About this research note:

Operate & Optimize notes provide recommendations for effective and efficient IT practices that help improve the performance or reduce the cost of technologies already deployed in the enterprise.

Greening the Data Center: Improve Energy Efficiency

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As energy costs begin to compete with the cost of maintaining the underlying hardware, IT decision makers no longer have the luxury of being complacent towards issues of power consumption and energy management. Any data center can be improved in regards to energy efficiency, cost efficiency, and environmental responsibility.

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Executive Summary

Data centers inherently conflict with the green movement: they operate in an “always on” state, consume copious amounts of energy, and use equipment containing toxic chemicals that can harm health and the environment. But all of that is changing. Rising energy costs coupled with growing power requirements, new advancements in technology, and changing attitudes towards the environment are causing enterprises to rethink their data center power strategies.

The first part in this three-part series looks at what IT can do to improve overall energy efficiency and reduce power requirements. Key topics include:

- Rising energy costs.
- Data center energy consumption.
- Power supply efficiency.
- Emerging energy standards for servers.
- High value, energy-saving tips for the data center.

Leading enterprises, vendors, analysts, governments, environmentalists, and even utility companies are all onboard when it comes to maximizing energy efficiency. It makes sense – save money and save the environment.

Optimization Point

Rising energy costs coupled with growing power requirements, new advancements in technology, and changing attitudes towards the environment are causing enterprises to reevaluate their data center power strategies. The new data center paradigm calls for maximizing efficiency and green thinking.

Power consumption (and cooling) will take center stage in 2007. While other environmental initiatives (e.g. PC recycling) remain important, the hard dollar savings and rapid ROI of energy saving investments will cause these projects to take priority. In fact, almost a third (29%) of respondents to a Ziff Davis survey indicated that data center energy efficiency issues had caught the attention of management as a way to reduce operational costs. This is not surprising considering that most estimates suggest energy costs consume approximately 20% of data center budgets.

Getting to Green

Info-Tech explores all aspects of developing an energy efficient and environmentally conscious data center in this three-part series. Subsequent notes will include:

» Greening the Data Center: Reduce Cooling Requirements

» Greening the Data Center: Manage Asset Lifecycles

Key Considerations

Rising Energy Costs

In the U.S., energy costs continue to soar, see Figures 1 and 2 below. This is not good news for data centers, which already spend significant amounts of money on electricity.

According to the Lawrence Berkeley National Laboratory (Berkeley Lab) the average high density server rack drawing 20 kW of power consumes more that $17,000 per year in electricity, not including air conditioning (which can double this figure). This is consistent with HP Labs' estimate of approximately $11,000 per year in electricity for a 13 kW server rack. Using different assumptions, Cisco states a figure of $486,618 per year for a megawatt of data center power.

California-based Pacific Gas & Electric (PG&E) estimates that data centers in Northern and Central California use between 400 and 500 megawatts of power – enough power to serve 300,000 homes.

