High-Performance Buildings for High-Tech Industries

Guidelines for Field Data Collection to Benchmark Data Center UPS Efficiency

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Background

Prior benchmarking efforts led by Lawrence Berkley National Lab (LBNL), as part of a data center energy efficiency roadmap development process, have identified uninterruptible power supply (UPS) systems as a large opportunity for energy savings (http://datacenters.lbl.gov).

UPS systems operate continuously and constantly consume electrical energy to provide standby power and power conditioning for information technology (IT) equipment and some facility systems. The efficiency of UPS systems is affected by the load conditions under which they operate. In general, the efficiency of a UPS system drops off significantly at part-load conditions, which are typical of how most data centers operate. Redundancy strategies can also impact UPS efficiency depending upon how they are implemented. Likewise, system losses, which materialize as heat within the data center or facility, add to the cooling load (especially during summer months), resulting in even higher energy costs and poorer facility efficiency.

On behalf of LBNL, Electric Power Research Institute Power Electronics Applications Center (EPRI PEAC) and Ecos Consulting are conducting an in-depth assessment of the "real-life" efficiency of data center UPSs. This effort will lead to establishing a credible benchmark of UPS efficiency that will help state energy commissions, EPA's Energy Star Program, and other state and federal energy efficiency programs to develop voluntary or mandatory energy efficiency standards/labeling criteria. A credible benchmark will also allow interested electric utilities to provide incentives for higher efficiency UPSs.

Data Center Definition

A data center is defined as a facility that contains IT equipment concentrated in one location to perform one or more of the following functions:

- store,
- manage,
- process, and/or
- exchange digital data and information.

Such digital data and information is typically applied in one of two ways:

- to support the informational needs of large institutions, such as corporations and educational institutions, or
- to provide application services or management for various types of data processing, such as web hosting, Internet, intranet, telecommunication, and information technology.

For purposes of this test protocol, we do not consider spaces that primarily house office computers, including individual workstations, servers associated with workstations, or small server rooms, to be data centers. Generally, data centers are designed to accommodate the unique needs of energy intensive computing equipment. This typically includes a specially designed infrastructure to accommodate high electrical power consumption, redundant supporting equipment, and heat dissipation.

Purpose

The purpose of this procedure is to provide instructions/guidelines for reporting the efficiency of UPS systems that are installed in data centers. Data collected from this project will be shared with the UPS industry including manufacturers such that they can compare actual field data with technical specification data (if any). The data collected will also be used to help specify UPS efficiency on UPS nameplates such that end users can be informed about UPS efficiency. The development of energy-efficiency indicators for UPSs largely depends on a credible set of field data that will allow comparison of "real life" efficiency to "quoted" efficiency, as reported by manufacturers in product specifications.

This guideline takes into account the test measurement procedures described in IEC 62040-3, *Uninterruptible power systems (UPS) – Part 3: Method of specifying the performance and test requirements*. This IEC standard has also been adopted by the National Electrical Manufacturers Association (NEMA) as part of *NEMA Standards Publication PE-1 2003, Uninterruptible Power Systems (UPS) – Specification and Performance Verification*.

Procedure

There are five methods that can be used to acquire the efficiency information. Methods A and B are typically the easiest and most convenient, but may sacrifice accuracy. Methods C, D, and E are more complex, yet provide increased accuracy. If possible, UPS efficiency data should be collected using more than one of the five methods so that the relative accuracy of the different methods can be compared. We recommend using Method A or B *and* Method C, D, or E when comparing accuracy.

The five methods are as follows:

A. Collecting Data from a Front-Panel Display on a UPS: Many UPS systems have a front panel display on which the operator can visually monitor various parameters such as status, runtime, and input and output power associated with the load protected. If your UPS has a front panel display that can be accessed, use the instructions contained in Section A.

B. Collecting Data from UPS Monitoring Software: Many UPS systems are connected via a local area network (LAN) to a computer which has monitoring software installed. By manipulating the software, the necessary information to measure UPS efficiency can be obtained. If your UPS has monitoring software that is connected and accessible, use the instructions contained in Section B.

