Increased power and cooling requirements are creating intensified demand for data-center redesigns

By Ron Anderson
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Reader Note: On June 21st, Network Computing and InformationWeek merged. At that time, Network Computing Analytics became InformationWeek Analytics. As a result, throughout this report, you may find references to surveys and other stories done by Network Computing. While our team now exclusively uses InformationWeek to refer to itself and its work, the techniques and thoroughness that were hallmarks of Network Computing have been retained in InformationWeek Analytics.
Ron Anderson

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EXECUTIVE SUMMARY

It wasn’t all that long ago that raised-floor data centers with chilled water cooling and airflow systems that would be at home in wind tunnels seemed like overkill. Not so today: Rapid increases in server and storage-system densities are straining existing data-center power and cooling capabilities, yet our hunger for processing power and storage shows no signs of abating.

Although application specialists and IT architects have been packing data centers with blade systems, massive storage systems, and 1U and 2U servers, it’s only been by the grace of mainframe forebears that most facilities still function adequately. But don’t count on data center designs of the previous century to do the job much longer. A redesign may be in order.
IWK ANALYTICS

RESEARCH SYNOPSIS

SURVEY NAME: Network Computing Enterprise Data Center Survey
SURVEY DATE: March 2006
REGION: North America
NUMBER OF RESPONDENTS: 228
PURPOSE: To identify and quantify data center trends among Network Computing readers

METHODOLOGY: Network Computing surveyed 228 technology decision-makers at North American companies. Out of all respondents, 22.3 percent came from companies with revenue of $500 million or more, 10.5 percent came from companies with revenue of $100 million to $499 million, 19.5 percent came from companies with revenue of $10 million to $99.9 million, 13.2 percent came from companies with revenue of $1 million to $9.9 million, and 15 percent came from companies with revenue of less than $1 million. Government and non-profit organizations represent 19.5 percent of the respondents. Corporate officers and management made up 29.3 percent of respondents, 51.6 percent were IT staff, and the remaining 19.1 percent were non-IT executives (owners, consultants or engineers). The survey was conducted by an e-mail blast to qualified Network Computing readers involved in infrastructure, storage and servers, security, wireless, application convergence, network and systems management, and collaboration. There were no incentives offered to motivate respondents.

SURVEY NAME: Network Computing This Old Data Center Survey
SURVEY DATE: March 2005
REGION: North America
NUMBER OF RESPONDENTS: 304
PURPOSE: To gauge the attitudes of Network Computing readers regarding data center technologies

METHODOLOGY: Network Computing surveyed 304 technology decision-makers at North American enterprises. Out of all respondents, 23.4 percent came from companies with revenue of $500 million or more, 10.9 percent came from companies with revenue of $100 million to $499 million, 21.1 percent came from companies with revenue of $10 million to $99.9 million, 18.1 percent came from companies with revenue of $1 million to $9.9 million, and 12.5 percent came from companies with revenue of less than $1 million in sales revenues. Government and non-profit organizations represent 14 percent of the respondents. Fifty-seven percent of respondents were corporate officers and management, 38.2 percent were IT staff, and the remaining 4.8 percent were non-IT executives (owners, consultants, engineers or researchers). The survey was conducted by an e-mail blast to qualified Network Computing readers involved in infrastructure, storage and servers, security, wireless, application convergence, network and systems management, and collaboration.
POWER AND COOLING LANDSCAPE

Data center power usage will be the No. 1 infrastructure issue facing IT executives over the next three years, according to a 2006 report from the Robert Frances Group. Five years ago, the average power requirement per rack was 1 kilowatt to 3 kW. With requirements for processor cycles, memory and storage continuing to increase, as does the density of the equipment we pack into each rack, it’s now common for a typical rack to consume 5 kW to 7 kW, with high-density blade server implementations hogging 24 kW to 30 kW per rack. Couple this dramatic increase in power consumption with the rising price of electricity and data centers’ inability to deliver this much power or cool the equipment using the power, and it’s easy to see why data center power usage is so important.

During the first quarter of 2006, we surveyed 228 NETWORK COMPUTING readers with infrastructure responsibilities and asked how likely it is that they will enhance their data center cooling and power capacity during the next year. Thirty-six percent of all respondents said capacity increases will happen or are likely to happen, while another 25 percent said that a decision has yet to be made (see Figure 1, below). When we filtered out responses from those with fewer than 50 servers in their data centers, the number indicating the need for enhancing power and cooling capacity increased to 49 percent (see Figure 2, below).

