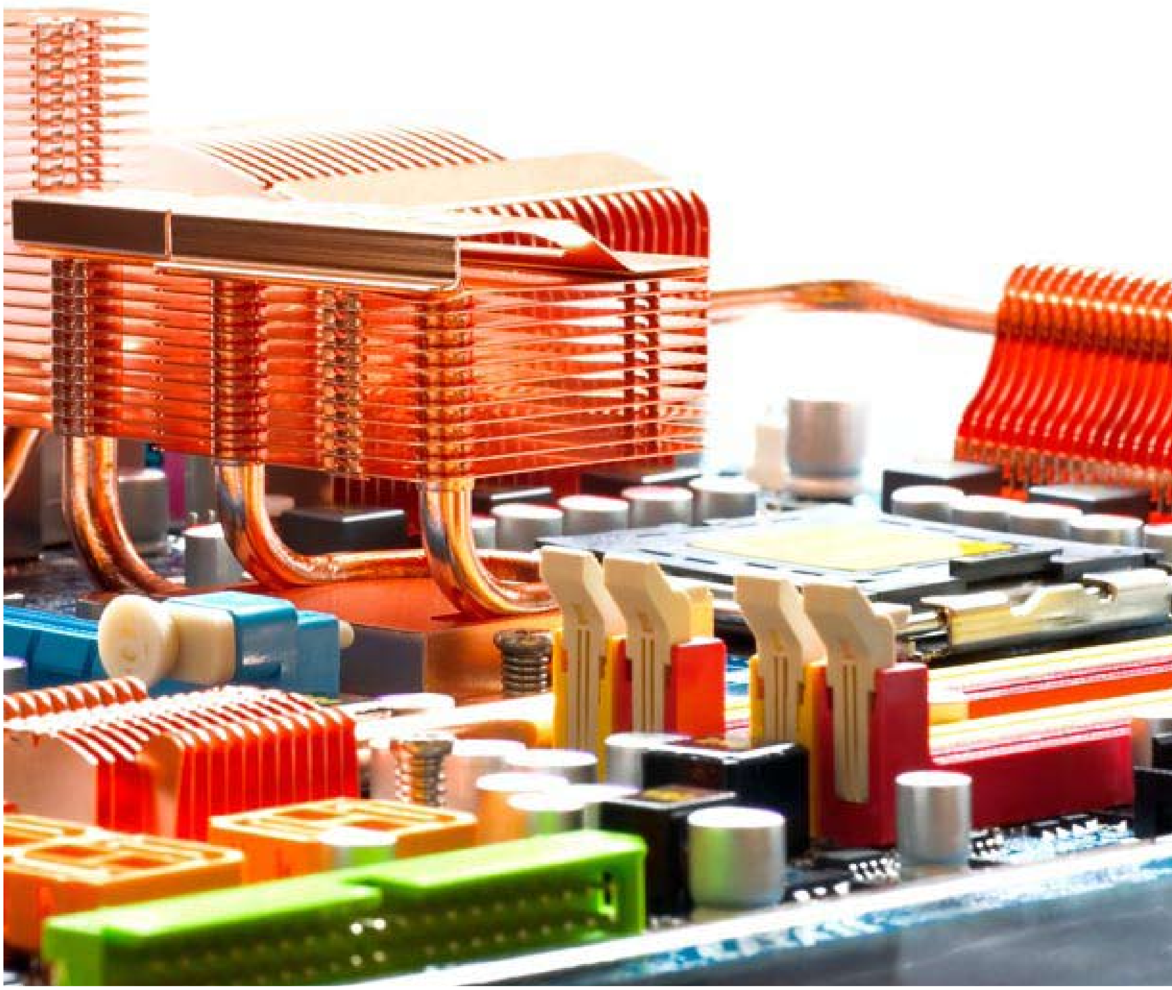
Optimize the cooling in your existing data center...