Figure 1. Growth in U.S. Electricity Demand

Source: U.S. Energy Information Administration

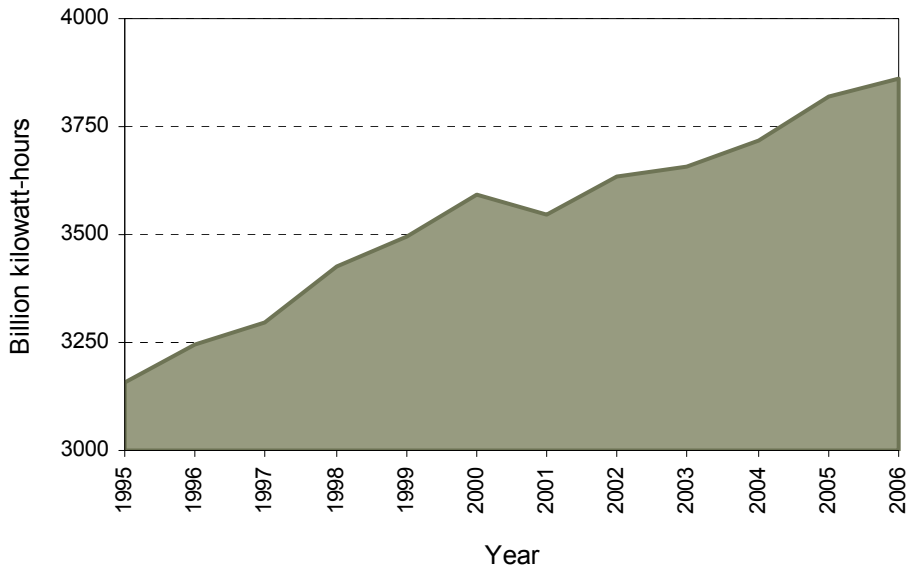
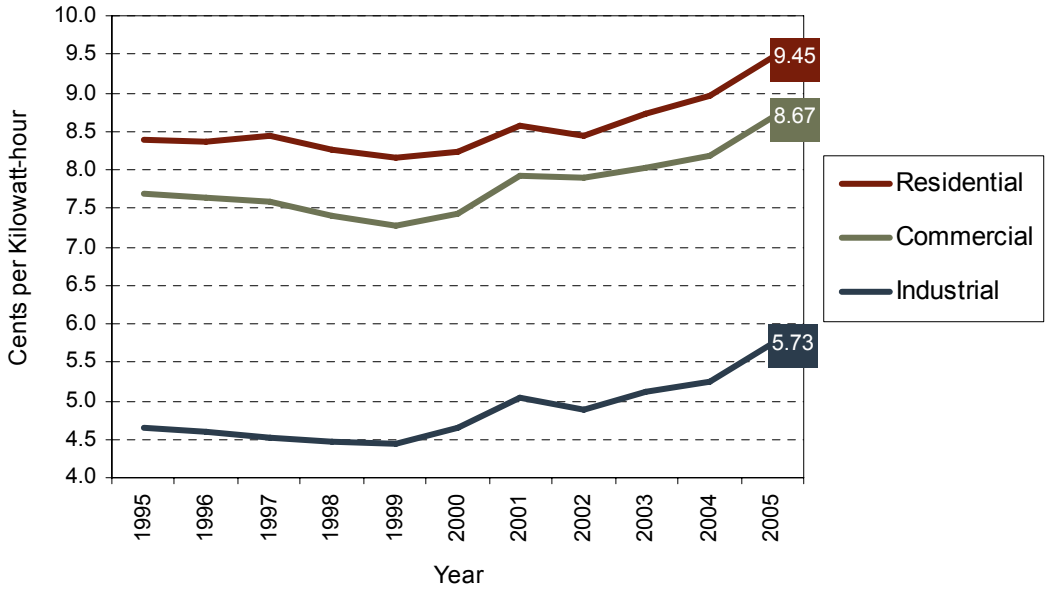


Figure 2. Increase in Average U.S. Electricity Price by Sector

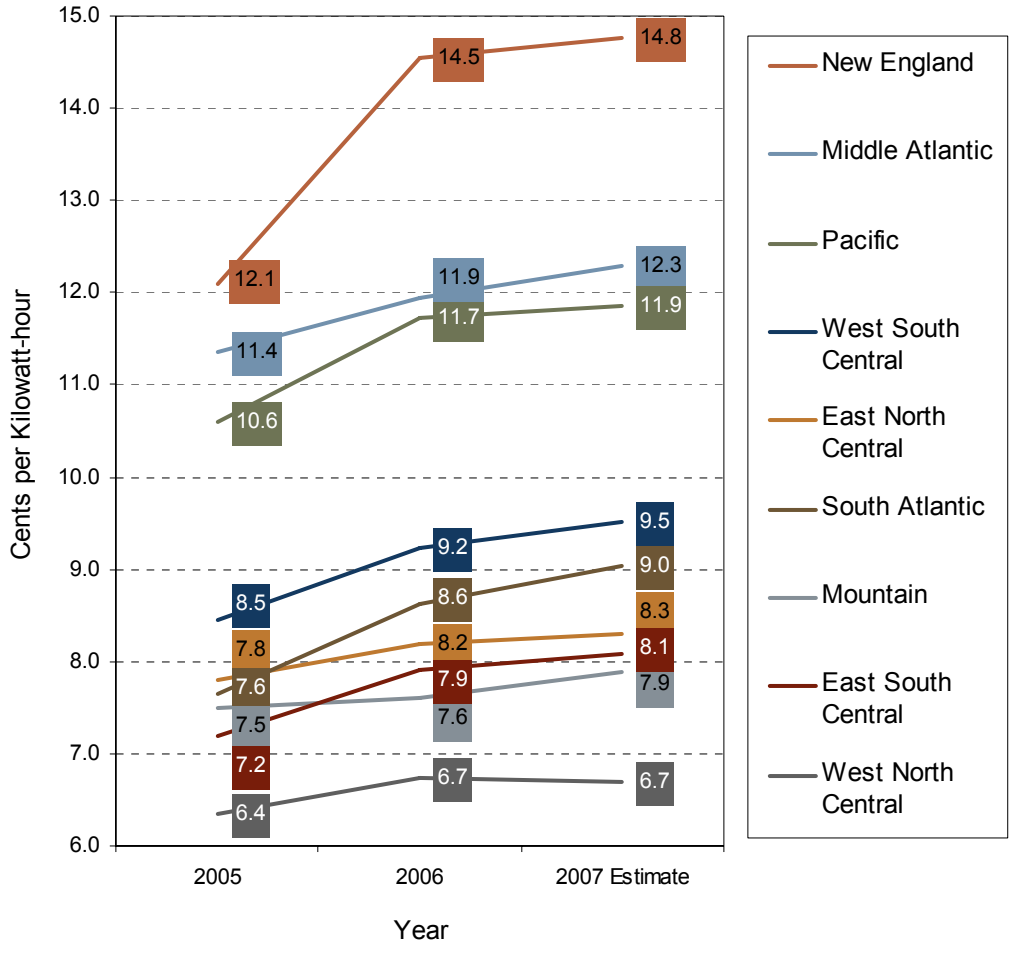
Source: U.S. Energy Information Administration



