# Energy Efficiency within Data Centers

*Is your IT organization capitalizing on the latest technology options and best practices?*

The unforgiving economic climate has left many organizations struggling to sustain (or restore) profitability. Many of them reacted by restructuring, trimming back R&D and marketing, and laying off employees. All of these moves leave the company in a vulnerable position when the market rebounds, which it inevitably will.

Meanwhile, *huge* potential savings are sitting, untapped, right in the company's data center.

Data center energy costs as a percent of total revenue are at an all-time high. In fact, energy costs are emerging as the second highest operating cost in the IT organization (behind labor). A typical one-megawatt data center consumes 16 million kilowatt-hours of electricity a year—roughly equivalent to the energy consumed by 1400 average U.S. households.

Fortunately, there are good solutions. More efficient power distribution systems, combined with recent advancements in electrical design and uninterruptible power system (UPS) technology, are bringing significant improvements in energy efficiency.

- Most managers of large data centers are planning to upgrade their existing 480V AC power infrastructure over the next few years, implementing more efficient 400V AC or 600V AC equipment.
- The latest generation of UPSs includes a multi-mode operation that delivers up to 99 percent efficiency without sacrificing reliability.

The Webcast, sponsored by *InformationWeek* and Eaton, featured Ed Spears, product manager for Eaton's Critical Power Solutions division and a 29-year veteran in the power systems industry. In the one-hour presentation originally broadcast in August 2009, Spears discussed power distribution options that reduce cost of ownership—and how new, high-efficiency UPSs further enhance the cost picture. Together, these energy-saving technologies and approaches can have a notable, positive impact on a company's profitability.

"The topic of energy efficiency in data centers is a large one, and I'm not going to try to address the entire spectrum," Spears noted at the outset. "We will be talking about specific sections that may be of interest to you or anyone involved in the design or operation of data centers," particularly Eaton's research into the cost impacts of data center powering at different voltages, with and without high-efficiency UPSs.

Maintaining the status quo—doing nothing to the power distribution system—will prove costly in the long run, Spears noted. "As of last couple of years, 2006 to 2007, the five-year cost for powering and cooling the data center started to exceed the cost of servers themselves. Think back to the 2000 to 2003 timeframe. If we spent a million dollars on server hardware, we would probably have spent about $100,000 a year in energy to support it. Today, a million dollars' worth of server hardware will consume $400,000 of power a year. By 2012, that figure jumps to more than a million dollars *a year* just to power and cool those servers."

"This reality caught a lot of folks off guard. Few organizations planned or budgeted for the large power infrastructure and utility costs that would be required." Many companies with large data centers face reduced profitability as a result. So it is no surprise that six out of 10 respondents in our Webcast survey said energy efficiency is "more of a priority" than it was before. But is the IT community exploiting all the opportunities?

## Beyond energy-efficient servers and virtualization

In the quest for better energy efficiency, data center managers tend to focus too narrowly on the efficiency ratings of IT, power and cooling equipment. "The efficiency of server power supplies ranges from as low as 60 to 75 percent to as high as 80 to 85 percent in some new servers," Spears said. If a server requires 300 watts, required input power could be as little as 350 watts or as much as 500 watts, depending on the power supply.

So server efficiency ratings are part of the equation, to be sure, but optimizing energy efficiency requires a more holistic perspective, looking at the entire power distribution system from utility input to servers.

Traditional power distribution systems rob a lot of the power that comes into the data center. Every element in the power chain takes a little bit of that power to do its job, and each element wastes a little bit of power too. By the time the power has passed through power protection systems, power distribution units with transformers and finally through server power supplies, more than half of the incoming power has been used or wasted. The wasted power is dissipated as heat, which drives up cooling costs.

"Only about 40 percent of the power brought into the data center is actually used for processing data," Spears said. "Most people, when they see this, find this to be an untenable situation and would like to take significant steps to improve that."

There has been a lot of positive momentum in the industry. For example, under legislation signed by President Bush, the EPA was directed to study energy use in data centers. It is likely that the EPA's work will result in benchmarks to judge the energy efficiency of servers, processors and other data center equipment, just as the EnergyStar program has done for home appliances and office equipment.

"At Eaton's Innovation Center in Cleveland, we're conducting our own research along these lines," said Spears. "We're not just looking at the energy efficiency of components, but end-to-end efficiency of the power delivery system. In the last year we conducted a study to compare the energy efficiency, capital expense and operating expense of six different power approaches for the data center. We found that by modifying the voltages at which power was distributed in the data center, we could dramatically reduce the cost of power equipment as well as energy consumption."

## Alternative powering options for data centers

Today's 480V AC power distribution systems—the standard in most U.S. data centers—are not optimized for efficiency. In a legacy 480V data center, the uninterruptible power system (UPS) might be about 94 percent efficient. The power distribution units are about 98 percent efficient, and the servers about 84 percent.

"So you have a little bit of power being skimmed off at each step along the way," Spears said. "Power gets converted between AC and DC *five* times along the way. End-to-end efficiency ends up being about 77 percent."

That's why managers of many large data centers are planning to upgrade their existing 480V AC power infrastructure to more efficient 400V AC or 600V AC equipment in the next few years. Servers run more efficiently. You eliminate the multiple isolation transformers and branch circuit conductors required in 480V AC and 600V AC power systems, and now there are only three points of AC/DC conversion. End-to-end efficiency is around 79 percent.

That doesn't sound like much of an increase, but the dollars really add up, especially when you consider that the typical data center has duplicate power systems for redundancy. That means two of everything either saving your money or wasting it. You can increase the savings even more by using new, high-efficiency UPSs.