![Figure 1 Overall Expectations](image1)

**Figure 1 Overall Expectations**

Over the next 12 months, how likely is it that you will enhance cooling and power capacity in your data center?

- It will happen 19.5%
- Likely to happen 16.8%
- The jury’s still out 25.2%
- Probably not needed 25.2%
- There’s definitely no need 13.3%

Source: NWC 2006 Enterprise Data Center Survey

![Figure 2 Expectations at 50+ Server Sites](image2)

**Figure 2 Expectations at 50+ Server Sites**

For sites with more than 50 servers, how likely is it that you will enhance cooling and power capacity in your data center in the next 12 months?

- It will happen 25.6%
- Likely to happen 23.3%
- The jury’s still out 24.4%
- Probably not needed 20.0%
- There’s definitely no need 6.7%

Source: NWC 2006 Enterprise Data Center Survey
For many enterprises, existing data centers aren’t full, and in a gross sense, existing cooling and electrical systems are often sufficient for the current load because equipment density hasn’t yet reached critical mass. Fifty-five percent of our survey respondents indicated that they have room to grow in their existing facility (see Figure 3, below).

The immediate problem is that today’s high-density systems can require much more localized power and cooling than is typically available. Even if a data center has space in which to add more hardware, higher-density hardware will increase cooling requirements at a greater ratio than lower-density hardware.

In our 2005 “This Old Data Center” poll (nwc.com/showitem.jhtml?docid=1610fl) of NETWORK COMPUTING readers, nearly half (47 percent) of the respondents said they recently upgraded their data centers, and 29 percent said they planned to do an upgrade within 24 months (see Figure 4, below).

Many enterprises also are building new data centers. Large companies, for example, are moving away from the monolithic, single-site computer facility and building smaller, geographically dispersed data centers that can work together. The number of enterprises with a single-site data center dropped from 51 percent in 1999 to about one third (33 percent) in 2004, according to a study.
by International Network Services. The trend toward multiple-location, centrally integrated data centers increased by about 9 percent during that timeframe, the research company said.

In our 2005 survey, 67 percent of respondents said they expect processor counts in their data centers to grow by at least 11 percent over the next five years. Approximately 18 percent said they expect processor growth to be between 26 percent and 50 percent, and 10 percent said they plan to increase processor count by a whopping 51 percent, to 100 percent, by 2010 (see Figure 5, below).

In a separate question in the 2005 survey, nearly half (48 percent) said “server consolidation” is one of the chief drivers behind data center renovation (see Figure 6, page 9).

Storage, too, is a major driver behind the renovation trend. In our survey, some 58 percent of respondents cited “storage management” as a primary reason for doing a data center upgrade. Many enterprises are rethinking their storage strategies as a result of the rapid evolution of SAN and iSCSI technology as well as regulations such as the Sarbanes-Oxley Act, which requires thorough maintenance of business records. In many cases, these new technologies and strategies require additional space in a clean, cool environment—and that means expanding (or at least rearranging) the data center.

On the business side, many enterprises look to data center renovation as a way to control costs, as well as making more efficient use of technology. In our survey, more than 38 percent of respondents cited “cost cutting” as a reason for upgrading. In addition to making more efficient use of server and storage resources, enterprises are looking for ways to consolidate staff, as well as office space and utility costs.

The conclusion is self-evident. High-density deployments will require a substantial investment in new power and cooling systems, and that means AC, electrical wiring, UPSs and generators. To that end, the Meta Group recommends that new data centers be designed to support 500W per square foot. But rare is the data center that meets this criterion, and even if it did, and even considering aisle clearances, that’s less than half the power a full rack of blade servers would require.

![Figure 5 Five-Year Growth Projections](image)

Based on processor count, what is the expected growth of your data center over the next five years?