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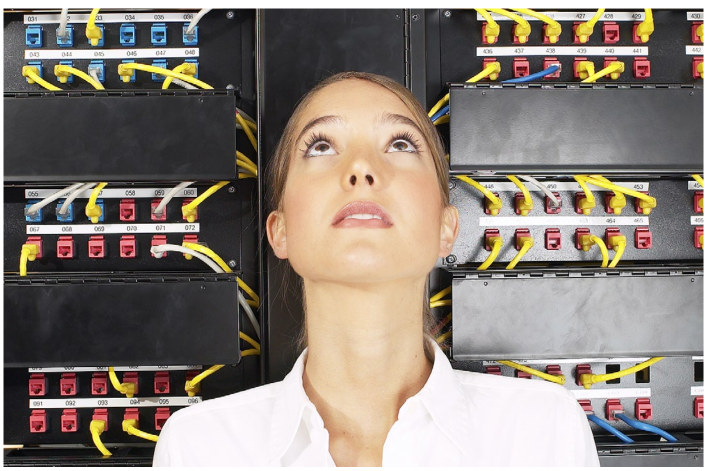
Optimize the Cooling in Your Existing Data Center

By George Spafford

The number of servers is causing power and cooling demands to rise in most data centers. This increasing need for cooling is not only negatively impacting operating expenses but also constraining growth because additional cooling needs can't be met with the existing infrastructure and requires either substantial capital investment in the existing facility or investment in a new data center. What some data centers may be overlooking are optimization methods that can increase the available cooling capacity substantially while also reducing costs.

This eBook will provide an overview of:

- The current pressures facing data centers relating to power and cooling
- The need to baseline current cooling utilization and costs
- Common improvement opportunities including both process and technical considerations



The Need for Improved Cooling

Computing, storage, and communication technologies all require electricity to operate. Two observed trends are increases in the density and performance of each. With these trends have come increased energy demands and expenses. This is especially evident in data centers where there are often hundreds, if not thousands, of devices running on a continual basis. In fact, data centers are consuming significant amounts of power. The Department of Energy conducted a study in 2006 and reported that data centers consumed 61 billion kilowatt hours of energy or 1.5 percent of energy used that year. The study then went on to project that demand could double by 2011, potentially requiring that 10 additional power generation facilities be built.[1]

Numbers such as these, coupled with anecdotal evidence, indicate that energy consumption within data centers, while significant today, will become increasingly problematic if left unmanaged. One of the chief concerns is that in tandem with the need for power comes the demand for cooling. The various systems in a data center generate heat as they operate and this heat must be removed or the data center will become too hot and the component failure rate will increase.

Exacerbating the power problem is that not only do the IT systems require power but the cooling systems themselves consume power. In general, one watt of power consumed in IT requires one watt of power required for cooling.

There are four challenges with this scenario. First, data centers are finding that either their site infrastructure cannot accommodate more power or their utility cannot provide more

> “… energy consumption within data centers, while significant today, will become increasingly problematic if left unmanaged.”

power. Second, data centers are finding that their facilities are not designed to handle additional cooling demands efficiently or effectively. Third, the capital and operating expenses associated with power and cooling are rising rapidly. Fourth, given the economy, both capital and operating expenses budgets are limited and, in many cases, shrinking. This means that budget growth in these areas will come at the expense of another area such as new service development. In short, the combination creates risks that need to be managed.

To address these challenges, two things must happen: energy consumption in IT systems must be managed, if not reduced. At the same time, cooling must become more effective and efficient. The purpose of this eBook will be to discuss means for existing data centers to address demands for additional cooling.

Baseline Current Environment

The first step is to understand the current state. There are two aspects to understand: demand and supply. It is important to understand cause-and-effect of the improvements performed and also to demonstrate to management and other stakeholders the results of improvement activities.

From the demand side, this means understanding the power going into the data center and how it's consumed with whatever level of granularity possible. Rack-level or ultimately component-level consumption data is the ideal, but initially understanding total use is a valid first step.

From the supply side, organizations are implementing increasingly sophisticated sensor grids to understand the temperature and humidity in the data center along with cooling-related power consumption, and other operational data points from the cooling systems themselves.

There is a growing body of studies and recommendations regarding how to deploy sensors to monitor environmental conditions and power. In general, the types of sensors, location, and density should be driven by costs and benefits. It is possible to collect data at the device level, in the aisles, air velocity in plenums, and so forth. Along with the sensors you need software tools that can help staff with the analysis of the data so they understand trends and generate various alert levels when defined conditions are met.

