The green data center

More than social responsibility: A foundation for growth, economic gain and operating stability

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Challenges facing CIOs transitioning to a green data center

- Whose job is it?
- Reducing cooling requirements
- Increasing facilities system efficiency
- Reducing power consumption with innovative technologies
- Do you have a game plan?

Introduction

Industry analysts have verified our findings that the data center is in crisis, noting that data center energy costs are 10 to 30 times more than a typical office building. It has also been reported that data centers have doubled their energy use in the past five years.[1] That is a significant increase in a very short period of time—an increase that is getting the attention of CIOs.

After years of being viewed by many as a concern for a relative few, environmental issues are now front-page news around the world. Faced with increasingly urgent warnings about the consequences of the projected rise in both energy demands and greenhouse gas emissions, governments and businesses alike are now focusing more attention than ever on the need to improve energy efficiency. For most CEOs, whose sights are firmly fixed on business growth and expansion, energy consumption and environmental concerns can take on a whole new meaning when they begin to impede the company's ability to grow. Corporate data centers are well known as significant power users. If the company's data center cannot accommodate new servers or storage because of power availability or infrastructure constraints, bringing new capabilities online can become a major challenge in terms of both time and money. For CIOs, that translates into finding ways to expand the capacity of data operations to meet the growth requirements of the business. A growing number of CIOs are realizing that environmental concern and business success can go hand in hand—and that a green, or environmentally friendly, data center may actually be one of the best ways to both accommodate growth and make a positive impact on their business's bottom line.

While creating an energy efficient data center can be a complex undertaking, there are many solutions and techniques available to support the transition.

With energy costs rising and information technology (IT) equipment stressing the power and cooling infrastructure—which, in turn, threatens operating resiliency—many see an economic and operational crisis looming. CIOs today are being challenged to rethink their data center strategies, adding energy efficiency to a list of critical operating parameters that already includes serviceability, reliability and performance. A data center efficiency initiative can help a company regain power and cooling capacity, recapture resiliency and help meet business needs—while, at the same time, dramatically reducing energy costs and the total cost of ownership. To further reward companies for energy-conscious behavior, many local utility and state energy funds are offering economic incentives or rebates for measures that reduce energy consumption.

Transitioning to an energy efficient data center and optimizing operating efficiency can be a complex undertaking. There are multiple components to factor into the equation—and best results are often achieved by integrating improvements from multiple fronts. The good news is that there are many solutions and techniques available to support such a transition. Furthermore, the process can occur in a step-wise manner, reducing risks and helping to realize benefits along the way. Going green is becoming more than an altruistic aspiration to save the planet. It's now clear that acting in an environmentally responsible manner is a necessity that companies will need to embrace—sooner rather than later—to survive economically.

High-density rack-mounted servers can increase hot spots and tax cooling systems, making it difficult for aging data centers to keep up with today's demands.

Challenges facing CIOs

Responding to customer demand for better performance at lower prices, the information technology industry has delivered faster servers, lower-cost storage and more flexible networking equipment. While these new components can often deliver ever-greater performance per unit of power, they can also be increasingly power hungry. In addition, the evolution of high-density, rack-mounted servers has typically increased heat density, creating hot spots and taxing cooling systems. The excessive heat can also threaten operating stability, resiliency and staff productivity.

Many of the data centers housing this "hot" new technology are now 10 to 15 years old. As a result, their critical infrastructure equipment is likely to be growing inefficient and reaching the end of its useful life. These aging data centers are having a hard time keeping up with today's demands. Typical data centers draw approximately one half to three times the amount of power required for the IT equipment because conventional data center designs are oversized for maximum capacity and older infrastructure components can be very inefficient.[2] The cost associated with this level of power consumption can significantly impact the total cost of ownership for data center facilities and IT systems.

The rising cost of a kilowatt of electricity has further compounded the problem. Cooling and electrical costs currently represent up to 44 percent of a data center's total cost of ownership.[3] According to The Uptime Institute, the three-year cost of powering and cooling servers is currently one-and-a-half times the cost of purchasing server hardware.[4] As a high-level university administrator recently discovered,

Cooling and electrical costs represent up to 44 percent of a data center's total cost of ownership[3] although some companies are finding that they can't buy extra electricity at any price.

