WORKING TOWARD A MORE ENERGY-EFFICIENT DATA CENTER

EXECUTIVE SUMMARY

- Companies are faced with skyrocketing electricity costs, which are bringing data center energy usage into focus
- Newer equipment is consuming even more power and is raising the power density per rack to unprecedented levels
- Companies can take a number of steps to reduce power consumption
- What's needed are complete solutions that efficiently and cost-effectively address data center power and cooling

In today's 24x7 world of information availability, on-demand services, and round-the-clock commerce sites, companies increasingly are adding high-performance servers, storage and other equipment to their data centers to satisfy user and customer demand. As a result, companies find they need more and more power to run and cool this equipment. At the same time, the cost of electricity is on the rise. And many companies are trying to be good corporate citizens by becoming green (or at least greener).

The combination of these factors is forcing many IT departments to evaluate their data center power consumption and find ways to become more energy-efficient.

DATA CENTER CHANGES WARRANT ATTENTION

Several trends are driving up data center power requirements significantly. First, most companies need more computing power to run their Web sites and business and financial applications, for which servers often must run round-the-clock. Second, newer computers use higher performing processors that consume more electricity. And third, there is a trend to physically consolidate servers by moving to high-density rack and blade servers, thus packing more processing power into smaller spaces within data centers.

The result is that the power usage in corporate data centers is shooting through the roof. In fact, data centers typically required, on average, 1 kilowatt (kW) per rack in 2000. However, in 2006, the average per rack was up to 6.8 kW, according to IDC. The amount of electricity needed to cool the equipment in these racks has risen in a similar fashion.

Most companies are finding that their data center electricity costs are skyrocketing. A November 2005 Wall Street Journal article about the growing power requirements of data centers noted that some medium-size companies had experienced a seven-fold increase in power requirements from 1998 to 2005. And over that time, the electrical costs to run those data centers had grown from $10,000 per month to $40,000 per month. The annual electricity costs for many larger data centers were in the high–six- to seven-figure ranges. The amount of electricity needed today is even higher.

A July 2006 CIO Insight magazine article put these rising costs into perspective. In the article, Robert Frances Group senior research analyst Adam Braunstein noted that up to 40 percent of the operating costs of a building that houses a data center could be power- and cooling-related expenses.

And if nothing changes, power and cooling issues (and costs) are likely to only get worse in the future. That's because the price of electricity is expected to rise, and many newer systems are expected to require more power.

BEST PRACTICES TO REDUCE POWER DEMANDS

Faced with growing power consumption requirements to run and cool data center equipment, companies are looking for ways to reduce electrical usage and costs.

To figure out where to focus attention on energy, one must understand what contributes to power consumption. The global consulting firm EYP Mission Critical Facilities estimates that 50 percent of data center energy is consumed by IT equipment, and another 35 to 40 percent is for cooling.

Given that IT equipment is the biggest energy consumer, it makes sense to look at equipment itself to reduce power usage. But that has not been the case. Most companies do not even know how much power their equipment is drawing. For example, a 2006 CIO Insight magazine survey of 195 companies found that only 28 percent measure the energy consumption of their servers at least once per year.

Companies now need to start looking for ways to be smarter about energy use. For instance, one of the least efficient pieces of equipment in a data center is the server power supply. A paper presented at the IEEE's 2005 Applied Power Electronics Conference noted that about a quarter of the energy used to power 1U and 2U servers could be saved by improving server power supply efficiency from the average of 66% to more than 80%. Since then, server power supplies have been introduced that are more than 90% efficient.

CONSOLIDATION

Another approach to reducing data center power consumption would be to simply use fewer servers. And in fact, that is exactly what many companies are doing today by virtue of server consolidation and virtualization projects.

In 2005, 60 percent of companies had a server consolidation project underway, while another 28 percent were looking into consolidation, according to Gartner.

Virtualization software extends the benefits of physical consolidation even further. With this approach, applications run on virtual machines – several virtual servers on one physical box – which consume computing resources based on an application's needs. This allows for even more efficient use of a server's capabilities.

Consolidation and virtualization can produce significant results. In some cases, companies have been able to realize a 10-to-1 reduction in the number of servers they required. (Similar benefits can often be realized with storage consolidation.) This would obviously cut power consumption.

PROPER SEALING OF THE DATA CENTER ENVIRONMENT

While IT equipment is the ideal place to start to make the largest impact on reducing energy usage, there are significant opportunities to be realized through optimizing data center cooling.

First, IT managers should ensure the data center is properly sealed with a vapor barrier that isolates the controlled environment from the building environment. Vapor seals can be created using plastic film, vapor-retardant paint, vinyl wall coverings and vinyl floor systems. This may be one of the least expensive, but most important and often overlooked, factors to controlling relative humidity levels in a data center. Broken or improper seals can allow humidity from the outside to get in, making it more difficult to cool a data center. Additionally, bad seals can result in cooling loss through floors, walls and ceilings, thus reducing cooling efficiency.