Improvement Opportunities

There are many ways to improve the cooling capacity of existing data centers. The following are common opportunities that might yield significant improvement in your environment:

Reduce Cooling Demand

The first step to improving available cooling capacity is to literally reduce the demand for cooling. It may seem simple, and some aspects of it are. The very first thing to do is talk to staff and discuss their ideas and observations on how to reduce the power being used by IT equipment.

An easy first step that has low costs and high potential benefits is to identify and remove ghosts. These are servers that are still running, consuming power and cooling but the service they were providing to the business is no longer needed and nobody told IT to decommission the systems. Ghosts can be identified with network monitoring and systems management tools, which can identify systems with little to no network traffic and/or CPU utilization.

Another approach is to consolidate applications and IT services into as few as possible. Large organizations that have grown organically, or had extensive mergers and acquisitions, are likely to find many needlessly redundant applications and services being provided to the business. For example, 10 accounting packages in use versus one. The duplicate systems should be identified and actions identified. Some duplicates will be very easy to consolidate, whereas others may take substantially more effort to gain approval.

Reducing the number of servers and volume of data storage through consolidation and virtualization is another method. The whole intent is to reduce the amount of power being consumed and thus heat being generated by IT equipment that must be cooled.

Whereas the above options all mention servers, it is important to note that of the power going into the data center, only approximately 30 percent is actually consumed by IT systems. The majority is consumed by environmental systems (45 percent) then power related infrastructure (24 percent), and then a small amount for lighting rounding out the list (1 percent).[2] Depending on how a data center is designed and the equipment used, these levels can vary significantly and understan ding the current state can help prioritize improvement approaches. One can imagine there will be data centers that find large savings outside of servers. For example, some organizations may find that they can recover a significant amount of cooling by moving all of the UPSs out of the climate-controlled data center.

A last approach to mention is to evaluate if some level of outsourcing to collocation and cloud computing vendors may help alleviate resource constraints and reduce costs. There is a lot to consider before pursuing this approach, including technical architecture, legacy system support, information security, and regulatory compliance to name a few. However, cloud computing is gaining a strong following and even business leaders are taking note – the savings are out there and the risks of using a cloud vendor may actually turn out to be quite low.

Increase Data Center Temperatures

Now we will shift our attention to the environmental systems. Some organizations may find that they can increase the temperatures in their data centers and immediately reduce cooling demands. The American Society of Heating, Refrigeration, and Air-conditioning Engineers (ASHRAE) has increased its recommended temperature to cooling and humidity requirements to 18 to 27°C (68 to 77°F) dry bulb temperature and 40 to 55 percent relative humidity.[3]

Despite ASHRAE's recommendations it is still important to review vendor recommendations and warranties. It may be that some systems require a lower temperature and running outside of the specification will invalidate warranties. Thus, some research is needed and risks considered before simply raising the temperature.

There is one critical misconception to clarify at this point – air temperature is measured on the cool air intake side, not on the exhaust side. It is the temperature of the incoming air that is expected to cool the systems that matters. Organizations that have thermostats located by exhausts where there is heated air are unnecessarily cooling the environment as a result.

Improve Computer Room Air Conditioning (CRAC) and Humidity Coordination

Another common error is failure to coordinate the activities of cooling systems and humidification systems. Traditional humidifiers pass warm air across water to cause evaporation and then fans move this relatively warm humid air into the data center to reduce the risk of static. The key here is that warm air is used and that warm air can cause the cooling system to attempt to cool it. This then reduces the humidity, causing a loop where both systems run unnecessarily. The air movement can be analyzed and management practices have evolved to limit this battle for supremacy between the two systems. Another approach is to replace the old heat-based humidifier with new technology, such as an ultrasonic system, that can introduce water particles into the air without heat.

Utilize Economizers

Economizers are one of the leading means to reduce cooling costs while increasing capacity. Essentially, the environment is leveraged to cool air before the chiller to reduce the amount of mechanical cooling required. In cold environments, there are organizations that rely on the economizer and use very little mechanical cooling. The approach has earned the title "free cooling."

