Powering Business Worldwide

Thought Leadership White Paper

Power Monitoring 101

Supervisory, connectivity and protection options that add an umbrella of protection over your entire IT infrastructure

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Abstract

Spiraling power demands and utility rates. Power sags, surges and outages. Heat-generating blade servers. Shifting utilization patterns in virtualized environments.

Data center managers have a lot to keep them awake at night. The servers that once could be powered for say, $4,800 a year are now consuming $28,000 or more in energy a year. Power now represents the single largest component of operating cost. Yet, rarely is energy as closely managed as it should be.

Many data center managers don't know the efficiency of their IT equipment or the site infrastructure, nor do they have a clear path in mind for maintaining and improving that efficiency. There's a lot of low-hanging fruit being overlooked—readily available opportunities to substantially reduce energy costs and become "greener" in the process.

With the right power monitoring system, your organization can protect data and applications while optimizing the power delivery infrastructure for efficiency and lower cost. New supervisory, connectivity and protection capabilities provide an envelope of protection for your entire power infrastructure.

With a real-time, unified view of power and facilities systems, organizations can:

- Proactively manage power quality to enhance the availability and service life of IT equipment.
- Dynamically provision servers to respond to changing energy conditions.
- Intelligently balance workloads to optimize energy usage and control costs.
- Identify ways to improve data center energy efficiency and power usage effectiveness.
- Provide chargebacks to users based on the actual energy consumption of their IT services.

Monitoring options are available for organizations of any size. You can remotely monitor and manage a single uninterruptible power system (UPS), an enterprise-wide network of many UPSs and power distribution devices, or a complete IT support infrastructure, including generators, environmental systems and detection devices, and other components from multiple vendors.

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The first time the hosting provider's 144,000-square-foot data center suffered an outage, customers groused, and the company apologized on its blog.

The second time, they didn't get off so easily.

When power generator failures triggered a "brief loss of network connectivity to some servers," causing customer applications to go down for part of the day, a blogged apology wasn't enough. The company was compelled to pay out between $2.5 million and $3.5 million in service credits to impacted customers.

The most rigorous redundancy in servers, storage and networking means nothing if you lose the power to run it all, even briefly. If power fluctuates for even a few seconds, data can become corrupted or lost. A brief power disturbance can trigger events that require hours of data recovery time. Invisible power anomalies can damage sensitive components and cause malfunctions in crucial servers and processes.

The costs are high. According to the U.S. Department of Energy, a cellular communications company loses an average of $41,000 per hour of downtime. An airline reservations center loses about $90,000. A credit card operations center stands to lose more than $2.5 *million* per hour. And these figures are eight years old (*Distributed Energy Resources Program and Strategic Plan*, 2001). The cost is even higher now.

In seeking to prevent the costs and disruption of power-related downtime—and optimize for energy efficiency—facilities managers and IT managers face some serious challenges:

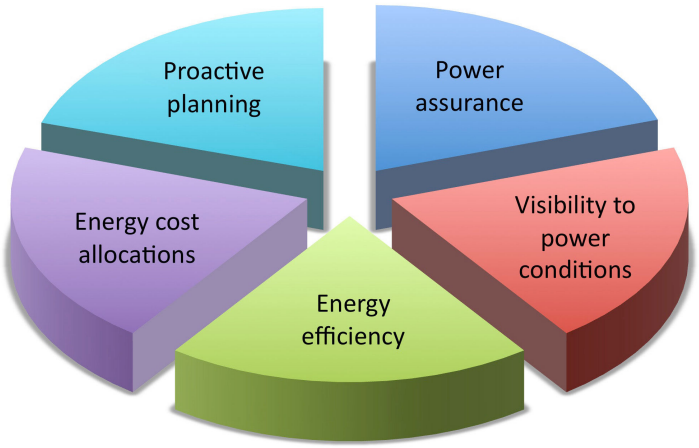
- **Higher density—**With blade servers and virtualization, power consumption may soon reach up to 40 kW per rack. Power demand can easily double or triple during peak periods, and it fluctuates with every move, add or change. Adding a 1U or 2U server used to mean drawing 200–300 more watts from the branch circuit; a new blade server consumes *20–30 times* as much power.
- **Vulnerable assets—**Today's storage devices, servers and network processors are more valuable than ever, as virtualized environments have placed tremendous importance on every device operating properly. Even a brief power disturbance can cause file or data corruption or loss, hardware or firmware damage, and system lock-ups. Recovery may take hours.
- **Hidden risks—**IT managers need to be continually aware of power conditions, such as when a circuit is overloaded, a UPS is operating on battery backup, a battery is approaching the end of its service life and more. It is a challenge to keep up this level of vigilance in multi-location organizations that operate around the clock and around the globe.
- **Shrinking workforces—**IT/facilities departments are pressed to do more with less—tasked to add another 9 to system reliability (99.9999 percent for some) with fewer resources than ever. One staffer is probably already doing the work of two or three. What if tonight's on-call person lives an hour away?

