Thought Leadership
White Paper

Is your data center running out of power or cooling?

Seven ways to extend the value of what you have and optimize the plan for what you need

By Ed Spears, Product marketing manager
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Abstract

The challenge. To keep pace with business demands, data centers pack in more power-hungry, heat-generating IT systems than ever. Many power and cooling systems are reaching their limits. Older power protection, power distribution and HVAC systems could be bottlenecks to needed expansion. Since these support systems represent 40 percent of the cost of IT equipment, a wholesale upgrade is generally not an option.

So, what is the best way to augment and extend existing capacity within the constraints of tight budgets and limited support staff? How can you establish a power and cooling infrastructure that is ready for growth but not over-provisioned for an uncertain future?

The solution. This white paper offers strategies that enable IT managers to:

- Plan a more efficient and adaptable power and cooling infrastructure, starting with an audit of the present state and evaluation of alternative approaches and technologies.
- Monitor and measure power and cooling systems, so they can be managed more effectively and economically.
- Optimize the existing cooling system through mechanical and room layout changes, using relatively inexpensive devices to redirect and concentrate available airflow.
- Augment UPS and power distribution systems by using modular approaches and the latest, high-efficiency products.

With simple changes in infrastructure and practices, any data center can extend the value of available backup power and cooling systems—delaying the point where those systems would have to be upgraded to match data center expansion.

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Ten years ago, the primary goal of data center designs was to establish the raw processing horsepower to keep pace with mushrooming applications. The support infrastructure was a given. Only a few years later, that scenario was reversed. The raw processing horsepower is now a given, but the infrastructure to support it is most definitely in question.

In many data centers, power and cooling systems are stretched to the limits, quickly approaching capacity. Power and cooling already account for more than 50 percent of IT spend. Power demands continue to escalate. High-density servers generate more heat than ever—heat that has to be addressed by overstressed cooling systems that consume more power that in turn generate more heat. In this vicious spiral, more than 40 percent of data centers will run out of power capacity in 2009–2010, according to Uptime Institute™ (*Data Center Capacity and Energy Efficiency*, March 2008).

This is a scary proposition, especially as new server architectures exponentially increase demands for power, outlets and redundancy. Your data center might not be maxed out today, but if you project current trends into the next three to five years, what does the picture look like? Chances are, you're looking at a major upgrade or overhaul within the planning horizon.

Fortunately, you have options. There are practical and affordable ways to take advantage of stranded capacity, extend the value of what you have, and forestall the day when you will have to make major investments in the power and cooling infrastructure.

Here are seven strategies you can capitalize on today. Some seem self-evident, common sense, but surprisingly few organizations take full advantage of these recommendations:

1. Schedule a power audit to see where you stand.
2. Monitor and measure power and cooling, so it can be managed.
3. Evaluate and compare available cooling enhancements.
4. Reduce the power consumption of IT equipment.
5. Create a more efficient power infrastructure.
6. Build for today, expand on demand with modular components.
7. Stretch data center capacity through outsourcing.

Recommendation One—
Schedule a power audit to see where you stand.

When and where are you likely to max out your data center's support infrastructure? What do you need to do about it now? Are you missing opportunities to use systems more effectively and extend their value? Chances are, yes. Even newer data centers built on prevailing best practices have been found to use power and cooling systems in inefficient or even risky ways.

For example, in 2008, Eaton® conducted an energy efficiency analysis for a 4-megawatt data center, certified to LEED® Silver status and built in 2005. Designed to Uptime Institute Tier III guidelines, the data center was engineered for 99.98 percent reliability. It had redundant utility feeds, backup generators, uninterruptible power systems (UPSs) and chillers. The staff was well trained, maintained an up-to-date line diagram of the configuration, and included an on-site electrician 7x24.

At first inspection, it would seem all bases were covered. However, a power system audit revealed a number of weaknesses that diminished the efficiency of power and cooling systems and placed IT systems at risk. A similar audit of a brand new hospital data center revealed hundreds of places where power systems had not been engineered or installed up to code.