"With the growing demand for cheaper and ever-more-powerful high-performance computer clusters, the problem is not just paying for the computers, but determining whether we have the budget to pay for power and cooling."

Meanwhile, some companies can't even deploy more servers because extra electricity isn't available at any price. Many utilities, especially those in crowded urban areas, are telling customers that power feeds are at capacity and they simply have no more power to sell.

A study by Jonathan Koomey, Lawrence Berkeley National Laboratory and Stanford University, has indicated that server energy demand has doubled from 2000 to 2005. The study estimates that power used by servers, cooling and ancillary infrastructure in 2005 accounted for about 1.2 percent of the United States' electrical usage—the equivalent in capacity terms of about five 1,000 MW power plants.[5]

This issue hasn't escaped the attention of power companies or government organizations. In the U.S., over 80 local utility and state energy efficiency programs are offering rebates for increasing energy efficiency.[6] One of the first utilities to offer such a program is Pacific Gas and Electric (PG&E) of California. The company has approved a plan to reimburse part of the costs of server and storage consolidation projects, including software, hardware and consulting, up to a maximum of US$4 million per customer. Marc Bramfitt of PG&E said, "We don't want to build any more power plants. We want our customers to save energy and we'll pay them to do so."[7]

With energy costs rising and in limited supply, the data center infrastructure is being taxed and its ability to meet business demands is at stake.

In addition, governments at both the country and regional levels are initiating energy efficiency programs. In the United States, the U.S. Department of Energy and the U.S. Environmental Protection Agency are developing assessments and rating systems for data centers and IT equipment.[8] The European Union has established a directive to drive a 20 percent reduction in energy usage by 2020.[9] And Australia requires all companies using more than 150,000 MWH of electricity per year to prepare an energy efficient assessment and action plan.[10]

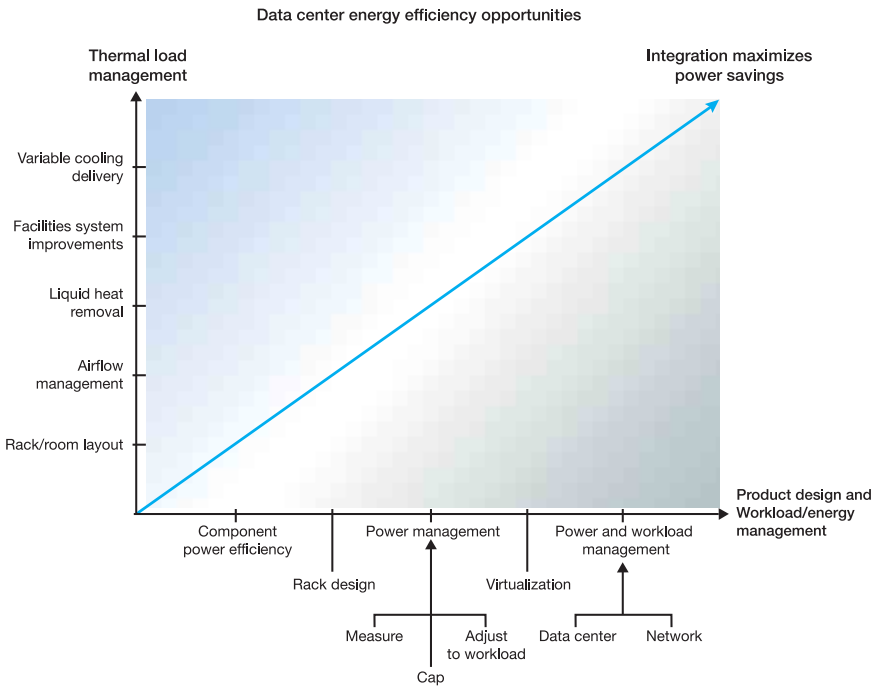
The message is clear: Energy costs are rising, supply is limited, the data center infrastructure is being taxed, and its ability to meet business demands is at stake. CIOs who want to solve these problems will need to focus on data center innovation. Fortunately, green strategies and technologies exist today to help optimize space, power, cooling and resiliency while improving operational management and reducing costs—at the same time, helping to position companies for growth and enabling CIOs to meet expanding business needs.