The imperative for power monitoring

The power distribution system is more easily stressed by even the simplest changes in your data center. How much current are your servers drawing right now? Are electrical circuits approaching capacity, ready to trip a breaker if transaction processing rises or a new component is added? Would you be able to see trouble coming?

You need to be able to monitor and communicate with components of the power protection and distribution system from anywhere, any time. Power monitoring systems support these missions by providing for:

- **Power assurance**—The ability to see the health and status of power distribution, power quality and backup power systems from anywhere
- **Visibility into power conditions**—Delivering the detailed and aggregated information needed to prevent tripped circuits, understand where new systems can be deployed, balance loads and diagnose power problems
- **Energy efficiency**—Understanding the overall power usage effectiveness (PUE) of the facility or data center, and using that knowledge to better manage server utilization, peak utilization, power factor, UPS efficiency, heat management and more
- **Energy cost allocations**—Tracking the power consumption of the facility to confirm the accuracy of utility billing, and tracking the power consumption of departments, business entities or collocation customers so they can be billed for the energy they use
- **Proactive planning**—Being able to identify trends, perform capacity planning, plan a logical power evolution path and head off trouble or a capacity bottleneck before it occurs



At what points in the infrastructure can you monitor power conditions?

Naturally, organizations will vary in the degree to which they must have visibility and control over the power infrastructure. A small to mid-sized business (SMB) might decree that as long as consistent power is coming into the premises through a monitored UPS, everything is okay. Most organizations will view the data center as important enough to also monitor its support systems. And any data center that runs essential applications will want highly granular visibility and control over power conditions, probably to the server level.

The power monitoring architecture can be as simple or as complex, as high-level or granular as an organization needs, simply by choosing where in the power infrastructure to deploy monitoring systems.

At the point of utility service entry into the building…

A power meter can be installed directly on the low- or medium-voltage switchgear that brings the incoming utility power into the building. The meter can be mounted on the wall or inside the switchgear cabinet, but it is typically mounted into a cutout in the front panel of the switchgear cabinet for easy viewing without opening the equipment. The meter has a wiring harness that connects current transformers (CTs) to the incoming three-phase power to deliver measurements of voltage, current and frequency; and from that data, the meter can calculate watts or kVA.

Where facilities systems support the critical enterprise environment…

Meters can enable monitoring of larger, power-consuming systems that are vital to the enterprise, such as air conditioners, chillers and air-handling equipment. These meters are usually compact—a cube about six inches square with terminal blocks to connect voltage and current wires.

Other devices, such as gateways (protocol translators), connect to ancillary equipment from various vendors, such as air conditioners, security cameras, door sensors, environmental monitors and fire detection/suppression equipment. These gateways are used to gather data from these devices and convert it to intelligent information that can be transmitted via the TCP-IP network.

Simple gateways accept on-off signals from dry contact or relay devices—such as status on/off or UPS on battery power or not—then translate that information into digital form and send it up the line for action. More sophisticated gateways have one or more serial ports that can transmit descriptive information as well, such as temperature, humidity, AC compressor operating speed or other critical characteristics of the operating environment.

Where power enters the critical enterprise equipment, such as the data center…

A large, central UPS system, such as an Eaton® 9390 UPS, delivers information about itself to a local display and to a network-based, remote power management system, showing voltages, loads, availability, battery status and service events. This could be the UPS that feeds the production line, the data center, medical imaging room or other critical, high-powered systems.

An optional environmental probe connected to the UPS reveals local operating conditions, such as temperature, humidity, vibration, smoke or intrusion.

At the primary power distribution panelboard or subfeed breakers…

A branch circuit monitoring system can continuously measure the current on branch circuits and warn of impending trouble, to enable proactive action. The architecture is straightforward; branch circuit wires are threaded through CTs, which sense the current going through the wire and send the information to a universal controller. The controller assimilates the information from CTs at multiple panelboards and relays it to a local display or remote management system for analysis and reporting.