The challenges of keeping up with power and cooling technologies are intensifying. Power and cooling systems are stressed in ways never before imagined. If trouble is looming, it can come faster than ever, and you might not see it coming. A power audit can help you identify both the risks and the potential—and take proactive action.

In a power system audit, experts come on site to conduct visual inspections, take electrical measurements using power quality monitoring equipment, interview on-site personnel, and review utility bills and data. Using “Gold Book” analysis methods set forth by the Institute of Electrical and Electronics Engineers (IEEE), auditors can identify points of vulnerability and opportunities for improvement.

With a holistic perspective on the entire support infrastructure as a synergistic entity, auditors can assess the best approaches: whether to upgrade critical elements, modernize with new systems, or simply rehabilitate existing systems. Cost and payback information generated out of the audit enable you to make a strong business case for any needed changes.

Recommendation Two—
Monitor and measure power and cooling, so it can be managed.

Many data center managers don’t know the efficiency of their IT equipment or the site infrastructure—or have a clear path in mind for how to improve that efficiency to reduce demands on power and cooling systems. There’s a lot of low-hanging fruit being overlooked, readily available opportunities to substantially reduce energy costs and become “greener” in the process.

How much of the data center power budget goes to IT systems, and how much to support systems such as climate control, security and power distribution? For every kilowatt-hour of power being fed to IT systems, how much real IT output do you get? The answers to these questions provide a picture of how much power is consumed for every unit of real business productivity, such as Web pages served, transactions processed or network traffic handled.

Although there are no true industry benchmarks for IT efficiency, there are some industry benchmarks for *site* infrastructure efficiency. The non-profit organization, The Green Grid (www.thegreengrid.org) recommends a metric called the Power Usage Effectiveness (PUE) ratio—or its inverse, Data Center infrastructure Efficiency (DCiE)— where:

PUE = Total data center power in / total power used by IT equipment
DCiE = 1 / PUE

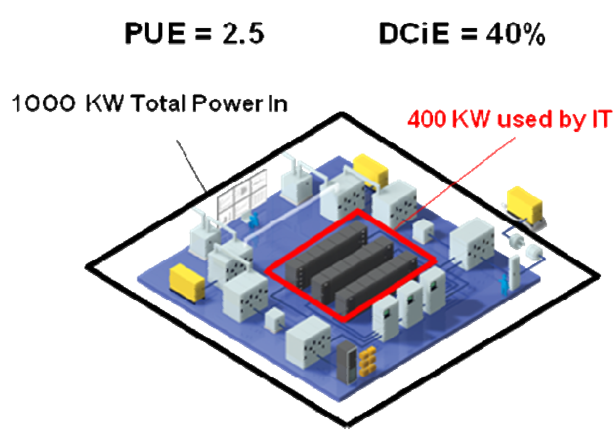

Figure 1. PUE (power utilization effectiveness) is a ratio of total power in to power used by IT.

For example, a data center that consumed a total of 1000 kW, where the IT equipment consumed 400 kW, would be said to have a PUE of 2.5 and a DCiE of 40 percent. The ideal would be a PUE of 1.6, but any well-designed and operated data center could realistically achieve a PUE of better than 2, while meeting business objectives.

If you know where you start on this metric, you can track efficiency over time and reveal opportunities to maximize IT output while lowering input power—such as using server power management, server virtualization and blade servers—and where you can reduce losses and inefficiency in support systems.

Visibility into these issues is coming both from the IT side and the Facilities side:

- *Enterprise-wide power monitoring systems*, such as Eaton's Power Xpert® Architecture, enable IT, financial and facilities executives to see all their critical energy-related assets—primary switchgear, generators, building management systems, cooling, access control, UPSs, branch circuit monitoring, etc.—in a single dashboard rather than in ad hoc monitoring systems.
- *IT monitoring and control systems*, such as IBM Tivoli and Active Energy Manager®, now enable IT operators to provision power management on servers and monitor items such as power, temperature, humidity, air flow and access control.