"Economizers are one of the leading means to reduce cooling costs while increasing capacity."

There are two types of economizers – "air side" and "fluid side." The air side system uses external air when certain conditions are true. The relatively cool external air is passed through filters to remove particulates, humidified/dehumidified as required, and then introduced into the data center.

Fluid side systems have a liquid coolant that is cooled via the outside air, relatively cool ground, or external water source, etc. and then passed back to a heat exchanger that is used to cool data center air. This is method considered a "closed" system because external air and any potential contaminates it may contain aren't introduced.

Depending on the geographic location of a data center, economizers may yield benefits at night, seasonally, or nearly continuously. This is definitely a technology for constrained and cost-conscious data centers to investigate.

Optimize Air Flow

Data centers that rely on airflow for cooling need to carefully assess how air is moved and then take steps to optimize the flows of cold and hot air. There are many potential improvement opportunities to evaluate including:

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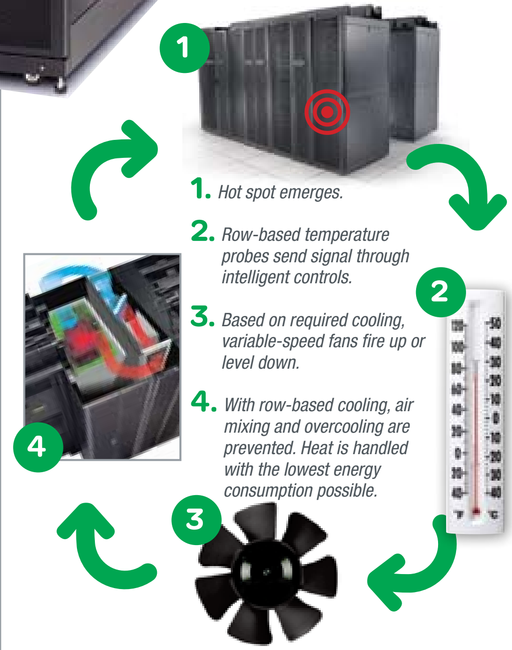

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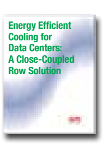

Download a FREE copy of APC White Paper #137: "Energy Efficient Cooling for Data Centers: A Close-Coupled Row Solution"

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- **The use of the "Hot Aisle/Cold Aisle" Layout:** this proven method arranges racks so that cool inlet air and warm exhaust air are segregated. Not only does this allow for the inlet air to be as cold as possible, but it also allows for the exhaust air to be as hot as possible. This latter part is important because the hotter the exhaust air is and the greater the difference between that temperature and the ambient temperature of the economizer, then the greater the benefits of economizers will be.

- **Installation of Partitions:** barriers are put in place to prevent the unmanaged comingling of warm and cool air. Approaches range from installing ceilings directly above the cold aisle to using various materials that are hung from the ceiling to segregate the hot and cold aisles, different temperate zones, and so forth.

- **Optimize Raised Floor Air Pressure and Flow:** one method of delivering cool air is to pressurize a raised floor space to deliver a determined amount of air volume through perforated floor tiles. To accomplish this, the raised floor needs to be of the correct height and supported by chillers and variable speed fans appropriately sized to deliver the specified volume of cool air.

- **Clean Under the Raised Floor:** debris, tangled cables, and so on can accumulate under a raised floor and hamper air flow. Routine inspection and cleaning are needed to ensure air flows as efficiently as possible.

- **Cable Management:** Network and power cables that are not properly managed can become a tangled barrier to air flow. Organizations should assess whether to locate the cables under the raised floor or overhead in trays. The ideal layout will minimize negative impacts on cooling.

- **Seal Openings in the Raised Floor:** any place where air leaks from the raised floor should be sealed. This includes cable openings, seams, and the perimeter of the floor. Air leakage can significantly impact the efficiency and effectiveness of the raised floor.

- **Perforated Floor Tiles:** must be in the correct locations – aligned with the air intakes, which are often at the front of racks. Furthermore, tiles that are no longer needed should be removed and replaced with solid tiles to conserve precious cold air. Personnel need to understand how the tiles are to be used and their movement/installation/removal should be governed by the enterprise IT change management process.