The Eaton Energy Management System monitors up to eight 42-circuit panelboards (up to 336 pole positions and/or 16 three-pole sub-feeds), in addition to monitoring the main input/output parameters of the distribution equipment, such as a power distribution unit (PDU) or remote power panel (RPP).

At power distribution points throughout the data center…

A freestanding or wall-mounted remote power panel (RPP) can be factory-equipped or retrofitted with the same type of branch circuit monitoring system as at the main panelboard(s). Current transformers on every branch circuit, subfeed and main breaker report power conditions to a universal controller and optionally to a building management system or power management system.

A tower or freestanding UPS, such as the Eaton 9135 UPS, can communicate its status over the company's Ethernet LAN or the Internet, answering important questions such as:

- Is input voltage within the acceptable range?
- If the power went out right now, how long could the UPS run on battery power?
- Did the UPS successfully pass its last automated battery test?
- Is the UPS running on battery power right now?
- Are there any active events I need to know about?
- Is the UPS online or is power flowing on the bypass path?
- Is output voltage within acceptable limits?
- What percent of UPS capacity is being used right now?
- Is the battery being charged or discharged?

Inside the enclosure…

Several power elements offer monitoring capabilities to prevent overload conditions and tripped circuits and, where applicable, to accurately bill internal customers for power usage. For example:

- A *rackmount UPS*, such as an Eaton BladeUPS® or Eaton 5130 UPS, can communicate its power conditions and operating status in a variety of networking environments, including the Web. LEDs on the front panel (and audible alarm indicators) provide a quick read of UPS status.
- A *rack power module (RPM)* supports remote monitoring of each branch circuit over an Ethernet network, using only a Web browser to view power usage data. There's no need to check individual power strips in the rear of the cabinet.
- Some *enclosure-based power distribution units (PDUs)* can monitor the current passing through the unit and display power utilization for any receptacle, circuit branch or the entire unit. More advanced units enable you to securely view the status of each circuit from anywhere on your company intranet or the Internet, and to receive automated alerts of potential trouble.

  Note that very few enclosure PDUs on the market support outlet-level monitoring. Most only show aggregated current at the branch circuit or PDU level. You need this detailed information to see how close a circuit is to exceeding its overall rating—and whether or not a device can be safely added to a branch circuit or PDU.

The right configuration for any given organization is a balancing act between critical needs and cost. Is it enough to know that reasonable power is coming into the data center, or do you need to know load/utilization/power quality at the primary (panelboard) and secondary (remote power panel) levels? Or do you need visibility into power conditions for groups of servers within a single rack, to manage high-density, virtualized environments or to bill customers for their energy use?

