs designed for partial loads are typically oversized. What requirements can be put in place to avoid over sizing and improve energy efficiency?
4. How can ENERGY STAR address the concept of modularity and scaling in UPS?
5. Are there any additional power consumption or efficiency test procedures that should be considered for reference in the ENERGY STAR specification?
6. Do the test procedures listed above accurately quantify UPS energy efficiency? Are any performance or energy efficiency criteria missing from existing test procedures that should be addressed by an ENERGY STAR test procedure?
7. What are the typical loading ranges for different categories of UPSs? Are there any component or hardware differences for devices intended for redundant operation?
8. What role does the Value Added Reseller (VAR) play in the UPS market (e.g., number of sales or % of total sales)? What system configuration modifications are typically provided by VARs and how do they impact the UPS efficiency?

Building Block #4: Information and Management Requirements

a. **Purpose:** EPA is interested in developing tools to facilitate the efficient design and operation of data centers. EPA is interested in developing or adopting (1) Standard Information Reporting requirements and (2) Data Measurement and Output requirements for data center UPS devices. These requirements are intended to facilitate proper capacity planning, procurement of efficient equipment, and efficient device operation.

- Standard Information Reporting requirements will likely require that manufacturers publish a Power and Performance Data Sheet for all ENERGY STAR qualified UPS products for use in data centers. The data sheet is intended to provide information on energy performance, advanced power saving features, and other characteristics of the UPS in a standard and accessible format. EPA is aware that manufacturers of larger equipment may publish product data sheets in a standardized format to comply with IEC 62040-3 requirements. EPA intends to pursue further discussion on this topic to see if such reports meet the goals of the Standard Information Reporting Requirements and could be broadly implemented.
- Data Measurement and Output requirements for data center UPS help to ensure that data center operators have access to real-time system performance data when the device is in use.

EPA also recognizes that Data Center facility efficiency may be enhanced by an ENERGY STAR UPS program, since UPS devices are typically installed at the interface between the power distribution architecture and the IT load. Best practices for data center efficiency measurement increasingly call for data collection at or near the UPS (e.g., a PUE calculation for the ENERGY STAR Data Center Buildings Metric). As such, there is an opportunity for UPS products to implement features that directly serve the goal of optimizing broader data center operational efficiency.

b. **Initial Approach:** Following are excerpts from the Standard Information Reporting and Data Measurement and Output requirements from the Version 1.0 Computer Server specification, with modifications for UPS devices.

- **Standard Information Reporting Requirements:** Partners must provide a standardized Power and Performance Data Sheet with each ENERGY STAR qualified UPS product. This information must be posted on the Partner's Web site where information on the qualified model, or qualified configurations, is posted. Each Power and Performance Data Sheet must include the following information, at a minimum:
  - Model name/number, SKU and/or configuration ID;
  - System characteristics (e.g., form factor, max rated load, power specifications);
  - Compatible energy storage technologies;
  - Efficiency and power-factor curves over the rated load range;
  - Available / enabled power saving features (e.g., power management); and
  - Information on the power measurement and reporting capabilities of the device.

- **Data Measurement and Output Requirements**: A UPS must have the ability to provide input power consumption, inlet air temperature, and utilization data on request over standard network connections. A service processor, embedded power or thermal meter (or other out-of-band technology shipped with the device), or preinstalled operating system may be used to collect and disseminate data. Data must be made available in a published or user accessible format so as to be readable by third-party, non-proprietary management systems. When an open and universally available standard protocol becomes available to report and collect data, manufacturers should incorporate the universal standard into their systems.

c. **Questions for Discussion:**

1. What, if any, aspects of the Standard Information Reporting or Data Measurement and Output requirements for Servers are not relevant to UPS devices? Do any existing UPS standards approximate the ENERGY STAR requirements as described above?
2. What is the typical performance data measurement, reporting, and output capability of a data center UPS? Are there industry trends towards the inclusion of more robust reporting capabilities?
3. What additional information specific to UPS should be included on a Power and Performance Data Sheet?
4. Do UPS devices have the ability to measure and self-report operational characteristics (e.g., power consumption, load utilization, temperature) in an open, accessible format when interfacing with a third-party management software?
5. How is utilization defined for UPSs? What utilization information would be helpful to managers for procuring the proper equipment for use in their data centers?