C. Collecting Data from Permanently Connected Energy or Power-Line Monitors: Some installations make use of permanently connected energy or power-quality monitors. If your facility has either type of monitor, it may be possible to extract the necessary information from files created by the monitor. If you would like to provide data using a monitor file, please use the instructions contained in Section C.

D. Collecting Data from a Building Energy Management System: Some installations make use of energy management systems (EMS) which are part of the building operating system. For example, a building may contain a SCADA (Supervisory Control and Data Acquisition) system embedded within the infrastructure of the electrical system. If your facility utilizes an EMS, selected data files containing the necessary information can be extracted from the EMS. If you would like to provide data using an EMS file, please use the instructions contained in Section D.

E. Temporary Connecting of Power-Line or Energy Monitors: If the temporary connection of power-line or energy monitors is allowed within the facility at the input and output of a UPS, it is possible to arrange for a technician to go to the site with the appropriate instruments and make the measurements directly. If you would like to arrange for a technician to visit, please contact:

Philip Keebler, EPRI PEAC Corporation: phone: (865) 218-8015; email: pkeebler@epri-peac.com.

Section A. Collecting Data from a Front-Panel Display on a UPS

Typically, one or more UPSs are contained in today's data centers. Backup power for the UPSs may be provided via standard UPS batteries or via a rotating mechanical energy storage system (i.e., a flywheel). Most UPSs used in data centers contain a front-panel display that allows the operator to routinely monitor the electrical and thermal conditions of the UPS. There is no standard design for the format in which these displays provide this data to the end user. Before collecting data from a display, the end user should consult the UPS manual and become familiar with how to scroll through and read the display.

When collecting data from a display, follow these steps:

1. Make sure that the UPS is turned on and ready to protect the critical load. In this mode, the circuitry inside the UPS draws power and the efficiency can be determined.

2. Make sure that the UPS batteries are fully charged or the flywheel mechanism is fully up to speed. The data used to calculate efficiency should be taken only in this steady-state condition. The UPS spends nearly all of its time with its batteries charged or its flywheel ready to delivery mechanical energy to the UPS.

3. Please turn to the Information Collection Sheets provided at the end of this document and answer the following sections:

    - Part 1. Characteristics of Load Protected by UPS(s)
    - Part 2. Redundancy Arrangement
    - Part 3. UPS Technology
    - Part 4. Company/Contact Information
    - Part 5. Nameplate Information
    - Part 6. UPS Load Data (for three phase UPS)
    - Part 7. UPS Load Trend Data

Section B. Collecting Data from UPS Monitoring Software

Some users of large-kVA UPSs utilize UPS monitoring software that allows the operator to routinely monitor the electrical and thermal conditions of a UPS via a local area network (LAN). There is no standard design for the format in which these software systems provide this data to the end user. Before collecting data from such software, the end user should consult the UPS software manual and become familiar with how to operate it and read the data.

When collecting data from a software system, follow these steps:

1. Make sure that the UPS is turned on and ready to protect the critical load. In this mode, the circuitry inside the UPS draws power and the efficiency can be determined.

2. Make sure that the UPS batteries are fully charged or the flywheel mechanism is fully up to speed. The data used to calculate efficiency should be taken only in this steady-state condition. The UPS spends nearly all of its time with its batteries charged or its flywheel ready to delivery mechanical energy to the UPS.

3. Please turn to the Information Collection Sheets provided at the end of this document and answer the following sections:

    - Part 1. Characteristics of Load Protected by UPS(s)
    - Part 2. Redundancy Arrangement
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    - Part 4. Company/Contact Information
    - Part 5. Nameplate Information
    - Part 6. UPS Load Data (for three phase UPS)
    - Part 7. UPS Load Trend Data

Section C. Collecting Data from Permanently Connected Power-Line Monitor

Some data center facilities utilize permanently connected power-line monitors that allow the operator to routinely monitor the electrical and in some cases thermal conditions of the room environment where a UPS is located. Data from the monitor should be available via the front panel of the monitor. Monitors are typically located inside the switchgear with the readouts exposed on the surface of the switchgear panel. There is no standard design for the format in which these monitoring systems provide this data to the end user. Before collecting data from a monitor display, the end user should consult the monitor's manual and become familiar with how to operate it and read the data. Data may also be provided via a monitor data file or report that the monitor may be able to generate.