Transitioning to a green data center

How do you go about creating an energy-efficient green data center? IBM's 30-plus years of extensive, hands-on experience in designing, supporting and operating data centers has allowed it countless opportunities to learn what works and what doesn't. It's also provided us with a unique perspective on how to apply that learning to help create workable strategies for improving energy efficiency.

The technologies and strategies for improving data center energy efficiency span the data center ecosystem.

As the following graphic shows, the technologies and strategies for improving data center energy efficiency span the data center ecosystem. Companies typically achieve the best results by addressing both the physical infrastructure and the Information Technology equipment. Advanced technologies such as virtualization, energy efficient hardware, and advanced datacenter management software can increase equipment utilization and match power use to workload demand. Further gains can be realized by using more efficient infrastructure equipment and matching cooling delivery to power demand.



Data center energy efficiency opportunities

A best practices assessment and energy audit make it possible to pinpoint areas of high energy use, while establishing a baseline for further planning.

Although there is clearly no single "right way" to create a green—and energy efficient—data center, experts believe that the most productive first step for CIOs is to conduct a data center energy audit to "get the facts" on their energy usage. This systematic approach offers a real-time profile of the data center's energy use and evaluates it against an industry metric for the data center energy efficiency—called either the Power Usage Effectiveness (PUE) or the Data Center Infrastructure Effectiveness (DCiE). These metrics and the detailed measurements of power usage make it possible to establish a baseline for future planning and to pinpoint areas of inefficient energy use.[11]

At the same time, CIOs should develop a holistic view of the environment, taking the following factors into account:

- An inventory of your current systems, their power usage and locations
- Your company's business and growth plans—to help forecast future needs
- Current or planned governmental energy efficiency regulations in your area
- Available energy efficiency rebates or economic incentives from government programs or your energy provider
- Any already established goals for reducing your company's carbon or greenhouse gas emissions inventory—and the timeframe set for achieving those goals.

Opportunities to improve energy efficiency can range from major infrastructure upgrade projects to a number of simple and inexpensive measures.

A careful review of the assessment and profile will allow a CIO to build a list of opportunities to drive maximum energy efficiency in the data center. If the team hasn't yet looked closely at the thermal characteristics of the company's data center, it's likely that they'll find many opportunities to improve energy efficiency. They can range from major infrastructure upgrade projects such as upgrading chillers or uninterruptible power supplies (UPS) to simple and inexpensive measures, including:

- Blocking cable openings to prevent cold air waste in the hot aisle
- Removing under-floor cable blockages that impede airflow
- Turning off servers that are not doing any work
- Turning off computer room air conditioning (CRAC) units in areas that are over provisioned for cooling
- Optimizing perforated tile locations
- Blanking panels internal to server racks to fill empty positions

Of course, any analysis of your current situation needs to recognize the likelihood that business needs will change. For example, it would be wise to employ a modular approach to the design of future power and cooling capacity, allowing for easy expansion or modification. Factoring in local conditions and time periods can also be important. While IT equipment and UPS usage probably will be fairly constant, chiller or heating, ventilation and air conditioning (HVAC) energy usage will vary with outdoor temperature and humidity conditions. In addition, it's important to ensure that power and cooling scenarios are designed for recovery, and not just for steady-state operation.

Facilities and IT departments need to collaborate—sometimes with the addition of outside help—in finding ways to meet environmental and energy challenges.

Whose job is it?

Until recently, environmental management and energy expenditures were typically the responsibility of facilities departments. But rising energy costs and evolving IT demands are changing all that. It's becoming critical that the facilities and IT departments form a partnership and collaborate in this area. Even then, many companies will not have the skills or the tools to profile and model thermal conditions and appropriately apply the information to data center planning or upgrades. Because these are highly specialized skills, obtaining outside help during this part of the process may be well worth the investment.

Reducing cooling requirements—the major physical infrastructure user of energy

According to Gartner, "Traditionally, the power required for non-IT equipment in the data center (such as that for cooling, fans, pumps, and UPS systems) represented, on average, about 60% of total energy consumption."[12] Based on the best practices in IBM data centers and the results of doing dozens on data center energy audits in the past year, there are a number of factors that should be considered in developing a plan for improving power and cooling efficiency by reducing the heat generated in the data center.