- 0% 3.3%
- 1% to 10% 29.4%
- 11% to 25% 39.3%
- 26% to 50% 17.8%
- 51% to 100% 10.2%

Source: NWC 2005 This Old Data Center Survey
The most cost-effective way to future proof investments will be to use modular and flexible power and cooling equipment as existing data centers are upgraded or built (we’ll discuss future-proofing again further down in this report). However, that may not always be a realistic approach given corporate dynamics. There’s a lot of discussion among cooling and power system vendors and data center designers about just how to deploy power backup and cooling systems. No one doubts that oversizing UPSs, generators and cooling systems wastes money in terms of energy, battery life and initial capital outlay. Yet the realities of project planning may simply require that new data centers be initially equipped with as much power and cooling as they’re ever likely to need. It’s just the nature of corporate politics that physical infrastructure is most easily budgeted when the building or remodeling actually occurs.

While a more modular design will allow for growth in reasonable increments, corporate overseers must understand and agree that their investment in a data center isn’t a one-time capital expense. They need to recognize that incremental designs will lead to lower operating expenses initially, and that expansion will require new capital. If management doesn’t think this way, then go for the whole data center enchilada at once but remember that you can’t afford to ignore efficiency since it’s unlikely energy costs are going to decrease over the next 10 years.

**Figure 6 Growth Factors**

What factors are driving your organization’s plans to upgrade your data center?

- Storage management
- Server consolidation
- Increase in customers
- Integration
- Cost cutting
- VoIP services
- Wireless services
- Grid computing
- Utility computing
- Video surveillance
- Other
- No plans to upgrade

Source: NWC 2005 This Old Data Center Survey
THE DATA CENTER’S CHANGING FACE

Clearly, there are many reasons to consider a data center makeover. But in many cases, the “new look” is vastly different from the sprawling, glass-house environment of yesterday’s mainframe computer rooms. The layout and composition of today’s data center is shifting, and many IT planners are struggling to keep up.

For one thing, enterprises have a lot more choice when it comes to site selection. In the past, many companies segregated the data center from the rest of the business, housing it in special facilities—and sometimes a dedicated building—to ensure security, power redundancy, fire suppression and a host of other resources. Although this approach is optimum, it’s too expensive for many companies, and many enterprises are locating their data centers in standard office buildings, even multitenant buildings. In our survey, 61 percent of respondents cited “cost” as one of the most important factors in selecting a site for a data center (see Figure 7, below).

Some companies even choose to house their data center equipment far from headquarters and operate it remotely.

Just as data center locations are changing, so is the size of the typical data center owner. A decade ago, only the largest companies built separate data centers, primarily because of the special needs of the mainframes they housed. Thanks to e-business, however, many small companies want high-availability setups to support 24/7 global businesses, just as larger companies do. As a result, it’s not unusual to see smaller data centers—between 250 and 5,000 square feet—being built all over.

Figure 7 Basis for Location

Which of the following do you consider most important when selecting the location(s) of your data center(s)?
(Select only four.)

<table>
<thead>
<tr>
<th>Basis for Location</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost</td>
<td>64</td>
</tr>
<tr>
<td>Proximity to the central office</td>
<td>56</td>
</tr>
<tr>
<td>Risk (natural or manmade disaster)</td>
<td>48</td>
</tr>
<tr>
<td>Technically skilled labor force</td>
<td>40</td>
</tr>
<tr>
<td>Power availability</td>
<td>32</td>
</tr>
<tr>
<td>Space availability</td>
<td>32</td>
</tr>
<tr>
<td>WAN availability</td>
<td>24</td>
</tr>
<tr>
<td>Proximity to major customers</td>
<td>16</td>
</tr>
<tr>
<td>Vendor support and presence</td>
<td>16</td>
</tr>
</tbody>
</table>

Multiple responses allowed

Source: NWC 2005 This Old Data Center Survey
the world. In fact, more than 80 percent of the respondents to our 2005 survey said they are supporting data centers of 5,500 square feet or less (see Figure 8, below).

Larger companies, too, are building smaller, regional data centers that can be networked and managed centrally. Of those surveyed that operate a data center, 42 percent said they operate multiple data centers.

**Build a Solution That Fits Your Business**

All data centers are not and should not be created equal. Data center design is a function of your business’s tolerance for infrastructure-related downtime and your ability to foot the bill for your desired level of uptime. The Uptime Institute (www.uptimeinstitute.org) has developed a widely recognized tier classification system for describing data center design topology and operational sustainability. Each of the four tiers represents successive levels of uptime, from Tier I’s 99.67% availability to Tier IV’s 99.99 percent availability. It should be no surprise that the cost of building a data center increases significantly as availability grows, since fault-tolerant design and redundancy add substantial costs.