AIR FLOW IMPROVEMENTS

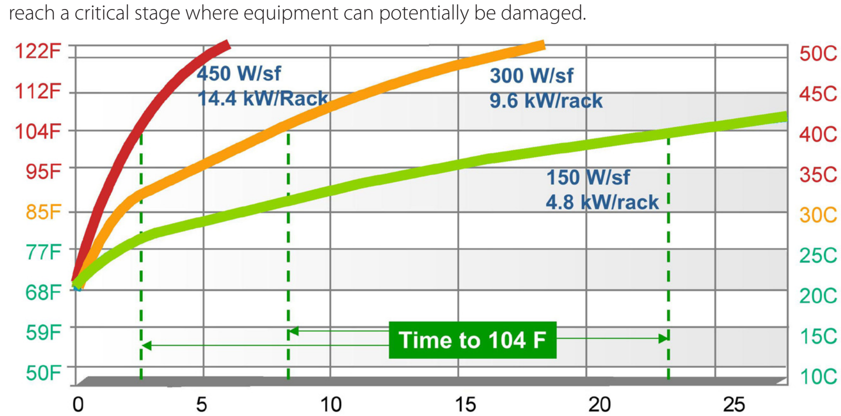
Another area to focus on is optimizing air flow within the data center. In the past, data center racks were typically arranged to all face the same direction. But because most equipment manufactured today is designed to draw air through the front and exhaust it from the rear, there is a more efficient way to set up racks: the hot-aisle/cold-aisle arrangement.

As recommended by ASHRAE TC 9.9 (American Society of Refrigerating and Air Conditioning Engineers Technical Committee 9.9) in its Special Publication "Thermal Guidelines for Data Processing Environments," this approach arranges racks front-to-front so the cooling air rising into the cold aisle is pulled through the front of the racks on both sides of the aisle and exhausted at the back of the racks into the hot aisle. Only cold aisles have perforated tiles, and floor-mounted cooling is placed at the end of the hot aisles – not parallel to the row of racks. Parallel placement can cause air from the hot aisle to be drawn across the top of the racks and to mix with the cold air, causing insufficient cooling to equipment at the top of racks and reducing overall energy efficiency.

Air flow management of another sort should also be taken into account. Specifically, the high number of servers in many data center racks often means there are many power and Ethernet cables running throughout any single rack or under the floor of a raised-floor data center. In some cases, the cables obstruct air flow and do not allow the heat to be removed or the cool air to circulate. IT managers thus should check to be sure the cables are not obstructing air flow.

SHRINKING TIME FRAMES FOR SAFETY

As the power density per rack increases, it takes less time when power is out for temperatures to reach a critical stage where equipment can potentially be damaged.



Additionally, in many high-density situations, it often makes sense to basically bring the power closer to the equipment. For instance, this can be done by using high-voltage power strips or power distribution units within each rack. This would reduce the number of power cables and thus improve air flow.

ECONOMIZERS

In many parts of the country, winter provides an opportunity to augment traditional data center cooling. In particular, outside air can be used to help cool data centers.

Accomplishing this requires the use of what are called economizer systems, which come in two types.

First, there are air-side economizers that allow outside air to enter a data center to aid in cooling. The second type of economizer is a fluid-side economizer. These systems are commonly incorporated into a chilled-water or glycol-based cooling system.

A Battelle Laboratories study on building control systems found that, on average, the normalized heating and cooling Energy Use Intensity of buildings with economizers was 13 percent lower than those without economizers.

COOLING SYSTEM OPTIMIZATION

Precision air conditioning units are a staple in the data center, and three factors are critical to optimizing their efficiency. These factors are:

- How efficient the units operate at partial load.
- How efficient the units are at removing sensible heat as compared to latent heat.
- How well multiple units work together.

INCREASING EFFICIENCY AT PART LOAD

Data centers are designed with some level of cooling system redundancy. Plus, the actual capacity of a precision air conditioning unit increases as the outdoor temperature decreases below the peak design condition (typically 95 F). This means equipment is operating at less than 100 percent load all of the time, creating the opportunity to design systems to operate more efficiently during normal operating conditions. Because operating conditions aren't stable, this requires some method of varying capacity based on operating conditions.

There are several approaches to providing variable capacity. The two most common are four-step compressor unloading, and Digital Scroll™ compressor technology.

The concept of four-step compressor unloading works by shutting off the flow of refrigerant to some of the cylinders within the system; thereby, minimizing the need to cycle compressors on and off to control capacity. Because unloading essentially changes the compressor operating point, it enables the cooling system to operate more efficiently at lower capacities. For example, a system operating with two compressors "unloaded" will consume approximately 50 percent of the energy of a fully loaded system but will deliver 76 percent capacity because the condenser and evaporator are sized for full load.

Digital Scroll compressor technology precisely matches capacity and power consumption to the desired load and can deliver significantly lower energy consumption compared to standard "fixed-capacity" compressors.