Higher than average costs for Pacific states spell trouble for Silicon Valley, see Figure 3. Indeed, it is notable that many of the most forward-thinking energy initiatives are coming from California, which has the third highest electricity cost among all of the states. Hawaii and New York rank number one and two respectively in terms of cost of electricity.

Figure 3. Average U.S. Electricity Price by Region

Source: U.S. Energy Information Administration



Data Centers: The SUVs of Corporate

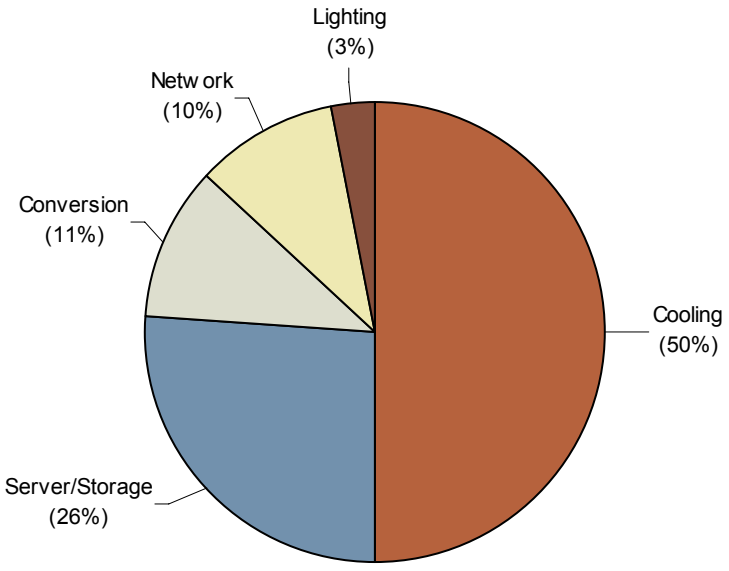
The average data center has 10 to 30 times the energy requirement (and cost) of an equivalent sized office space. In fact, conservative estimates put the total energy consumption of data centers in the U.S. at between 2% and 4% of total national demand.

From an environmental standpoint, increased energy demands translate into emissions and pollution created during energy production. As an example, the power required to run one PC for a year equates to approximately 838 pounds of coal.

To turn the SUV into an economy car, the enterprise must identify and assess factors that are contributing to energy loss and waste. The optimization of cooling presents the single largest area of opportunity for IT to save energy, see Figure 4. As such, we have devoted a separate ITA Premium research note to this topic, “Greening the Data Center: Reduce Cooling Requirements.” The remainder of this note will focus solely on the other 50% of the pie; that is, non-cooling related energy-saving initiatives.