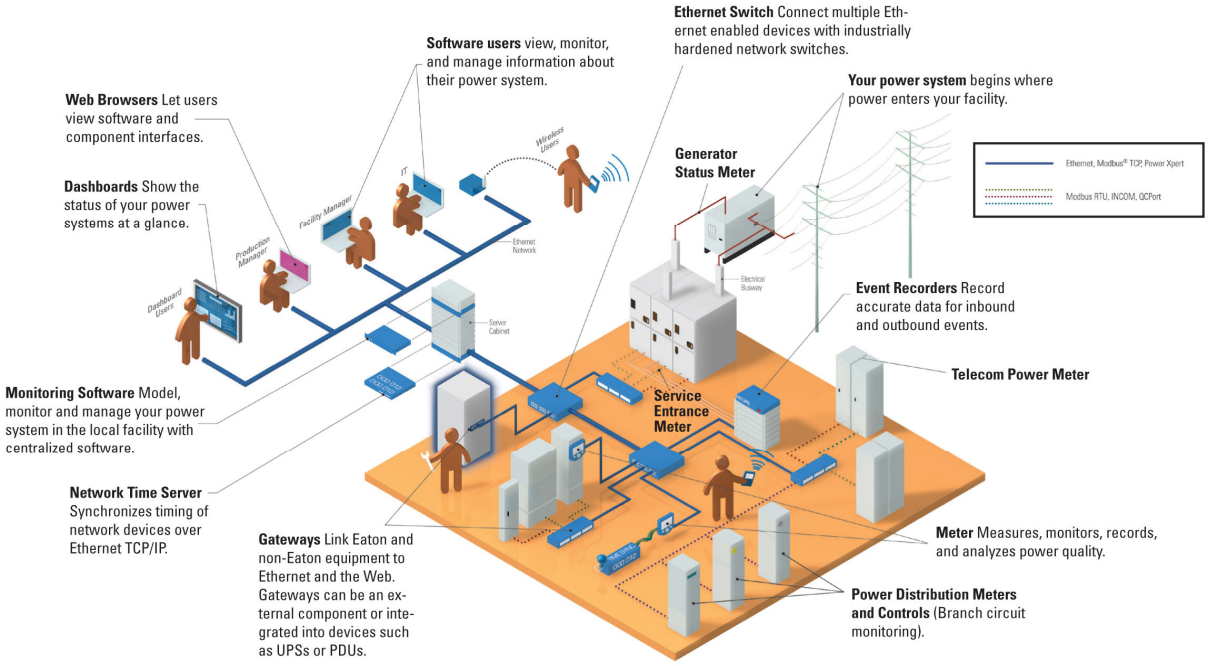


Figure 1. Power monitoring can take place at multiple points in the power infrastructure, from the service entrance to the level of individual outlets to servers.

What kind of information is gathered?

Power meters, branch circuit monitoring systems, UPSs and power distribution units capture and transmit a broad range of power data—some of it overlapping, some unique to that type of device—and of course, the data varies quite a bit by model even within one vendor's product portfolio. It would be impossible to provide a comprehensive list of monitored metrics and parameters by product, but here are the basic categories of information you can receive from the power system:

- **Basic UPS status**—Such as normal operating conditions and load protected, operating mode (e.g., high-efficiency or double-conversion), on bypass or battery, or load not protected
- **Voltage and power**—Input and output voltage levels, frequency, battery status (for a UPS), emergency power/standby power status, kVA load level and more
- **Peak loads**—Timing and statistics for current, power and frequency minimums and maximums
- **Power quality metrics**—Time-stamped waveform capture, records of total harmonic distortion, frequency variation, power factor and more
- **Events**—Time-stamped metering and alarm information for power events, such as sags, swells and harmonic distortion, even for transients that arise and disappear in a few thousandths of a second. A central, real-time clock synchronizes time-stamping among disparate monitoring devices, to correlate events for troubleshooting and diagnosis.
- **Power usage**—Power utilization as seen by the device, to better understand how business services consume power or to allocate costs among multiple business units or customers
- **Load profiling**—Trend information, usually provided for 23 months, to provide proactive notification of developing or potential problems and support the best decisions for energy planning

- **Environmental conditions—**Temperature, humidity, vibration, smoke, fire, moisture, intrusion, dust, etc.
- **Basic relay device status**—Signals from dry contact sensors to indicate a simple A/B status, such as door open/closed, device on/off or breaker open/closed
- **Security conditions**—Indicators of open door to a rack or large UPS, cover off the switchgear, or motion in a restricted area when a service technician is not present

In many cases, information can be shown at various levels within a single unit. For example, the Eaton Energy Management System shows power conditions for individual circuits, each panelboard, and at the equipment level (power distribution unit or remote power panel)—three tiers of visibility within a single unit.

How does power monitoring information get communicated?

Local communications—Branch circuit monitoring systems, power distribution units and UPSs generally offer one or more ways to communicate with a local user. For example:

- The Eaton Wall-mounted Remote Power Panel has a large, 8" by 40" **LCD display**, so technicians always have an up-to-the-minute view of power conditions right at the equipment.
- The Eaton Rack Power Module has a bright, easy-read "power equalizer" **LED display** that shows the load on each circuit (as a percentage of the circuit's rating) and the system overall.
- Eaton 4000 to 8000 series Power Xpert Meters have an optional large, LCD display plus a built-in **Ethernet port** for local access; just walk up to the unit and plug in a local laptop to perform a full range of analysis and reporting. An embedded Web server enables monitoring via Internet.

Some UPSs have all three—status LEDs, a multi-line LCD interface that provides detailed information and menu-driven functions for UPS management, and a local serial port where an on-site technician can connect a laptop.

Remote communications—In the past, communications with power metering and monitoring equipment required complicated connectivity accessories and proprietary protocols. Not anymore. Today these devices tend to be very connectivity-ready. For example:

- **Optional communication interface cards—**Eaton UPSs, power meters and power distribution elements can be configured with gateway cards for remote communications with an IT or facility monitoring/management system over your LAN/WAN and the Internet.