- **Overhead Diffusers:** air that is delivered via overhead plenums need diffusers that are designed to route the air straight down in front of the devices that need to be cooled (assuming the air inlets are in front). General-purpose four-way diffusers like those seen in general-use office areas should be avoided due to the relative lack of focused air delivery.

- **Nonstandard Intakes and Exhausts:** IT equipment with cold air intakes or exhaust ports that do not conform with the typical front-to-back airflow model should be assessed and corrective action taken. Either the equipment should be re placed with equipment that conforms to the standards of the data center or some form of ducting or baffles should be used to re-direct the intake and exhaust to meet standards.

- **Face Blanks:** when racks are not fully populated then the openings should be sealed with blanking plates to prevent uncontrolled airflow.

- **Flexible Ducting:** should be inspected and any kinks, obstructions, and/or sharp bends corrected. Junctions should be sealed appropriately. Any tears or cuts in the ducting should either be repaired or the ducting replaced.

- **Variable Speed Fans:** should be utilized to proportionately increase/decrease speed (and thus energy use) depending on demand.

- **Computational Fluid Dynamics (CFD):** can be used to model airflow in a data center and help identify potential problems and opportunities for improvement.

- **Routine Inspections:** the entire cooling system should be inspected on a scheduled basis. Various components could be examined on a rolling schedule, but it's important that there are formal inspections looking for various problems that require correction or opportunities to improve.

Utilize Liquid Cooling

As another example of the old becoming new, liquid cooling at the rack and device level is returning. The use of water to cool mainframes has been around since the dawn of electronic computing. With the introduction of distributed systems, the use of fluids declined but is now making a strong resurgence. The simple reason is that liquid cooling is far more efficient than air cooling – literally thousands of times more.[4]

Liquid systems can be installed in existing data centers to precisely address the cooling needs of the new high-performance high-thermal density blade systems. Liquid cooling technologies are evolving rapidly in response to needs and offer proven cost-effective solutions.

Improve Facility Insulation

One basic element is to ensure that the data center is properly insulated to minimize the influence of changes in environmental temperatures during the course of the day. External walls, ceilings, and so on all need to be appropriately designed to protect the data center's environment.

Understand the OpEx vs. CapEx Trade-Off

Some data centers are quite old and their cooling infrastructure dates back to the construction of the building. These older systems are built on older technologies, different design concepts, and so on. A broad general statement that can be made is that new systems are more efficient. Organizations that have a culture of "run it until it breaks" risk having higher operating expenses due to the age of the systems. Sometimes this is due to philosophies around the use of capital, and management needs to understand that there are situations where capital investment can result not only in additional cooling capacity, but also in lower energy consumption from the cooling systems. In short, opportunities may exist whereby investing capital operating expenses can be reduced, sometimes dramatically.

Move Towards Less Environmentally Sensitive IT Hardware

The long-term direction of the industry must be toward the development and use of systems that are more tolerant of higher-temperatures and variability in the overall environment. Continued pressure applied by customers (data centers) will compel vendors to continue to improve their systems to do this. Microsoft's Fourth Generation Data Center program is an example of a data center vision moving in this direction.[5]

Foster Teamwork: Data Center Facilities and IT Engineering Groups

In some organizations there is a barrier between the engineering group responsible for the data center facility and the IT engineering group responsible for IT servers, storage, networking, and so on. This schism needs to be closed and the groups must work together to better address demands for power and cooling. This may mean changes in reporting structure, compensation, and so on. The exact method will vary depending on the organization however the message must be very clear – these two groups must work together to improve capacity and lower costs.

Capacity Management and Green IT...

Organizations are very concerned about the environment for a variety of reasons these days. For IT, one of the challenges is that our services fundamentally need energy to operate. Literally, if we turn off the power then we shut down all the IT services. In the current socioeconomic situation of skyrocketing energy costs, concerns over global warming, and the need to manage risks, IT organizations would be very well served to take a closer look at the ITIL Capacity Management process as a means to better manage energy consumption.