The Uptime Institute calculates the basic cost of building a raised-floor facility at $220 per square foot in 2005 dollars. This figure would likely escalate slightly from Tier I to Tier IV because the increased power densities typical in the higher tiers would force the raised-floor height higher to provide increased air flow for additional cooling capacity, 12 inches for Tier I up to 36 inches for Tier IV. The real differentiator is the cost for the power and cooling equipment necessary to meet the availability specifications relevant to each tier. These costs range from $10,000 per kW of usable UPS output for a Tier I installation up to $22,000 per kW at Tier IV. The following table summarizes the relative costs of a 15,000-square-foot data center in 2005 dollars based on the Uptime Institute’s cost estimates and using Meta Group’s recommendation of 500W of available power per square foot (see Figure 9, page 12).

As a one-time consideration, it’s also interesting to note that the typical time to implement a Tier I installation is three months versus 15 to 20 months for a Tier III or IV installation.

**Figure 8 Data Center Size**

<table>
<thead>
<tr>
<th>What is your data center’s square footage?</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 250 sq. ft.</td>
</tr>
<tr>
<td>251 to 1,500 sq. ft.</td>
</tr>
<tr>
<td>1,501 to 5,500 sq. ft.</td>
</tr>
<tr>
<td>5,501 to 10,000 sq. ft.</td>
</tr>
<tr>
<td>More than 10,000 sq. ft.</td>
</tr>
</tbody>
</table>

Source: NWC 2005 This Old Data Center Survey
### Figure 9 Building Costs

<table>
<thead>
<tr>
<th>Tier</th>
<th>15,000 sq. ft. raised-floor data center</th>
<th>500W / sq. ft. usable UPS output*</th>
<th>Total cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tier I</td>
<td>$3.3 million</td>
<td>$75 million</td>
<td>$78.3 million</td>
</tr>
<tr>
<td>Tier II</td>
<td>$3.3 million</td>
<td>$82.5 million</td>
<td>$85.8 million</td>
</tr>
<tr>
<td>Tier III</td>
<td>$3.3 million</td>
<td>$150 million</td>
<td>$153.3 million</td>
</tr>
<tr>
<td>Tier IV</td>
<td>$3.3 million</td>
<td>$165 million</td>
<td>$168.3 million</td>
</tr>
</tbody>
</table>

*includes cooling

Source: Meta Group, The Uptime Institute
POWER AND COOLING ISSUES MARCH IN LOCKSTEP

Any conversation about power in the data center has to include a detailed discussion about cooling since more power means more cooling. One equipment rack that consumes 24 kW of power (equivalent to about 30 kVA) requires six to seven tons, or about 78,000 BTUs, of cooling capacity. And cooling capacity is only one part of the equation; airflow, measured in CFM (cubic feet per minute), is equally critical. The equipment in our 24-kW rack will require about 3,800 CFM of airflow to maintain operating temperatures within manufacturer specifications. When you consider that today’s average data center is designed to deliver 300 CFM of airflow per rack and that the average perforated floor tile in a raised-floor data center can deliver a maximum of only 600 to 700 CFM—assuming that the floor is high enough to permit that volume of airflow and that the space under the floor isn’t significantly restricted by the tangle of power and data cables inhabiting that space—it’s easy to see why the increased demand for power in the data center is creating a double-edged design problem (see Figure 10, below).

Determining the optimum height for a data center’s raised floor is a matter of striking the proper balance between airflow and weight. Present-day raised floors are rated for a uniform loading of 250 lbs. per square foot or less. If you’re dealing with one 10 years old or older, it may only be rated for 75 lbs. per square foot. Certain earthquake-prone communities may require even lower loading. They may also require that racks maintain a lower center of gravity than usual.

A single rack of HP ProLiant BL p-Class blade servers would weigh in at more than a ton. Problematically, raised floors that can handle a ton in each rack are less likely to allow for the required cooling

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**Figure 10** Getting Cool Air to Hot Racks

![Diagram of cooling systems in data centers](image)

Raised-floor cooling often needs extra help to cool high-density servers. Passive airflow is sufficient for equipment drawing 1 kW to 4 kW. Fans, particularly in floor tiles, can improve cooling capacity by as much as 7 kW. Closed racks with assisted airflow and air channels are costly, but can cool loads in excess of 20 kW.