With an umbrella view that correlates data across many monitoring systems, you can make optimized decisions in holistic context—and wring more work out of existing power and cooling capacity across the organization.

Recommendation Three— Evaluate and compare available cooling enhancements.

As much as 30 to 60 percent of the data center utility bill goes to support cooling systems, including air handlers and chiller systems. If that figure seems too high, it is. Many computer room cooling systems are inefficiently deployed or not operated under recommended conditions.

Poor airflow management reduces both the efficiency and capacity of computer room cooling equipment. Leaking floor tiles, excessive cable openings, poorly placed overhead supplies, under-floor plenum obstructions and inappropriately oriented rack exhausts can reduce the usable capacity of a computer room air conditioner (CRAC) unit by 50 percent or more.

The good news behind this figure is that you might therefore have some ready opportunities to reduce demands on the cooling system through simple and inexpensive modifications, such as these:

- Use hot aisle/cold aisle enclosure configurations. By alternating equipment such that there is an aisle with a cold air intake and another with hot air exhaust, you can create a more uniform air temperature throughout the data center.
- Use blanking panels inside equipment enclosures and curtains or chimneys above enclosures, so cool input air doesn't mix with hot output air.
- Seal cable entry points to minimize "bypass airflow," whereby cool air is short-cycled back to cooling units instead of circulating evenly throughout the data center. This phenomenon—often caused by simply removing an entire floor tile for cabling and leaving the space open—can affect as much as 60 percent of the cool air supply in computer rooms.
- Orient computer room air conditioning units close to the enclosures and perpendicular to hot aisles—or place cooling right in-row—to maximize cooling where it is needed most.

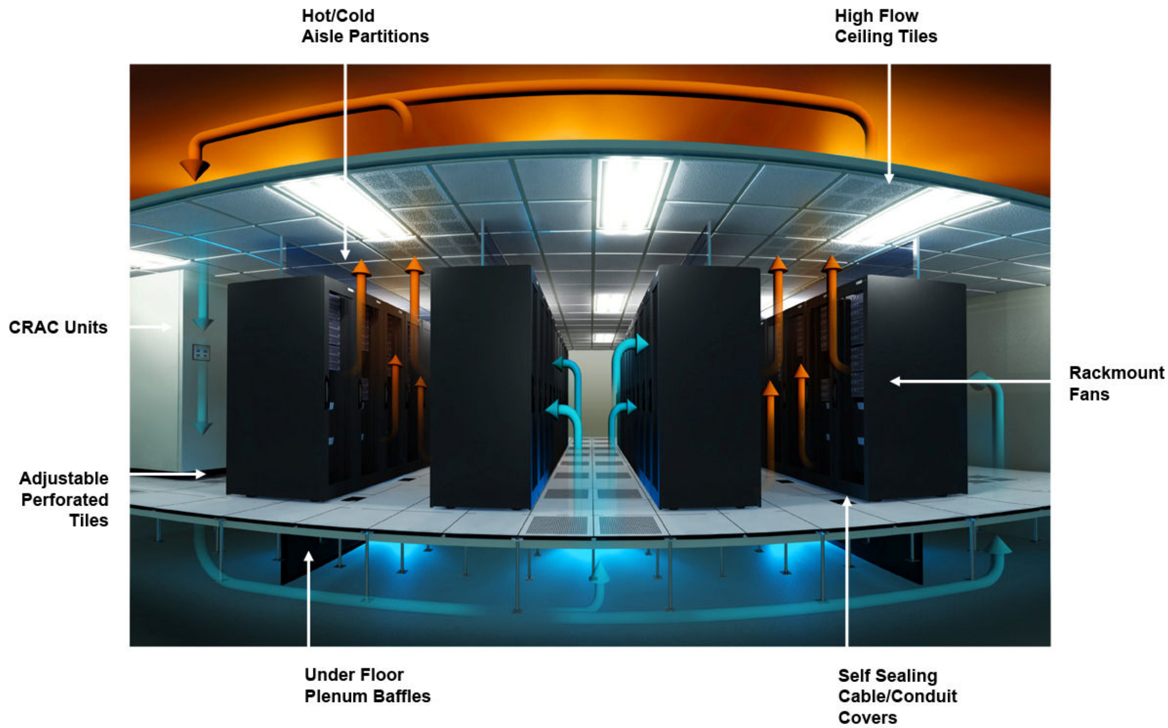

Figure 2. Simple and inexpensive airflow management practices can produce significant savings.