When collecting data from a power-line monitor, follow these steps:

1. Make sure that the UPS is turned on and ready to protect the critical load. In this mode, the circuitry inside the UPS draws power and the efficiency can be determined.

2. Make sure that the UPS batteries are fully charged or the flywheel mechanism is fully up to speed. The data used to calculate efficiency should be taken only in this steady-state condition. The UPS spends nearly all of its time with its batteries charged or its flywheel ready to delivery mechanical energy to the UPS.

3. Please turn to the Information Collection Sheets provided at the end of this document and answer the following sections:

    - Part 1. Characteristics of Load Protected by UPS(s)
    - Part 2. Redundancy Arrangement
    - Part 3. UPS Technology
    - Part 4. Company/Contact Information
    - Part 5. Nameplate Information
    - Part 6. UPS Load Data (for three phase UPS)
    - Part 7. UPS Load Trend Data

    Once you have completed all four sections of the Information Collection Sheet, please continue with Step 4 below.

4. What type of power-line monitor is being used to collect data? Please complete Table 1 below.

Table 1. Power-Line Monitoring Information

Brand	
Type	
Model Number	
Serial Number	

5. Is your monitor/facility set up to capture the data files from the monitors? If so, please provide a data file as a part of this completed test procedure to:

   Philip Keebler, EPRI PEAC Corporation: phone: (865) 218-8015; email: pkeebler@epri-peac.com

6. If you need assistance in reading data from your monitor or would like to set it up to capture data to create a file, please contact:

   Philip Keebler, EPRI PEAC Corporation: phone: (865) 218-8015; email: pkeebler@epri-peac.com

Section D. Collecting Data from an Energy Management System (EMS)

Some data center facilities utilize energy management systems (EMS) that may allow the operator to routinely monitor the electrical and thermal conditions of each part of the electrical and mechanical system via the EMS control center. It should be noted that some EMSs might not have electrical load monitoring capability. An electrical distribution monitoring system, separate from an EMS, may be used in the facility to provide the desired data. Only selected data from such a system would be necessary to determine UPS efficiency. There is no standard design for the format in which these systems provide this data to the end user. Before collecting data from a distribution monitor system, the end user should select the nodes within the system that could be used to provide electrical data for each UPS system. Any power data retrieved from an EMS should be reported as real power (i.e., in watts).

When collecting data from an EMS, follow these steps:

1. Make sure that the UPS is turned on and ready to protect the critical load. In this mode, the circuitry inside the UPS draws power and the efficiency can be determined.

2. Make sure that the UPS batteries are fully charged or the flywheel mechanism is fully up to speed. The data used to calculate efficiency should be taken only in this steady-state condition. The UPS spends nearly all of its time with its batteries charged or its flywheel ready to delivery mechanical energy to the UPS.

3. Please turn to the Information Collection Sheet provided at the end of this document and answer the following sections:

    - Part 1. Characteristics of Load Protected by UPS(s)
    - Part 2. Redundancy Arrangement
    - Part 3. UPS Technology
    - Part 4. Company/Contact Information
    - Part 5. Nameplate Information
    - Part 6. UPS Load Data (for three phase UPS)
    - Part 7. UPS Load Trend Data

    Once you have completed all four sections of the Information Collection Sheet, please continue with Step 4 below.

4. What type of EMS is being used to collect data? Please complete Table 2 below.

Table 2. Energy Management System Information

Brand	
Type	
Model Number	
Serial Number	

5. It is also important to know what transducers are being used and how is the data transferred to the EMS (analog or digital signal).

   a. What types of transducers are used to monitor voltage? _____

   _____

   _____

   b. What types of transducers are used to monitor current?_____

   _____

   _____

   c. How is the data transferred to the EMS? (Please circle one):

      i. As an analog signal

      ii. As a digital signal

6. If trending data is available, please specify the beginning and end dates and times for the trend(s). Please complete Table 3 below.