Source: IT Architect
That’s because this can require a sub-floor-to-raised-floor gap of approximately three feet, whereas most raised floors are designed with less than a two-foot gap. This clearance is sometimes reduced even further to increase the weight-bearing capacity, resulting in an even bigger drop in cooling capacity. In most instances, the problem can be addressed by pressurizing overhead air ducts as well as the floor gap. That way, when floor-based airflow isn’t sufficient, it can be augmented by ceiling-based ducts. Spot cooling solutions can also be added to augment cooling capacity and airflow.

Blade servers increase your processing-per-foot ratio but suck up power and generate serious heat. NAS (network-attached storage) systems pack many terabytes of storage—and thousands of watts of heat generation—into similar devices, as do 10-Gigabit Ethernet network switches. Add to these loads the requirements of high-availability network components, VoIP (voice over IP), information security and a flexible deployment approach, and what you need is a high-demand, heavy-load, quickly reconfigurable data center.

Equipment Density and Heat Production Test the Limits

The pressure to keep server and appliance densities high (and put as many devices as possible into 1U or 2U packages) has led to what we call the sandwich effect—when you mash down on the top, what’s inside has to come out, either on the sides or the back. Vendors have chosen the back. Although they’ve stuck to the 19-inch standard width, they’ve increased the length from 36 inches to 42 inches to 46 inches and more, requiring organizations to expand the depth of their rack enclosures. In server rooms with many rows of rack enclosures, this is a growing problem: A few extra inches of depth in each row reduces aisle space to the minimum allowed by fire code, the amount of space needed for proper airflow and the number of rows you can place in the room.

Although water-cooled computers are less common than they once were, heat problems haven’t evaporated. With flexibility an overriding concern, cooling is moving away from giant floor units that require a raised floor to rack-specific air-conditioning units, such as the Liebert RackCooler for individual racks and the American Power Conversion NetworkAir for individual rows of rack enclosures. Spot-cooling products don’t eliminate the need for room air-conditioning units, but they do let designers reduce the size of the whole-room units, as individual rack- or row-cooling systems pick up the thermal load introduced by new equipment. Since you can focus your capital on buying the right amount of cooling for the equipment you’re introducing to the data center, the flexibility of this “right-sized” solution will save you money.

Redesign Considerations

For existing data centers, the notion of fully packed racks pumping out trillions of compute cycles per second or storing hundreds of terabytes is an attractive one but not very practical. A more realistic arrangement is to spread out the equipment and leave open rack space to reduce density and enhance the use of available airflow.
We stated at the outset that in a great many cases, existing power and cooling systems are adequate to support the gross loads present in many data centers. While that’s true, what’s new is that spot loads, both for cooling and power, will easily outstrip the design of current data centers. Power can be moved around, but cooling is another matter.

In the good old days of mainframes, much of cabinet design was based not on the real estate of the electronics involved, but rather on the electronics’ cooling requirements based on typical data center design. Given a set of processing and storage requirements, IBM not only happily mapped out the mainframe and storage systems needed, but also specified the physical systems of many data centers. That often included chilled water runs for CPU cabinets.

Now the modular design of modern compute and storage systems makes such a specification almost impossible. First, there’s the heterogeneous nature of the data center environment, which prevents vendors from reasonably specifying room designs for equipment other than their own. Then there’s the fact that these systems can be arbitrarily located in racks. Vendors specify clearances, but position within the rack is just as important as proximity to other equipment. Systems higher in the rack are prone to pulling the heated air from systems beneath them unless measures, such as a blanking panel (usually a 1U-high piece of plastic that fills an empty rack slot), are taken to eliminate recirculation.

As a result, localized cooling systems from third parties are often the best way to support higher system densities. In many cases, this simply means ingress and egress fans that force cooled air into and pull hot air out of the racks. In some environments, specialized rack-based cooling systems, such as IBM’s eServer Rear Door Heat Exchanger and HP’s Modular Cooling System, may make sense. Such cooling systems may require external refrigerant compressors or chilled water, so while the systems are easy to assemble, there’s likely to be some plumbing work required as well (see Figure 11, below).