Further optimization of cooling systems can be achieved by using:

- Air handlers and chillers that use efficient technologies such as variable frequency drives (VFD)
- Air-side economizers, which bring in outside air whenever it is appreciably cooler than return air (and humidity conditions are acceptable), or water-side economizers, which use the evaporative cooling capacity of a cooling tower to indirectly produce chilled water to cool the data center during mild outdoor conditions (particularly at night in hot climates)
- Humidity and temperature settings according to ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers) guidelines (http://tc99.ashraetcs.org/), which are higher than those stated by most IT equipment vendors

If a data center with 1000 servers could trim even 25 percent from its cooling costs using these practices, the annual energy savings would be more than $100,000.

The right UPS can minimize cooling costs.

A more efficient UPS dissipates less power as heat and therefore reduces the cost of cooling. For example, a UPS operating at 97 percent efficiency can reduce air conditioning costs by $246 a month for a 60 kW system, compared to a model that rates only five points lower in efficiency.

The savings compound with data center size. For example, in a mid-sized data center with 200 racks at 15 kW per rack, the more efficient UPS would reduce cooling requirements by 47 tons. A large data center with 2000 racks at that same density could expect a 469-ton reduction in AC requirements just by selecting the more efficient model.

Recommendation Four—
Reduce the power consumption of IT systems.

When you maximize the energy efficiency if IT systems, you can support more processing power with your existing power and cooling systems. If you have picked up any trade magazine in the last five years, you have certainly seen no shortage of advice to achieve higher efficiency, such as the following tips:

Turn off idle IT equipment. IT equipment is inefficient at light processing loads and consumes high levels of power even when idle. A typical x86 server consumes 30 to 40 percent of maximum power even when it is producing no work at all. For every idle moment, that's money in, nothing out—the kind of inefficiency that data center managers can no longer accept.

Identify underutilized equipment and power it down. Identify and remove "bloatware," ineffective software that uses excessive CPU cycles. More efficient software helps reduce CPU cycles, which enables a platform to generate more real processing output for the same power input.

Virtualize servers and storage. Virtualization dramatically improves hardware utilization and enables you to reduce the number of power-consuming servers and storage devices.

Consider a typical small company, running 240 applications, one application per server, each server operating at about 10 to 15 percent CPU utilization. In a typical scenario, about 200 or more of these applications would be candidates for virtualization, at an average rate of four applications per server. Consolidation would trim the configuration down to 52 physical servers in a virtualized environment and 30 conventional servers each running a single application, for a total of 82 hardware boxes. The savings are dramatic, as shown in Table 1:

Table 1. Representative savings from server virtualization

The ROI of virtualization	Before virtualization	After virtualization
Data center size	240 servers	82 servers
Server power draws	240 @ 200W	30 @ 200W, 52 @ 270W
Total power required	48 kW	20.04 kW
Cooling	13.6 tons	5.7 tons
UPS/electrical loss	7.2 kW	3.0 kW
Electrical cost	$.08 per kWhr	$.08 per kWhr
Yearly electrical costs (IT only)	$33,638.40	$14,016.00
Additional costs (UPS/electrical)	$5,045.76	$2,102.40
Additional costs (cooling)	$27,078.91	$11,282.88
Total yearly electrical spend	$65,763.07	$27,401.28
Total savings per year		**$38,361.79**
Power cost improvement		**58 percent**
Reduction in cooling		**7.9 tons**
Reduction in UPS/electrical loss		**4.194 kW**

If we assumed an energy cost of $.10 per kWhr (kilowatt-hour) going forward, the savings from this virtualization example come to:

—**$3675 per year** in electric utility bills
—**$18,000 in utility cost savings** over a server's five-year life
—**$11,000 in cooling savings** for the five-year period
—**$29,000 in total savings** (for IT and cooling systems)

Another Eaton customer found that with virtualization, 1000 servers could be reduced to about 200. Even if we assumed a utility rate of only 10 cents a kilowatt-hour, this customer stands to save $700,000 in the first year alone.