Table 3. Dates and Times for Trending Data

	Date	**Time**
Beginning		
End		

Information Collection Sheets

Part 1. Characteristics of Load Protected by UPS(s). Please indicate the general characteristics of the loads that the UPS(s) are used to protect:

1. Internet data center equipment
    a. Servers
    b. Routers
2. Corporate data center equipment
    a. Servers
    b. Routers
3. Telephone switch equipment
4. Chillers
5. CRACs (computer room air-conditioners)
6. Other (please list):_____

Part 2. Redundancy Arrangement. What is the redundancy arrangement for this and other UPSs of this type? Is this a single installation UPS (N), or is this an N + 1, N + 2, 2N, or other arrangement?

According to IEC, redundancy is defined as the "addition of functional units or groups of functional units in a system to enhance the continuity of load power." N may be defined differently by various industries. For this guideline, N is defined as the number of equal-sized units—whether a UPS or a chiller, etc.—needed to meet the peak load requirements of a data center. Please circle the appropriate arrangement.

1. N
2. N + 1
3. N + 2
4. 2N
5. Other (please list):_____

Part 3. UPS Technology. The UPS technology describes some of the typical circuit arrangements in use and their mode of operation as defined by the IEC. Please circle the type of UPS technology being tested:

1. Static Double Conversion UPS
2. Static Line Interactive UPS
3. Static Stand-by UPS
4. Static Delta Conversion UPS
5. Rotary Flywheel Based UPS (low speed, < 5000 rpm)
6. Rotary Flywheel Based UPS (medium speed, 5000 rpm to 9999 rpm)
7. Rotary Flywheel Based UPS (high speed, > 10000 rpm)
8. Rotary Motor Generator Set-based UPS
9. Other (please describe): _____

   _____

   _____

Part 4. Company/Contact Information. Please fill in the appropriate information in Table 4 below.

Table 4. Company Contact Information

Name	
Title	
Date	
Company Name	
Address	
Phone Number	
Email Address	
Description of Business	

Part 5. Nameplate Information. If more than one UPS or system, please fill out a separate table for each one. Use Table 5 below as your template. Attach sheets as necessary.

Table 5. Nameplate Information (Template)

UPS Manufacturer	
Model Number	
Serial Number	
Rated Input Voltage	
Delta or Wye Connection	
Frequency	
INPUT	
Rated Input kVA	
Rated Input kW	
OUTPUT	
Rated ac Output Voltage	
Rated dc Output Voltage[1]	
Number of Phases	3
Specified Efficiency	

[1] For dc output UPS only.

Part 6. UPS Load Data (for three phase UPS). Please fill in as many fields as possible in Table 6 below: this will allow for crosschecking and verification of data. Before recording any information in table, please verify that UPS batteries are fully charged.

Table 6. UPS Load Data Collection

Electrical Parameter	Phase A	Phase B	Phase C
INPUT			
Does the UPS contain an input filter?		Yes	No
Input Voltage RMS			
Input Current RMS			
Input kVA			
Input Power kW			
Input Current THD (% of Fundamental)			
Input Voltage THD (% of Fundamental)			
OUTPUT[1]			
Does the UPS contain an output filter?		Yes	No
Output Voltage RMS			
Output Current RMS			
Output kVA RMS			
Output Power kW			
Output Current THD (% of Fundamental)			
Output Voltage THD (% of Fundamental)			

[1]For dc output UPS only provide data for output voltage, current and power and fill in the cells for Phase A.

Part 7. UPS Load Trend Data. If input and output data is available for a period of time from the UPS software, building EMS system, local PQ monitor, or energy monitor, please provide the following information for the data file in Table 7 below. *(*Also see Question #6 of Section D.)

Table 7. UPS Load Trend Data

Data file format	
Channel names	
Software name and version used for data viewing and analysis	
Can the data be exported into MS Excel format? Yes No	