All of these will help you effectively manage the air flow to the IT equipment and can increase energy efficiency with relatively low upfront investment. The opportunities include:

- Implementing strict hot and cold aisle installation practices, including blanking plates, proper placement of perforated tiles and reducing under-floor air dams
- Positioning the equipment so you can control the airflow between the hot and cold aisles and prevent hot air from recirculating back to the IT equipment cooling intakes
- Leveraging low-cost supplemental cooling options—such as water or refrigerant heat exchangers

- Improving rack cooling efficiency by employing a rear-door heat exchanger or an enclosed racking system to dissipate heat from high-density computer systems before it enters the room. The rear door heat exchanger is like putting a car radiator on the back of the server as it uses coolant that is being pumped into the data center to run the air-conditioning systems already—it circulates that coolant to kind of a car radiator at the back of the server. In many cases this takes up to 55% of the heat generated from a rack before it exhausts into the room, significantly reducing the energy consumption by the air conditioning system. For lower powered racks (less than 10 kw), it may be possible to remove 100% of the rack heat load from the rear-door heat exchanger.[13]

Similarly, relatively simple airflow management improvements can boost energy efficiency. For example, you can:

- Take advantage of the current capacity by clearing under-floor blockages and implementing effective cable management
- Ensure that floor openings match the equipment thermal load by adding or removing perforated tiles at the equipment air intakes
- Consider adding ducted returns

Organizing data centers into thermal zones can eliminate hot spots that challenge cooling systems and enhance system reliability by helping to avoid heat-related hardware failures.

Ultimately, companies should consider organizing their data centers into thermal zones—assigning a defined set of IT equipment and floor space to specific HVAC or CRAC units. This type of space and thermal planning will eliminate hot spots that challenge cooling systems and will enhance system reliability by helping to avoid heat-related hardware failures.

Improving physical infrastructure systems—don't hog the power

A recent survey indicated over 50% of customers are looking to make incremental improvements to their data centers to increase energy efficiency.[14] This is especially true with the UPS and chiller systems that have useful lives of 15 or more years.

One of the biggest improvements we have found from our data center energy efficiency assessments is the need to improve the efficiency of the UPS systems. Many clients are not matching the IT load to the size of the UPS systems, which results in over-provisioned and inefficient power systems.

In addition, companies can save energy and gain cooling capacity by relaxing stringent relative humidity and temperature requirements for their data centers. Effective air management can lead to the ability to increase the CRAC unit utilization by increasing the air discharge temperatures (and chilled water temperatures if applicable) while still adequately cooling IT loads. Proper control settings can significantly reduce energy usage. Since these specifications are usually driven by the presence of hot spots, removing those hot spots will relax temperature and relative humidity requirements, helping reduce the energy required to operate the data center. Current ASHRAE Class 1 and 2 environmental guidelines recommend 20 to 25 C and 40 to 55% inlet air conditions. The ASHRAE TC9.9 committee has increased these recommended environmental conditions in July of 2008 to 18 to 27 C, a recommended lower limit of relative humidity between 25% and 45% depending on dry bulb and dew point temperature and an upper limit of 60% to allow customers to utilize more energy efficient solutions for their data centers.[15]

When looking to build a new data center or retrofit an existing data center it makes sense to look to new infrastructure equipment, since energy efficiency has significantly improved in recent years. Replacing chiller or UPS systems that have been in service for 15 years or more can result in substantial savings. For example, a 5% increase in the efficiency of a UPS unit can save over 422 MWH/yr ($38,000/yr) in a 15,000 square foot data center with no discernable impact on the data center's operation.[16] New chiller plants also can be installed with variable-speed drives, reducing pumping system energy usage and allowing better integration of the liquid cooling system into the chilled water infrastructure. Water-side economizers, which utilize outside air to directly cool the chilled water, can further reduce the energy required to run the chillers.

New chiller systems, thermal storage systems and air delivery systems can help reduce both energy requirements and costs.