Consolidate servers, storage and data centers. Why power and cool 100 1U or 2U servers, when blade servers could do the same work for 20 to 40 percent less power? Why support many lightly used storage devices, when you could consolidate to reduce energy usage in two key ways:

- *Tiered storage*. Consider using high-speed drives only where necessary, and using larger, slower but more efficient drives for applications that don't require instant response.
- *Consolidated storage*. Since larger disk drives are more efficient, consider consolidating storage to improve utilization and warrant the use of those larger drives.

For example, if you replaced 44 mid-tier drives (885 terabytes in 146-Gb drives) with two high-end systems (934 terabytes in 146-Gb and 300-Gb drives), the data center could trim energy consumption for servers by 50 percent to save $130,000 a year.

If underutilized data centers could be consolidated in one location, the organization would reap great savings by sharing cooling systems and backup systems to support loads.

Turn on the CPU power management feature. Several CPUs available today can power consumption by dynamically switching among multiple performance states (frequency and voltage combinations) based on CPU utilization, without having to reset the CPU.

If the CPU operates near its maximum capacity most of the time, this power management feature would offer little advantage, but it can save a lot of energy in typical scenarios, where CPU utilization is quite variable. If a data center with 1000 servers reduced CPU energy consumption by even 20 percent, this would translate into an annual savings of $175,000.

Many users have purchased servers with this CPU capability but have not enabled it. If you have the feature, turn it up. If you don't have it, consider its potential when making future server purchases.

Use IT equipment with high-efficiency power supplies. After the CPU, the second biggest culprit in power consumption is the power supply unit (PSU), which consumes about 25 percent of the server's power budget to perform power conversion. The typical PSU operates at around 80 percent efficiency – often as low as 60 or 70 percent.

Several industry initiatives are dramatically improving the efficiency of these components. The initial cost of high-efficiency PSUs is higher but worth it. If the PSU operates at 90 percent efficiency and voltage regulators operate at 85 percent efficiency, overall server energy efficiency would be greater than 75 percent. By making this one change, a data center with 1000 servers could save $130,000 worth of energy a year.

Recommendation Five— Create a more efficient power infrastructure.

Deploy more efficient UPSs. Advances in UPS technologies have greatly improved the efficiency of UPSs. In the 1980s, UPSs were 75-80 percent efficient. Today's models operate well in the 90s. New, ultra-high-efficiency UPSs dynamically transition among operating modes to deliver as much as 99 percent efficiency.

Even small increases in UPS efficiency can quickly translate into thousands of dollars, in more real power and lower cooling costs. In a one megawatt data center, a 10-year-old UPS is probably wasting about 150 kW of power and dissipating a lot of heat. Replacing that vintage equipment with new, high-efficiency UPSs can free up about 120 kW of that power to support new IT equipment and reduce the burden on cooling systems.

For example, a 10-year-old UPS delivering 60 kW and operating at 90 percent efficiency uses an average of 584,000 kWhr of power per year. In contrast, a UPS at 97 percent efficiency would consume only 541,855 kWhr—a reduction of more than 40,000 kWhr. Since the more efficient UPS also dissipates less heat—and therefore requires less cooling on the data center floor—you'd save approximately $30,000 in energy costs in less than five years (assuming a utility rate of 10 cents per kWhr).