IMPROVING SENSIBLE HEAT/LATENT HEAT REMOVAL CAPACITY

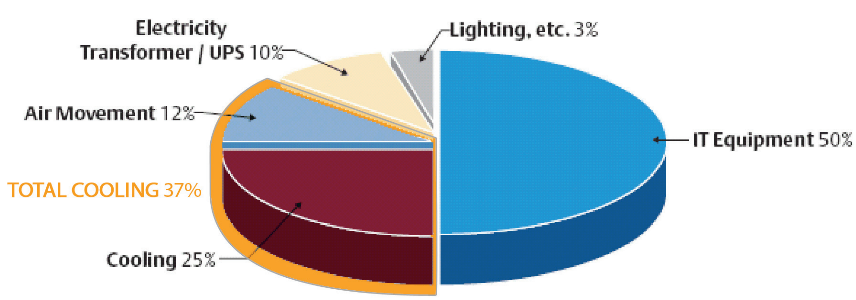
IT equipment generates sensible (dry) heat. Latent heat comes from people and outdoor humidity infiltration (that can be minimized through the vapor seal discussed previously). As server density or capacity increases, it creates a corresponding increase in the sensible heat load. The latent heat load is unaffected. Thus, using cooling solutions that can operate at a 100 percent sensible capacity, except when dehumidification is required, will result in reduced energy consumption.

IMPROVING COORDINATION ACROSS MULTIPLE UNITS

The data center environment has become more diverse as newer high-density servers are deployed alongside older systems. Without proper coordination between room cooling units, air conditioners may be operating in different modes of temperature and humidity control. For example, a unit on the

SOURCES OF DATA CENTER POWER CONSUMPTION

Source: EYP Mission Critical Facilities



north side of the room may be sensing low relative humidity conditions and adding humidity, while a unit on the south side of the room is sensing high relative humidity and removing moisture from the air. The actual moisture in the air is equal, but because the measurement is a relative measurement, the higher the temperature, the lower the relative humidity. Advanced control systems can be deployed across all the precision air conditioning units in a room to enable the units to communicate and coordinate their operation, enabling a coordinated teamwork mode.

SUPPLEMENTAL COOLING

While raised-floor cooling has proven itself an effective approach to data center environmental management, as rack densities exceed 5 kW, and load diversity across the room increases, supplemental cooling should be evaluated for its impact on cooling system performance and efficiency.

At higher densities, equipment in the bottom of the rack may consume so much cold air that remaining quantities of cold air are insufficient to cool equipment at the top of the rack. The height of the raised floor creates a physical limitation on the volume of air that can be distributed into the room, so adding additional room air conditioners may not solve the problem.

Rising rack densities and high room diversity can be solved by pumped refrigerant cooling infrastructure that supports cooling modules placed directly above or alongside high-density racks to supplement the air coming up through the floor. For example, when Pomona Valley Medical Center implemented an integrated workflow management system, the additional equipment needed drove data center temperatures well above safe limits. Twenty Liebert XDV supplemental overhead cooling units were installed above the racks to safely bring down the heat – without using valuable floor space.

Supplemental cooling solutions, like this one, have a number of advantages, including increased cooling system scalability, greater flexibility and improved energy efficiency. Two factors contribute to improved energy efficiency: the location of the cooling modules and the fluid used to transport the heat. A two-phase refrigerant (R134a) is the most preferred.

Higher density applications require fluid-based cooling to effectively remove the high concentrations of heat being generated. From an efficiency perspective, refrigerant performs better than water for high-density cooling. The R134 refrigerant used in the Liebert XD system is pumped as a liquid but converts to gas when it reaches the air. This phase change contributes to greater system efficiency. R134 is approximately 700 percent more effective in moving heat than water, which coincidentally, is 700 percent more effective than air. It also ensures that expensive IT equipment is not damaged in the event of a refrigerant leak.

In the Liebert XD system, refrigerant is delivered to cooling modules mounted as close as possible to the source of heat. This reduces the energy required to move air, creating additional energy savings. Together, the efficiency of the refrigerant and the location of the cooling modules can reduce cooling system energy costs by over 30 percent compared to relying only on raised floor cooling. Additionally, refrigerant use reduces chiller capacity requirements by 20 percent. This increases energy savings and also enables additional cooling capacity without adding additional chillers.

Traditional floor-mounted cooling systems with under-floor air delivery will continue to play an essential role in data center environmental management. It is recommended that traditional systems be configured to deliver the required cooling for the first 50-100 Watts per square foot of heat load as well as solve the room's full humidification and filtration requirements. Supplemental cooling can be deployed for greater densities.

ABOUT EMERSON NETWORK POWER

Emerson Network Power, a business of Emerson (NYSE:EMR), is the global leader in enabling Business-Critical Continuity™. The company is the trusted source for adaptive and ultra-reliable solutions that enable and protect its customers' business-critical technology infrastructures. Backed by the largest global services organization in the industry, Emerson Network Power offers a full range of innovative power, precision cooling and connectivity products and services for computer, communications, healthcare and industrial systems. Key product brands within the Emerson Network Power family include Liebert, ASCO, Astec, and Lorain. The Liebert Adaptive Architecture creates power, cooling and monitoring platforms for IT systems that combine high reliability and flexibility while delivering the lowest total cost of ownership. ■