Figure 4. Typical Data Center Energy Consumption

Source: American Power Conversion, Cisco, and Emerson Network Power



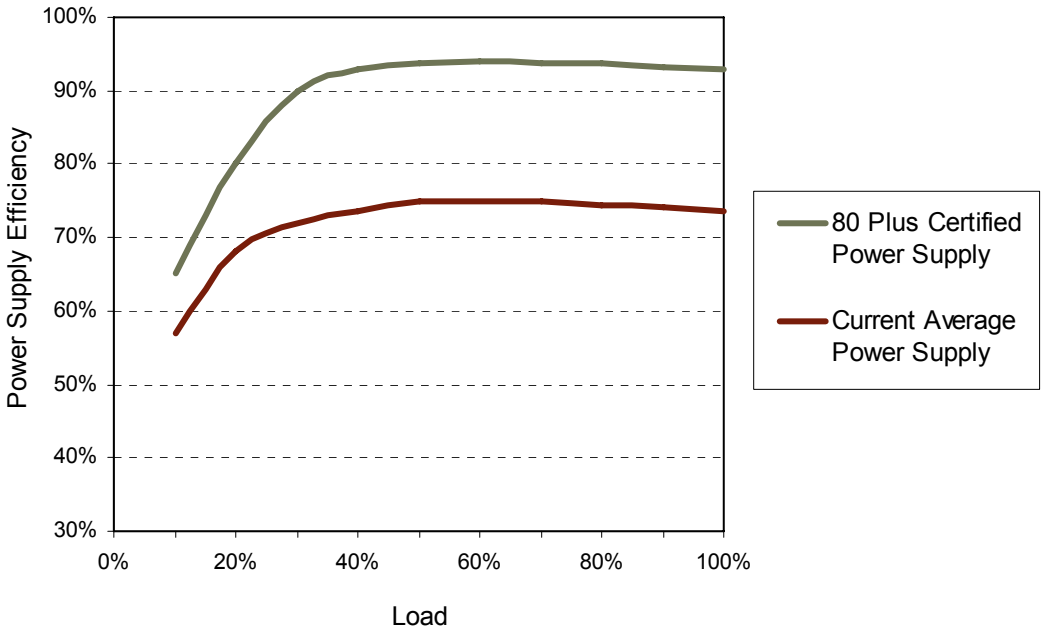
Before purchasing more power or expanding into a new facility, enterprises should assess all opportunities for reducing the energy consumption and planning for in the existing environment.

Power Supply Woes

Power supplies are an often overlooked opportunity to recoup lost energy. A joint study by Ecos Consulting and EPRI Solutions found that the efficiency of current server power supplies peaks at loads between 50% and 60% and drops off dramatically at loads under 30%, see Figure 5. However, most enterprises deploy servers with oversized and inefficient power supplies that typically operate at between 20% and 50% of their rated load. Blade servers, as an alternative, tend to have more efficient power supplies and use less power than their traditional counterparts. The latest generation of blade servers can also control the output of the power supplies; even turning some off, while still maintaining redundancy, if the load from the blades warrants doing so.

Figure 5. Average Server Power Supply Efficiency

Source: Ecos Consulting and EPRI Solutions



According to the study, an inefficient, oversized power supply can waste up to three times as much net AC power as a properly-sized, efficient unit. The same is true for UPC systems, which often waste power when lightly loaded. Berkeley Lab claims that switching to efficient power supplies can yield up to $3,000 per server rack per year in energy savings and allow server racks to hold up to 20% more servers. PG&E has a similar estimate, claiming that efficient power supplies can save between $2,700 and $6,500 per server rack per year. Of course, most enterprises won't risk voiding server warranties by replacing power supplies, so making efficient power supplies a selection criteria during the initial purchase decision is important.

In an effort to improve the energy-efficiency of power supplies in PCs and servers, Ecos Consulting, in an initiative funded by electrical utilities, launched the 80 Plus certification and incentive program. The 80 Plus performance specification requires power supplies to operate with energy efficiencies of 80% or greater at loads of 20%, 50%, and 100%.

Other power supply resources include the Server System Infrastructure initiative, which also sets efficiency guidelines, and EfficientPowerSupplies.org.