Spears showed calculations of total cost of ownership, capex and opex for various powering options. For data centers of all sizes evaluated, 400V distribution was the clear winner, at least until high-voltage DC power becomes a viable option.

"When you talk to the Finance folks who track costs in large data centers—who are allocating $500 to $1500 per square foot per year for operations—and you tell them you can eliminate all those PDUs [by switching to 400V distribution], it becomes a surprisingly large number over a 15-year service life. It gets their attention."
**Ed Spears, product manager, Eaton's Critical Power Quality division**

## Thoughts on DC power distribution

With all those back-and-forth power conversions between AC and DC, wouldn't it be more efficient to use DC power distribution for the data center?

"That's an important question that has been asked for the last 20 years," Spears said. "Telecommunications equipment, for instance, is powered by -48V DC power. Ma Bell took this powering approach all those years ago because they were running cables in corrosive and damp conditions, and they needed low voltage to protect the safety of line technicians. It's used today because that's what has always been done."

For data center applications though, -48 DC requires such large, expensive copper cabling to deliver a relatively small amount of power for any distance.

Higher DC voltage shows a lot of promise though. In 2007 the California Public Energy Commission did a study on 380V DC and found it was five to seven percent more efficient than best-in-class AC systems. They theorized that as much as 28 percent improvement is possible over today's average AC systems.

Trouble is, there are few standards for high-voltage DC power outside of industrial applications—none for IT systems, Spears said. "There is limited availability of IT equipment that will run this power. And there are some safety issues to be addressed. So 380V DC is promising, but at the moment it's a future vision."

Our Webcast poll confirmed this, with 80 percent of respondents reporting that their organizations are "not considering using DC power at this time," and only a very small number—less than five percent—successfully using DC power for communications or storage devices.

## Save even more with new, high-efficiency UPSs.

The business case for 400V AC power is compelling, but it can be improved even more by taking advantage of new, high-efficiency power protection systems.

UPSs vary a lot in their efficiency, depending on their vintage and how they operate, Spears said. "As recently as 10 years ago, a state-of-the-art UPS was about 93 or 94 percent efficient. The 2000s have brought some UPSs that operate at 97 percent efficiency or better and are optimized for today's IT equipment power supplies. Still, a typical one-megawatt data center could be forfeiting about $28,000 of its utility power each year to UPS energy losses."

At Eaton, we thought that figure was unacceptably high. So we developed new UPSs that operate at 99 percent efficiency under normal utility conditions. Eaton's Energy Saver System, available on several UPS models, continuously analyzes the quality of incoming power and selectively and automatically controls the power conversion circuitry to optimize power conditioning and efficiency.

Energy Saver System is supported only on transformer-less 400V AC and 480V AC UPSs. All 600V AC UPS systems available today feature transformer-based designs that are inherently less efficient.

Even a few percentage points' gain in efficiency makes a significant difference, Spears noted. "Suppose you are replacing an older 250 kW UPS that is 93 percent efficient, and you pay 11 cents per kilowatt-hour for energy. With the high-efficiency, multi-mode UPS, you would save about $24,000 per year. That's enough to pay for the UPS in the first few years. The savings continue on for the rest of the UPS's service life."

"Furthermore, the more energy-efficient UPS eliminates 481 metric tons of carbon emissions. To put that in real terms, that's the equivalent of taking 29 gas-sucking, carbon-spewing cars off the road."

## Not just another "eco-mode"

High-efficiency or "eco-mode" UPSs have been around for years and carry some negative connections, Spears said. "The impression has been that any so-called 'eco-mode' or 'multi-mode' UPS acts as a standby device and cannot react fast enough to power line disturbances."

"In some vendors' models, the internal circuitry in the UPS is actually turned off during high-efficiency mode," Spears said. "If power problems occur, that UPS has to start up those components, synchronize the electrical waveform, and then transfer the internal power path. There are delays that can cause problems."

In other models, the UPS inverter is running all the time. Transfers are then faster, but since these UPSs have a transformer, efficiency is no better than 96 to 98 percent. It is often much lower, especially when the UPS is lightly loaded, which is the usual.

The Eaton Energy Saver System works very differently. In high-efficiency operation, the inverter is charged but not running. It is always synchronized, so it can jump into action in two-thousandths of a second. It also uses more sophisticated detection circuitry to see trouble coming and reliably protect IT systems.

"We're glad to report that the latest technology advances in detection circuitry allow the best high-efficiency UPSs to provide exactly the same level of reliability and protection as conventional double-conversion UPSs without compromising efficiency levels. Efficiency as high as 99 ½ percent can be achieved without sacrificing protection for critical equipment."

**Ed Spears, product manager**
**Eaton Critical Power Solutions division**

## Closing thoughts

"The current level of energy waste is no longer acceptable," Spears said. "Power systems will have to change. The pressure is on server vendors and power system vendors to improve performance. We're working hard to meet that expectation.

"Major advancements in UPS and server designs have improved energy efficiency in data centers in recent years. However, the key to improving overall power efficiency is to look at end-to-end power distribution."

Of the alternative power distribution systems currently found in the U.S. and Canada, Eaton recommends 400V power distribution, stepped down to 230V to support IT systems. This approach has proven reliable in the field, conforms to current U.S. regulatory standards, can be easily deployed into existing 480V AC power systems, and doesn't require significant changes to IT systems.

Organizations that are particularly cost-conscious or have aggressive carbon abatement programs should also consider replacing legacy UPSs. New high-efficiency UPSs pay for themselves within a few years and then continue delivering savings for the rest of their 10- or 15-year service lives.