The capacity and efficiency of chilled water systems can be augmented with thermal storage systems that store energy generated at night, when chillers typically operate more efficiently, and then release this energy during the day, when energy costs are higher.

Air delivery to the data center also can be made more efficient, either through central HVAC systems or through CRAC units with variable speed drives. Central HVAC tends to be more efficient, as the systems are larger and more amenable to taking advantage of no-cost cooling when outside air temperatures are sufficiently low to provide some or all of the cooling requirements. CRAC units, on the other hand, provide greater flexibility in managing the data center.

In addition to cutting back on power usage inside its data center, a company can also reduce carbon emissions associated with energy use by taking advantage of options for more eco-friendly sources of power. Integrating renewable energy into the power distribution network—including solar, wind, hydro and bio-mass generated energy—is a good way to reduce dependency on fossil fuels. Companies with the flexibility to relocate or open new data centers are even choosing locations that are rich in renewable energy sources as part of their corporate environmental strategy.

Don't forget your building systems

While lighting in the data center may only account for 2 percent of the total energy used, it can often be a "low hanging fruit" type of line item. Implementing occupancy sensor lighting controls in the raised floor area, to turn off lights when not needed, is one item to consider.

Reducing power consumption with innovative technologies

With IT equipment becoming more energy efficient and greener all the time, replacing older IT equipment with newer models can reduce overall power and cooling requirements.

Applying innovative technologies within the data center can yield more computing power per kilowatt. IT equipment is becoming more energy efficient all the time. With technology evolution and innovation outpacing the life expectancy of data center equipment, many companies are finding that replacing older IT equipment with newer models can significantly reduce overall power and cooling requirements and free up valuable floor space. For example, IBM studies have demonstrated that blade servers save 35% on power, reducing power and cooling requirements over 1U technologies.[17] While it may seem financially unwise to replace equipment before it is fully depreciated, the advantages that new models can offer—lower energy consumption, plus two to three times more computing power than older models—combined with potential space, power and cooling recoveries are enough to offset any lost asset value.

Conventional servers use at least 60% of their peak power when idle.[18]

Virtualization

Virtualization can be a tremendous ally in reducing heat and expense—simply because it means that you'll need fewer servers. Servers use energy and give off heat whether they're in use 100 percent of the time or 15 percent of the time. Chase et al. found that conventional servers used at least 60% of their peak power when idle. In fact, all but one system used over 74% of their peak power at idle.[18] As cooling load delivery in a data center is fairly constant, there is currently a minimal difference between the energy required to operate and cool a server whether it is at full load or in idle. Thus, driving up server utilization delivers a significant increase in workload delivered with a minimal increase in energy consumed.

Virtualization is a technology designed to enable multiple application workloads—each having an independent computing environment and service level objectives—to run on a single machine. This eliminates the approach of dedicating a single workload to a single server—a practice that yields low utilization rates—and allows virtualized servers to function near maximum capacity. A virtualized environment also is typically more resilient than a dedicated server environment. Component failures can be automatically managed, and the workload restarted. What's more, resources in a virtualized environment can be managed from a single point of control, improving operations.

Just as server virtualization reduces the number of servers needed, storage virtualization reduces the number of spindles required.

The advantages of virtualization are not limited to servers. Storage virtualization can be used to combine storage capacity from multiple vendors into a single reservoir of capacity that can be managed from a central point. Just as server virtualization reduces the number of servers needed, storage virtualization reduces the number of spindles required, increasing the total amount of available disk space and optimizing utilization rates. Storage virtualization can also improve application availability by insulating host applications from changes to the physical storage infrastructure.

Application Infrastructure Virtualization (AIV) provides the ability to separate the underlying infrastructure from the applications that run on it. Workloads can then be dynamically placed and migrated across a pool of application server resources, allowing the infrastructure to dynamically adapt and respond to business needs and requests to be prioritized and intelligently routed to respond to the most critical applications and users.

AIV frees the enterprise from a tight coupling between an application and associated application servers. This loose coupling enables open standards-based software to intelligently manage and shift workloads according to agreed-upon business policy. For instance, high-priority applications can be allocated the majority of resources; lower priority applications are either designed to run later or moved to less capable resources. These operations are all seamless to the user.