AC/DC: The Debate Rocks On

In general, the fewer conversion points and the fewer power supplies there are in the data center, the more efficient it will be. Fully 11% of data center power consumption is related to conversion of electricity. DC-powered systems reduce energy loss associated with the DC-to-AC and then AC-to-DC conversions that typically take place in most data centers. DC-powered systems run DC throughout the data center (except maybe monitors and other non-DC peripherals). Since only a single (or redundant) AC to DC converter is required at the power input to the data center, instances of power and energy loss are reduced.

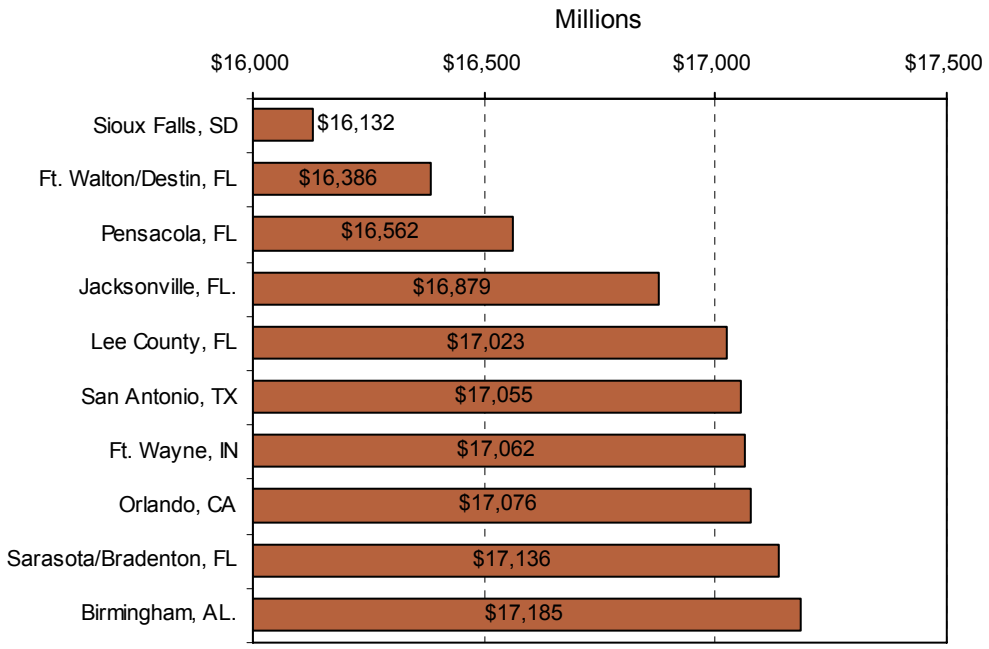
According to Berkeley Lab, enterprises can achieve between 10% and 20% energy savings by switching from AC to DC power. To prove their point, the group has created a DC power saving calculator that helps IT decision makers assess the opportunity. Still, IT decision makers should proceed with caution. While telecommunications companies have been using DC for decades to power network operations centers, DC power is still relatively unproven to the data center. Also, the long term savings from switching carry an initial cost that enterprises must consider when making the business case.

Location, Location, Location

A recent study conducted by site-selection specialists, The Boyd Company, found that location can have a significant impact on data center costs, see Figure 6. A comparison of U.S. cities found that an enterprise running a data center in a high-cost location could lower its costs by as much as 25% by selecting a different city.

Figure 6. U.S. Cities with Lowest Annual Data Center Operating Costs*

Source: The Boyd Company



*Assumes a 150,000 square foot facility with 150 employees.

In comparison, New York City ranked the highest at $22.5 million, followed by San Francisco with an annual data center operating cost of approximately $21.9 million. Factors considered in the study include probability of natural disasters, power costs, labor costs, and local incentives.

In general, consolidating infrastructure, but de-centralizing service delivery, is emerging as a best practice for many enterprises. Consolidation efforts can entail either building a large centralized data center or leveraging an existing corporate multi-site footprint to reduce costs. Enterprises currently undergoing consolidation projects should review the average data center costs for various locations.

Standards Are Coming

Several parties in the U.S., including the Standard Performance Evaluation Corp. (SPEC), the EPA, and the U.S. Legislature have recently begun to evaluate server energy efficiency metrics in an attempt to create standards. Major vendors are also on-side. SPEC (which includes representatives from Advanced Micro Devices, Dell, EMC, Hewlett-Packard, Intel, IBM, Oracle, Sun Microsystems, and many others) has already published some preliminary benchmarks. Another important group seeking to lower the overall consumption of power in data centers is The Green Grid, which lists AMD, APC, Dell, IBM, Hewlett-Packard, Rackable Systems, SprayCool, Sun, and VMware among its founding members.