The idea behind the Capacity Management process is to provide computing resources to the organization in a manner that makes the business sense. The premise is very straightforward: through advance planning and monitoring of the current state (in terms of the business, IT services and IT systems), proactive decisions can be made that lead to better procurement and/or development decisions. In turn, this reduces reactive decision-makin' that is inevitably rushed and results in suboptimal outcomes including the potential for higher costs and lower quality.

In terms of energy, it can be viewed the same as any other resource with limitations. There are limits to the power available from the utility today and limits as to what can actually get into the data center. There are also limits to growth as some groups are finding out. Their electric utilities are telling them that additional power is not available from the grid they are on.

continued

Understand the Importance of Processes

Formal processes that are designed and implemented correctly can help ensure that there is adequate cooling capacity available.

Three important processes to consider are:

- Capacity Management: the impacts of new IT services or changed IT services on power and cooling need to be understood before they go into production. Capacity Management is an ITIL process that can do just that.

- Change Management: All changes in production represent risk. Additional servers added to a data center, floor tiles that are moved, and cooling ducts that are rerouted could all impact the cooling of critical systems in done incorrectly. A Change Management process can help asses and properly manage risks.[6]

- IT Asset Management: This is a discipline that can help ensure standards are followed during procurement, that asset lifecycles are understood, that the trade-offs between operating and capital expenses are managed, and so on.

Pursue Continuous Improvement: Plan-Do-Check-Act (PDCA)

Like everything else, cooling will need to evolve over time to meet demands. Organizations must adopt a pragmatic stance of planning to meet demands. Depending on the level of work required, projects may be needed or perhaps task orders for simpler actions but they should always work through the Change Management process to better ensure that risks are properly mentioned.

The next part is to check the various processes and the state of cooling in the data center. It is critical that objective data be collected about the environment and the ability to understand the causal effects between changes in processes and/or technologies and the resulting impacts to the cooling capacity of the data center. This need cannot be stressed enough. In addition to monitoring, scheduled reviews must also take place to review the current state of processes and technologies to determine what opportunities for improvement may exist.

Given the results of the "check" phase are to actually take corrective actions and then the loop returns to planning to determine what to do next to best support the cooling needs of the data center and how it will support the overall business.

Where It Goes...

Another challenge to factor in is the IT equipment alone doesn't account for all the power a data center uses. In fact, it is common to see the IT equipment only account for 30 percent of the power consumed. The other 70 percent goes to cooling, power infrastructure, lighting, etc. So when power is being planned for, the overall needs of the system in which the IT equipment resides must be taken into account as well.

For each watt of IT equipment added in a data center, there also will be one incremental watt of cooling needed. There needs to be sufficient cooling capacity to keep IT equipment within defined temperature specifications to avoid heat related incidents. With today's dense, power intensive systems maintaining an acceptable temperature can be a challenge and presents another resource constraint to manage because cooling is itself limited and it also requires electricity.

There is another important reason to manage capacity as well. In general, as the level of utilization of electrical systems goes down, so do their efficiencies. Thus, a UPS running at 50 percent will be less efficient than a UPS running at 90 percent of stated capacity. This is also true for power supplies, cooling and other systems. Traditional approaches of "over sizing" various systems to "play it safe" can result in higher energy costs and need to be replaced with more deliberate management approaches.

continued

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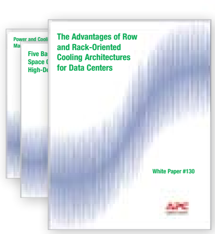

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Moving Ahead From Here

Hopefully this document has given you some ideas to investigate. Be sure to move ahead with careful planning. Understand the current state and have baseline data. Introduce changes and analyze the results – take the time to understand the causality of the actions undertaken. "Did my hoped for results materialize?" and if they didn't then understand why and change your approach. The idea should be to develop a roadmap for improving cooling capacity. Follow the roadmap and make adjustment as necessary such that risks are minimized and the value created maximized. ■

Additional Resources

The following are Web pages where additional information can be found:

- The News e-mail newsletter is published weekly by the author of this eBook and covers many aspects of IT management including Green IT by providing links to news stories and resources: www.spaffordconsulting.com/dailynews.html

- New resources are appearing all the time and a collection of Web sites of interest can be found at: www.spaffordconsulting.com/GreenITResources.html