  Choose from a range of industry standard physical interfaces (RS-485, RS-232, RJ-45 Ethernet) and communication protocols (Modbus/TCP, Modbus RTU, HTML, SNMP, SMTP).
- **Communication proxy option—**To save the cost of a UPS communication card (which can be $250 and up per UPS), Eaton offers a software feature that enables the UPS to connect to a management system using a Windows PC as the communications interface, connecting to a serial port on the UPS. This option is particularly appealing for organizations with many distributed UPSs, such as an office building with a UPS for every desktop.
- **Direct Ethernet connection—**Many enclosure-based PDUs and power meters have an RJ-45 network jack for a direct connection into the Ethernet LAN.

All monitoring and management communications should be encrypted, authenticated and secure, using password protection and standard security protocols, such as Secure Socket Layer (SSL) and Secure Shell (SSH).

Supervisory software for power systems

Since every organization will have unique needs for power monitoring and management, there are diverse choices in management systems, from very basic (often free) to high-end custom-programmed systems. A typical hierarchy of monitoring/management software options would span the following levels:

Basic—No special software is required to view and manage a device. Simply open a Web browser, type in the IP address of the device or its communication card, and you can monitor its status and, where applicable, gracefully shutdown or restart connected systems.

Aggregated view—Administrators can monitor and aggregate information from multiple devices, such as multiple UPSs or enclosure-based power distribution units in different locations, on a single PC screen.

Combined or enterprise-wide view of power systems—Data center and facilities managers can monitor the status of UPSs and other devices from multiple vendors, diagnose past events and predict future conditions.

Enterprise-wide intelligence on power and facilities systems—Some supervisory systems can analyze thousands of data points to proactively manage key equipment throughout an enterprise—not just power elements, but many other elements of the critical facilities infrastructure.

Converged IT and facilities monitoring—A converged monitoring solution gives IT and Facilities real-time visibility into power conditions, with power circuits correlated to IT resources and linked to business services. IT and Facilities can easily see when abnormal conditions threaten the IT infrastructure—and exactly which business services are at risk.

In addition to all these options, power users can always download data from a supervisory system into Excel or a similar tool and conduct their own unique analysis, such as for trending and capacity planning.

Representative tiers of supervisory software

	UPS supervisory software	Power chain supervisory software	IT/Facilities supervisory software
Monitor a single UPS from anywhere over the LAN/WAN or Internet	■	■	■
Remotely monitor **multiple UPSs** of different models in separate locations	■	■	■
Get a **near real-time view** of UPS data (e.g., voltage, load, batteries)	■	■	■
Get **time-stamped records** of power events (sags, swells, outages, etc.)	■	■	■
Monitor environmental conditions at a UPS with a connected probe or sensor	■	■	■
Receive **automated notifications** of alarms or alerts, with detail	■	■	■
View a **multi-year archive of events** for troubleshooting or trend analysis	■	■	■
Gracefully shut down or restart connected systems by UPS load segments	■	■	■
Export power data to a building management system or spreadsheets	■	■	■
Monitor UPSs **and power distribution devices** across the enterprise		■	■
Monitor UPSs and other types of power devices **from multiple vendors**		■	■
Aggregate power data from monitoring systems across the organization		■	■
Analyze the power infrastructure for troubleshooting and capacity planning		■	■
Unify management of the **facilities infrastructure** (HVAC, security, power, etc.)			■
Correlate IT resources and business services to their power circuits			■
Track power consumption of **services/applications** for chargebacks			■
View real-time and historical **power and thermal metrics for servers**			■
Consolidate **IT and power asset management** into a single system			■

What can you do with a power monitoring system?

With power monitoring options available on the market today, you can remotely monitor and manage a single UPS, an enterprise-wide network of many UPSs or a complete power protection infrastructure, including generators, environmental systems and detection devices, and other components from multiple vendors.

View real-time or near-real-time power conditions throughout the facility. From a Web browser or network/building management system, which may be hundreds or thousands of miles away, a system administrator can see power conditions, events and alarms up until a few seconds ago, for hundreds of power protection or power distribution devices at a time from a single screen.

Monitor and manage UPS status from anywhere. Perform remote UPS diagnostics, set up scheduled shutdowns of UPSs and associated servers, and shut down or reboot a remote UPS. The ability to manage UPSs without a site visit dramatically reduces field service expense and response time.

Automatically notify key personnel of utility failures, device status, environmental problems or other conditions via alphanumeric paging, email, user messages and SNMP outputs. System managers can stay informed even when away from their desks, through time-stamped displays designed to be viewed on mobile phones or PDAs (personal digital assistants). Rapid notification means rapid resolution, which saves time and money and can potentially forestall serious conditions.