The U.S. Senate and House of Representatives – concerned about the fact that U.S. enterprises spend $3.3 billion to power their data centers – have both passed a bill to study and promote the use of energy efficient servers in data centers (House Bill 5646, Senate Bill 3684). The Bill was signed by President Bush in December, 2006 thus delegating responsibility to the EPA to investigate the issue of power consumption in data centers and find ways to encourage enterprises to adopt more efficient technologies.

Improvement & Optimization

The following recommendations are listed in order of magnitude with the most immediate, applicable, and essential items presented first. All recommendations will lead to more efficient energy management, but start at the top of the list to get the biggest bang for your buck.

1. **Foster communication between IT and facilities.** Most of the time, energy costs are not visible to IT as they are either "General & Administrative" expenses or tucked into facilities. The majority of IT departments don't know what the annual energy spend is for the data center and IT and facilities departments don't generally coordinate efforts unless there's a move involved. However, for a green data center to work there needs to be better visibility of what the other side is doing. IT needs to understand how purchasing decisions affect facilities, and what the baseline is, in order to track improvement. Similarly, facilities must know ahead of time what's coming down the pipeline in terms of power, space, and cooling requirements.
2. **Get budget allocation.** One of the major challenges in going green is that in most cases, power costs are not part of the IT budget, and therefore, there is little motivation for IT to make the "green" decisions. In fact, the likely higher purchase price of green equipment will impact IT's budget, while facilities save money. If energy conservation is an enterprise-wide initiative, seek internal budget incentives for purchasing IT equipment that meets target efficiency levels. If not, make a business case for green purchasing with an ROI based on long-term savings and lower ongoing energy costs.

3. **Track and manage energy consumption.** Tracking energy usage in the data center provides a baseline for calculating the ROI of new energy saving initiatives and helps identify areas of opportunity. Moreover, energy management products can reduce energy use during regular operation and can keep critical applications running during brown-outs.
    - » A Ziff Davis study revealed that 71% of IT decision makers would consider using system-level tools to manage power and cooling down to the server or rack level.
    - » Many high-performance systems, such as blades, already include these types of management tools, but they are becoming increasingly popular for all (newer) server environments. As an example, HP recently announced Insight Power Manager (originally introduced as a blade product). The software allows administrators to track and adjust how much power servers are using. IBM's PowerExecutive offers similar functionality.
    - » For non-server energy consumption data (e.g. HVAC and UPS), IT will have to work with facilities to either physically meter the data center, or perform a percent allocation based on what the equipment footprint looks like.
4. **Explore server consolidation and virtualization to improve energy efficiency.** Virtualization, server consolidation, and the use of multi-core processors can help improve server capacity utilization, reduce the number of physical machines in the data center, and reduce electricity consumption.
    - » Blade servers can also help reduce physical space requirements while using less energy for the same processing power as rack mount servers.
    - » In large consolidation efforts (i.e. for disaster recovery or simply cost reasons), enterprises can also look to consolidate data center resources in an offsite location with lower operating costs.
    - » For storage virtualization, Cisco estimates that taking a tape subsystem offline can save $3,800 in power and cooling per year.
    - » To take savings a step further, utility company Pacific Gas & Electric (PG&E) (California only) offers rebates to IT shops involved in server consolidation and virtualization.
    - » For more information on virtualization, refer to the ITA Premium research notes, "Achieving the Business Case in Virtualization," and "Fifteen Servers Marks the Virtualization Tipping Point."