- "The Governance of Green IT" is a book by George Spafford that covers governance and process issues around power and cooling in the data center: www.itgovernance.co.uk/products/2106

- Internet.com Webcasts on Green IT include:
  - Leveraging Software to Improve Energy Efficiency http://solutions.internet.com/5346_default
  - Governing IT in a Green World http://solutions.internet.com/5341_default
  - Implementing a Green Data Center http://solutions.internet.com/4991_default

Endnotes

1 Report to Congress on Server and Data Center Energy Efficiency. Public Law 109-431. U.S. Environmental Protection Agency ENERGY STAR Program. August 2, 2007. http://www.energystar.gov/ia/partners/prod_development/downloads/EPA_Datacenter_Report_Congress_Final1.pdf

In response to concerns over energy consumption, groups need to review and formalize their Capacity Management process. At a policy level there needs to be guidelines and standards set forth about the organization's direction for green IT, and expectations around energy consumption and then the process designed and implemented accordingly.

At a process level, there needs to be integration with project management, procurement and Change Management to ensure that current capacity is understood for electricity, cooling, and so forth and that the potential impacts of new or changed services are clearly understood both at the point of initial implementation and trended over time.

Part of this necessitates that Capacity Management have the appropriate tools to monitor and model the various resources that it is responsible for. This includes access to relevant electrical bills, tools for monitoring power consumption to the data center, or even the rack and device levels. It also includes understanding relationships between business activities, the supporting IT services, and the resulting power demands.

Monitoring current consumption levels and tracking trends are critical. Through analysis of the variance between planned and actual, organizations can understand how they are progressing and use this as a feedback loop for continuous improvement and future budgets.

Reporting needs to be developed that provides the necessary management information for command and control to the relevant stakeholders. There are various metrics being developed in the industry

continued

2 "Guidelines for Energy Efficient Data Centers."
The Green Grid. 2007. http://www.thegreengrid.org/

3 ASHRAE, "2008 ASHRAE Environmental Guidelines for Datacom Equipment," (ASHRAE, 2008), available after registration at www.ashrae.org/publications/page/1900

4 Don Reisinger. "Keep Cool with Liquid Cooling". Processor.com. August 1, 2008. http://www.processor.com/editorial/article.asp?article=articlespercent2Fp3031percent2F22p31percent2F22p31percent2F22p31.asp

5 Mike Manos "Our Vision for Generation 4 Modular Data Centers – One way of Getting it just right…," LooseBolts, Blog Posted 2 December 2008. http://loosebolts.wordpress.com/2008/12/02/our-vision-for-generation-4-modular-data-centers-one-way-of-getting-it-just-right

6 The IT Infrastructure Library (ITIL) provides very good guidance on how to design many processes. It is still up to an organization to look at these reference processes and decide how best to implement a process given the current culture, state of process maturity, available time, supporting technology and so on.

George Spafford is a Principal Consultant with Pepperweed and an experienced practitioner in business and IT operations. He is a prolific author and speaker, and has consulted and conducted training on regulatory compliance, IT Governance, and process improvement in the U.S., Australia, New Zealand and China. Publications include: "The Governance of Green IT", "Greening the Data Center" and co-authorship of "The Visible Ops Handbook" and "Visible Ops Security".

George holds an MBA from Notre Dame, a BA in Materials and Logistics Management from Michigan State University and an honorary degree from Konan Daigaku in Japan. He is an ITIL Service Manager, TOCICO Jonah and a Certified Information Systems Auditor (CISA). George is a current member of the IIA, ISACA, ITPI, ITSMF, and the TOCICO.

to assist with the tracking of energy consumption. GreenGrid.org has identified Power Usage Effectiveness (PUE), Data Center Effective (DCE), and short-term metrics to track and then longer term the Data Center Performance Efficiency (DCPE) metric. Stakeholders must be consulted to understand what they need to know and how it should be presented to make effective decisions.

In closing, energy costs are going up and management attention is focusing on how to not only manage these costs but also minimize impacts to the environment. Through effective and efficient Capacity Management, organizations can achieve both in a sustainable manner. ■