Since UPS efficiency is a hot topic (no pun intended), there is a lot of marketing hype to watch out for. For example:

- *Don't take vendors' efficiency ratings at face value.* When evaluating a UPS, it's not enough to know the peak efficiency rating it can deliver at full load (the efficiency figure usually given). Since so many IT systems use dual power sources, the typical UPS is loaded at less than 50 percent capacity, as little as 20 to 40 percent in some cases. Many UPSs are noticeably less efficient under low loads. When assessing a UPS, be sure to evaluate its energy efficiency profile over the entire load range.
- *Consider the hidden costs of power performance.* If you choose a straight line-interactive topology for high efficiency, will you be able to protect IT loads from power transients and frequency variations? You could need input filters to reduce total harmonic distortion (THD) to acceptable levels. Some vendors advertise an attractive efficiency rating, but then they must use additional input filters to reduce THD, which diminishes reliability and efficiency. If the difference in efficiency is even one percentage point, at 500 kVA that loss translates into more than $10,000 a year.

Consider adopting power distribution at 208V / 230V. To satisfy global markets, virtually all IT equipment is rated to work with input power voltages ranging from 100V to 240V AC. The higher the voltage, the more efficiently the unit operates. However, most IT equipment in North America runs off lower-voltage power, sacrificing efficiency for tradition.

Just by using a different power cord to the equipment, you could save energy. For example, an HP ProLiant DL380 Generation 5 server operates at 82 percent efficiency at 120V, 84 percent efficiency at 208V and 85 percent at 230V. A data center could gain that incremental advantage just by changing the input power and the power distribution unit in the rack.

Higher voltage also increases the efficiency of power distribution. Typically the UPS operates at 480V, and a power distribution unit (PDU) steps down that power from 480V to 208V or 120V. If you could eliminate that step-down transformer in the PDU by distributing power at 400/230V, the power chain would be more efficient. Distributing power at 400/230V can be three percent more efficient in voltage transformation and two percent more efficient in the power supply in the IT equipment. This slight increase in efficiency is still worthwhile; a data center with 1000 servers could save $40,000.

Furthermore, each distribution breaker would change from double-pole to single-pole, saving distribution panel space.

Recommendation Six—
Build for today, expand on demand with modular components.

If you oversize the power and cooling infrastructure meet unknown future growth, it will cost too much to deploy for today's needs, and it will operate inefficiently because it will be so lightly utilized. New designs need to be modular to enable the infrastructure to grow as needed and run at efficient operating levels.

You could start by building out the actual physical space in sections, with the accompanying infrastructure growing in modular fashion. Initial capital outlay is lower, and future builds can capitalize on emerging technologies. You can also cluster IT systems with high power demands in "high-density" zones, so the power infrastructure can be closely tailored to the needs of a rack or row. There's no need to provide highest power capacity to every square foot of the data center, if only a certain percentage of the racks will need it.

Tailoring the power infrastructure in this manner can be readily achieved with today's modular UPSs and paralleling. In the past, a "pay as you grow" philosophy had been limited to smaller UPSs—single-phase and small three-phase UPSs rated at less than 50 kVA. Now you can also get modularity in the "big iron" world, where UPS sizes range from 500 kVA and up. For example:

- **For large applications**, the Eaton 9395 UPS expands in 275 KVA modules up to 1.1 MVA. Distributed systems with internal static switches can be paralleled up to approximately 4 MVA. UPS modules of unequal sizes can be paralleled up to 4MVA using a centralized bypass system.
- **For rackmount applications**, the Eaton BladeUPS® system delivers 12 kW of power protection in a 6U unit—expandable to 60 kW N+1 in one 19", 42U enclosure. Paralleling is accomplished using a plug-and-play bus structure that mounts in the back of the equipment rack.

UPS modularity gives data center managers a lot of flexibility in tailoring an efficient power infrastructure for today's power requirements, with built-in capabilities for expansion on demand.

Recommendation Seven—
Stretch data center capacity through outsourcing.

If you don't have to host an application in your own data center, you don't have to power or cool the IT systems to run it. You don't incur the capital expense to expand a support infrastructure that is already approaching its limits. Just sign a contract and procure the application or data management service from a secure vendor with a service level agreement. Access the needed resources over the Internet and pay as you go.