5. **Shop green.** Look for products with eco labels and include specific terms for power supply efficiency ratings when writing RFPs for new equipment.
    - » **Buy servers with energy-efficient power supplies.** Look to the EPA's Energy Star program to start offering ratings for server efficiency now that U.S. House and Senate bills encouraging EPA involvement have been passed. In the meantime, look for products containing 80 Plus Certified power supplies.
    - » **Seek rebates from utilities.** In an effort to reduce new investments in electricity generation, U.S. utility companies are creating incentives to try and counter the energy consumption of power-hungry data centers. Notably, PG&E is offering rebates ($700 to $1,000 per server) for Sun Microsystems' energy-efficient Sun Fire T1000 and T2000 servers. Expect other utilities and vendors to follow suit.
    - » **Look for new innovative offerings.** With the recent push towards energy efficiency, many vendors are coming out with innovative new products.
        - **3PAR** recently announced a Carbon Neutral Storage program via Thin Provisioning. For every terabyte of capacity sold in 2007, the company will purchase the equivalent carbon credits from TerraPass to offset the emissions generated in the delivery of that storage.
        - **Cisco** started 2007 on a green foot. In addition to getting its own house in order (the company's internal green initiatives will save $20 million over a three-year period) and hosting Webinars on green data center design, Cisco also offers a range of products that claim to reduce power consumption and improve operating efficiency.
        - **Sun** has developed more efficient chips and servers and claims that its UltraSPARC processor is so efficient that it could reduce worldwide server demand by 50%.
        - **IBM** and **HP** offer software to adjust the power consumption of servers to match the load.
6. **Seek energy-efficiency in UPS systems.** The efficiency of the most commonly used UPS devices ranges from 86% to 95%. PG&E estimates that by simply selecting a model that is 5% more efficient, a 15,000 square foot data center could save over $38,000 per year.
    - » **UPS systems are more efficient at higher loads** (achieving peak efficiency at close to full load with a significant drop-off in efficiency at loads below 40%). For battery-based systems, this could mean running multiple smaller units at higher loads, as opposed to a few large units at lower loads. This is especially true when designing for redundancy, where operating two large UPS devices with 100% capacity in parallel proves to be

extremely inefficient. Operating at higher loads can also be achieved by accurately estimating load estimates of IT equipment.

- » **In terms of UPS system design, passive standby configurations are the most efficient,** followed by line reactive systems, and then double conversion configurations. The main difference in the system designs is power conditioning, which is highest with double conversion systems where all incoming utility power is continuously converted to DC and then back to AC to supply the data center. While some power conditioning is desired for most data centers, the internal power supplies in servers do allow them to operate through significant power disruptions. In most cases line reactive systems provide adequate conditioning and higher efficiency. As a compromise between line reactive and double conversion, some UPS vendors offer double conversion systems that include an "economy" mode that can bypass the double conversion circuitry and offer efficiency savings of up to 5%.

7. **Investigate DC-powered systems.** Switching to DC power means fewer conversions and thus fewer opportunities for energy loss. However, DC isn't without its concerns. Consider the following:
   - » **Hardware and wiring must be DC-compatible.** Sun, Cisco, HP, IBM, and others all offer DC hardware.
   - » **Single point of failure.** Unlike the built-in redundancy of AC systems, with DC, there is a single power input. All vendors offer redundant DC connections and circuitry – but at a cost.
   - » **Cost.** While DC servers are cheaper to run, they are not cheaper to buy (despite lacking internal power supplies). For UPS systems, the initial cost can be 20% to 40% more for a DC system. Enterprises must also consider the downtime costs of making the transition.
8. **Purchase green power.** IT decision makers looking to influence corporate environmental initiatives can help promote the use of green power.
   - » The EPA has launched a Green Power Partnership campaign aimed at reducing the environmental impacts associated with conventional electricity use, accelerating the development of domestic renewable energy facilities, and helping enterprises gain public recognition for their purchase of green power.
   - » Canada-based Environmental Defense also list green power options across the country, including fixed-price green power contracts aimed at corporate buyers.
   - » U.K. enterprises can visit UK Green Power for information on green power alternatives.

- » For small enterprises, another option might be eco-friendly Web hosting. As an example, SolarHost and AISO are hosting companies that rely solely on solar power; ecoSky is powered by solar and wind energy.

9. **Design new facilities with certification in mind.** The U.S. Green Building Council (USGBC) has a certification for Leadership in Energy and Environmental Design (LEED). Mortgage company Fannie Mae and insurance company Highmark were the first to receive the designation for data centers (in Maryland and Pennsylvania respectively). Criteria include sustainable site development, water savings, energy efficiency, materials selection, and indoor air quality.

Bottom Line

As energy costs begin to compete with the cost of maintaining the underlying hardware, IT decision makers no longer have the luxury of being complacent towards issues of power consumption and energy management. Any data center can be improved in regards to energy efficiency, cost efficiency, and environmental responsibility.