Virtualization, especially when coupled with the green design of new server and storage hardware, offers an effective solution for keeping power and cooling costs in check. The most energy efficient equipment is equipment that's no longer in use—whether it's a server, a router or a storage device.

With virtualization, you can consolidate the workloads currently on a multitude of underutilized devices onto fewer, more efficient pieces of equipment—and begin to realize possible savings and efficiencies beyond what can be achieved through the design of even the greenest systems or buildings alone.

New power management technology makes it possible to meter actual power usage and cap the amount of power used by a single server or group of servers.

Power management in IT systems

Once you have established your baseline with an energy audit and understand how energy efficient your data center is today, you need to have an ongoing way to measure and manage your energy usage between the IT and facility equipment. Ideally, power usage in a data center should be proportional to the workload. One way to achieve this balance is to idle unneeded equipment. It's a technique that's effective but difficult to manage. New power management technology, however, gives data center managers full control over optimizing power consumption—thanks to workload management software and hardware capabilities. This technology makes it possible to meter actual power usage and produce trend data for any

Going green at IBM

Like many companies, IBM has found that supporting environment-friendly initiatives can be a smart business move. A significant area of focus is reducing a company's carbon footprint, or the amount of carbon dioxide (CO2) emissions a company is directly or indirectly responsible for producing. Power consumption is considered an indirect contributor to a company's carbon footprint because power companies produce CO2 emissions in the generation of electricity.

IBM has announced that we will double compute capacity by 2010 without increasing our power consumption or carbon footprint, saving 5 billion kilowatt hours per year—equivalent to energy consumed by Paris, "the City of Lights."[20]

single physical system or group of systems. The amount of power used by a single server or groups of servers can be capped—based on workloads and business trends—to optimize energy use and application performance without sacrificing productivity.

Eco-friendly disposal

IBM surveys find that fewer than 55% of clients have a plan for the responsible disposal of their assets. In fact, environmentally responsible disposal offerings are available to facilitate and accelerate the movement to greener equipment.[19] These services dispose of systems in an eco-friendly manner, redeploying systems with a useful life and typically ensuring compliance with regulations and removing data before disposal. Best of all, some programs will pay market value for the old equipment.

Do you have a game plan?

Most companies expect that their CIOs will supply a reliable, high-performance infrastructure to support the business within their allocated budgets. Are you prepared to continue meeting this expectation in the changing environment?

Do you know for sure that your data center can meet growing power and cooling demands? Yet, less than 80% of CIOs have direct accountability for the energy used in the data centers.[21] Do you have a plan to manage the impact of rising energy costs? Are you taking advantage of financial incentives or rebates? Are you prepared to contribute to corporate initiatives to reduce greenhouse gas emissions? Do you have a strategy for your data center to ensure that you can continue to meet your company's expectations? If your answer is not a resounding "yes" to meet of these questions, perhaps the time has come to evaluate your strategy.

The US Environmental Protection Agency has confirmed IBM estimates that it is possible to save between 25 to 55 percent of your annual data center energy bill by implementing simple to best practices for both your IT and physical infrastructure.[22]

Project Big Green

Project Big Green is a $1 billion investment to dramatically increase the efficiency of IBM products. New IBM products and services, announced as part of Project Big Green, include a five-step approach to energy efficiency in the data center that, if followed, can sharply reduce data center energy consumption and transform clients' technology infrastructure into "green" data centers.

CIOs' ongoing efforts to think green can help keep their companies operating in the black.

Conclusion

As governments and corporations intensify their focus on reducing energy demands and greenhouse gas emissions, pressure to improve data center energy efficiency will continue to grow. We believe that the following "four Rs" must play an essential role in the development of any initiative to create a green data center:

- Regain power and cooling capacity
- Recapture resiliency
- Reduce energy costs
- Recycle end-of-life equipment.

Successful CIOs will make these four Rs their mantra. And in doing so, their ongoing efforts to think green will help keep their companies operating in the black.

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For more information

To learn more about creating a green data center, please contact your IBM marketing representative or IBM Business Partner, or visit the following Web sites:

ibm.com/systems/greendatacenter

redbooks.ibm.com/redpieces/abstracts/redp4413.html

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