Given that IT demands can be volatile and fast-changing—and many data centers are strapped for power and cooling capacity—there has been a lot of buzz lately about new business models for outsourcing applications, such as these:

- **Software as a Service (SaaS)—**A provider licenses a software application to customers to use as an on-demand service. The software vendor may host the application on its own Web servers or download it to the customer's device, disabling the software after use or after the contract period expires.
- **Cloud computing—**Dynamically scalable and often virtualized IT resources are provided as a service over the Internet (the "cloud"). Customers do not have to own the infrastructure; they pay for computing resources either on a utility basis (paying for the actual resources they consume), or on a subscription basis (paying by time period). When IT demands fluctuate with business changes, the customer isn't stuck with either inadequate or stranded infrastructure.

There are some concerns and risks associated with these emerging business models, but if your data center is approaching the limits of its power and cooling infrastructure, these options are worth investigating. Some form of outsourcing could postpone the day when a major overhaul is due. You could explore the concept with a smaller or nonessential application, prove the value of the approach, and then add other applications as the business case and your experience warrant.

Closing thoughts

Data centers and servers consume a considerable amount of the nation's total supply of electricity—some 61 billion kilowatt-hours (kWhr) as of 2006, about 1.5 percent of total U.S. electricity (*Environmental Protection Agency (EPA) Report to Congress on Server and Data Center Energy Efficiency*, 2007). That's about the same as the energy consumption of the entire U.S. transportation industry (including manufacture of cars, planes, trucks and ships). Data centers consume more power than all the color televisions in the country put together—double the demand of only six years ago.

The good news is that most data centers can dramatically reduce that demand simply through wise choices in management practices, IT hardware, power and cooling infrastructure. For example, the three-year utility savings from an energy-efficient server can nearly equal the cost of the server itself. Couple this strategy with energy-efficient power and cooling systems, and a mid-sized data center with 1500 servers could save millions of dollars—while reducing your organization's carbon footprint.

Typical power savings from a more efficient server and UPS

Power (watts) for a 1U server	Nominal	Best in class
Power used for processing	300	300
Power supply efficiency	60 percent	75 percent
Input power to server	500	400
Backup power efficiency	82 percent	92 percent
Input power	610	435
Power for cooling	732	261
Total input power	1341 W	696 W
Three-year energy cost at 0.10/kWhr	$3,525	$1,828 **50 percent savings**

With a more efficient allocation of power, you will not only reduce utility bills and total operating cost, but also achieve more with available backup power and cooling systems—delaying the point where those systems would have to be upgraded to match data center expansion.

About Eaton

Eaton Corporation is a diversified power management company with 2008 sales of $15 billion. The company has approximately 75,000 employees and sells products to customers in more than 150 countries.

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 is your source for data center infrastructure solutions, including power distribution, power protection, backup power, enclosures and accessories for network closets, computer rooms and data centers. For more than 40 years—from the first commercial UPS to today's high-efficiency, modular, scalable designs—Eaton UPSs have set the standard for power protection and backup power.

For more information about Eaton solutions for extending the value of your data center power and cooling systems, visit www.eaton.com or call us at 800-356-5794.

Eaton named "Best Overall Power Systems Provider"
For virtualization and data center technology

In November 2008, Nemertes Research published the results of their most in-depth research project ever conducted in the areas of virtualization and data-center technology. The research project assessed 1,252 companies using Web-based surveys and detailed telephone interviews. The results were 100 percent based on the experiences of virtualization and data-center decision-makers.

Nemertes asked these IT decision makers to rate their providers across a wide range of technologies on three dimensions: technology, value and customer service. Eaton received the top honors as "Best Overall Power Systems Provider," with an overall rating of 4.08 on a scale of 5.

"As modularity, scalability and management become increasingly critical for powering data centers, the selection of the right power vendor is critical," stated the Nemertes award announcement. "The growing interest in more intelligence is driving organizations to invest in leading power-management solutions such as those available from Eaton."

About the author

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