Dynamically reprovision loads. A converged IT/Facilities monitoring solution enables you to balance IT and power resources, especially critical in virtualized environments. For example, the branch circuit monitoring system could sense a usage spike that threatens to overload a circuit, send an alert notification to IT and Facilities, and trigger the dynamic re-provisioning of workloads to run on other systems. Strategic planning can be based on the actual power consumed by business services, as well as the assessment of risk as a result of power system issues.

The converged perspective also enables you to compare current power utilization and costs to an optimal configuration, and to perform powerful “what-if” analyses to understand the potential impact of changing the data center environment.

Conduct orderly, unattended shutdown of connected equipment during power outages. This capability can be provided by the UPS, the supervisory system or power distribution equipment. Hundreds of devices in remote or unmanned sites can be protected without requiring an on-site visit from a technician. User-defined sequencing of outlets and time delays permits controlled, remote boot-up of servers. Virtual grouping of outlets permits single-click reboot of multi-corded servers, entire racks or non-critical loads.

Selectively shut down non-critical systems to conserve battery power during idle times or prolonged power outages. By controlling power usage at a granular “load segments” level, you increase the time that more important equipment can be up and productive during extended power outages, extend overall battery life and, in turn, delay the costs of battery replacement.

The latest shutdown modules offer two key advantages: displaying all IT equipment powered by a given UPS, and enabling connected servers to shut down in their normal fashion while saving all work up until the moment of shutdown. Eaton supports this feature on VMware virtualized servers as well.

Analyze, graph and predict trends. With intelligence distilled from performance data, you can predict what’s going to happen next, how to prevent a recurrence of a past problem, or head off a more serious problem. For example, graphic representations of battery, load and temperature data enable you to gauge battery health, perform accurate capacity planning, and prevent overload and over-temperature conditions. If a battery is still working but approaching the end of its service life, you’d like some advance warning to budget for a replacement.

Manage power assets. The latest supervisory systems for power monitoring/management can auto-discover power elements on the network. The system searches for IP addresses in a range defined as power devices and auto-populates the asset inventory. Administrators can update the list with descriptive identifiers and organize devices by group to make tracking easier.

Quickly upgrade UPS firmware. Automatically upgrade the operating system for hundreds of remote UPSs by pushing a button. The system auto-installs the updated software on every UPS of that type connected to the network. There's no need to download firmware individually or have a technician travel to the UPS site. Some power meters can be updated remotely as well.

Closing thoughts

Power monitoring and management capabilities deliver confidence—confidence that power systems are doing what they should, that personnel will be immediately notified of alert conditions in time to resolve, not just react, and the confidence of being able to predict and prevent problems before they occur.

Even if administrators are at home, off-site, or attending to other tasks, they have at their fingertips the early indicators and tools they need to prevent power-related system crashes, avoid data loss and corruption, protect hardware or firmware from damage, and ensure trouble-free operations.

The benefits span all industries and geographies. For example:

- In healthcare institutions, monitoring, graphical analysis and alarm notification capabilities help ensure continuous uptime for critical diagnostic and treatment equipment and administrative systems.
- In industrial environments, the ability to remotely monitor a broad range of environmental conditions can help prevent unplanned equipment outages caused by excessive dust, vibration, moisture or other damaging conditions.
- Governmental, healthcare and financial organizations—any data centers where sensitive data is stored and subject to federal privacy regulations— benefit from secure, encrypted communications and complete audit trails of system events.
- Telecommunications providers can count on remote monitoring and notification to help meet government- and customer-mandated availability standards, monitor environmental conditions in outside plant enclosures and remote offices, and prevent intrusion that could result in vandalism or theft of service.

To learn more about power monitoring and management for your organization, contact your Eaton representative or Eaton Corporation at www.eaton.com/powerquality or 1-800-356-5794.

About Eaton

Eaton Corporation is a diversified power management company with 2008 sales of $15 billion. Eaton is a global technology leader in electrical systems for power quality, distribution and control; hydraulics components, systems and services for industrial and mobile equipment; aerospace fuel, hydraulics and pneumatic systems for commercial and military use; and truck and automotive drivetrain and powertrain systems for performance, fuel economy and safety.

Eaton has approximately 75,000 employees and sells products to customers in more than 150 countries. For more information, visit www.eaton.com.

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