Using these systems alone, vendors claim to support up to 10 kW per rack. APC offers the Infra-StruXure Small Data Center solution with eight usable racks, supplying power and cooling for up to 10 kW per rack as well as dual-ended (2N) power, which adds redundancy over a single-ended

<table>
<thead>
<tr>
<th>Model</th>
<th>Power consumption</th>
<th>Weight</th>
<th>Rack height</th>
<th>Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>HP BladeSystem p Series</td>
<td>26.5 kW</td>
<td>2,355 lbs</td>
<td>47U</td>
<td>192 Opteron 2.4 GHz</td>
</tr>
<tr>
<td>HP BladeSystem p Series</td>
<td>31.0 kW</td>
<td>2,227 lbs</td>
<td>47U</td>
<td>192 Xeon 3.06 GHz</td>
</tr>
<tr>
<td>HP ProLiant DL140 1U</td>
<td>13.4 kW</td>
<td>1,200 lbs (approx)</td>
<td>42U (40 systems)</td>
<td>80 Xeon 3.6 GHz</td>
</tr>
<tr>
<td>HP ProLiant DL145 1U</td>
<td>12.0 kW</td>
<td>1,200 lbs (approx)</td>
<td>42U (40 systems)</td>
<td>80 Opteron 2.4 GHz</td>
</tr>
<tr>
<td>IBM DS6800 + 12 DS6000</td>
<td>7.1 kW</td>
<td>1,620 lbs</td>
<td>39U (13 3U, 16-bay systems)</td>
<td>62.4 TB (using 300 GB drives)</td>
</tr>
<tr>
<td>Cisco Catalyst 6513</td>
<td>8.0 kW (approx)</td>
<td>560 lbs</td>
<td>40U (2 20U systems)</td>
<td>13-slot chassis, all filled</td>
</tr>
</tbody>
</table>

*Source: IT Architect*
system. The entire system has a footprint the size of 12 racks and a cool list price of $378,300. New plumbing and electrical work are additional costs.

Depending on the age and condition of your existing data center, it may not be feasible or cost-effective to retrofit it to handle a large number of high-density servers and storage systems. Consider alternatives such as building a new remote or adjunct data center, if you insist on in-house data center facilities, or using collocation facilities to handle some of the high-density load.

**Power Efficiency Is Critical**

If you don’t already assess equipment efficiency as a regular part of your purchasing evaluations, you should consider this factor as a critical component for your next round of purchases. The idea is to attain the lowest TCO in light of the fact that power and cooling costs are escalating.

Sun’s SWaP (Space, Watts and Performance) metric (see [www.sun.com/servers/coolthreads/swap](http://www.sun.com/servers/coolthreads/swap)) is a good self-serving attempt by an equipment vendor to quantify efficiency’s effect on your total cost of ownership for a particular piece of equipment. The metric is determined by dividing a performance value, such as operations per second, by the equipment rack space multiplied by the power consumption. An added benefit of using a metric like SWaP is that, the more people who use it, the more pressure will be put on vendors to design equipment to operate with maximum power efficiency. If we’re lucky and enough people become SWaP-sensitive, the next generation of servers could come with a bright yellow DOE EnergyGuide sticker listing the average yearly utility cost for operating the device.

A rack of blade servers will run up a yearly electrical bill of between $13,000 and $26,000 depending on locality—and that’s just for the IT gear. The cooling system will also suck up about half that same amount of electricity. Over a three-year useful life, electricity can easily be the most costly part of running this rack of gear. Luckily, Intel and AMD finally understand that power consumption and power efficiency in data centers is an issue.

APC recently published a white paper that puts the TCO of a high-availability data center at $120,000 per rack over the data center lifetime. About half of that cost is capital expense: racks (3 percent), cooling equipment (8 percent), power equipment (36 percent) and building improvements (8 percent). The other half is operating expense: electricity (19 percent), data center service (17 percent) and the cost of owning or leasing the space (9 percent). Although APC’s numbers are designed to support its case for investing in more efficient power equipment and so therefore are not unbiased, they do provide some insight on the breakdown of costs for maintaining the data center facility. Obviously, these figures don’t include IT operational costs, which can change the equation dramatically.

**Vendors Are Designing for Efficiency**

There are essentially three things that CPU designers can do to decrease power demand without sacrificing performance. One very effective measure is to reduce the size of the transistor gates.
Intel’s move from a 130nm fabrication process to a 90nm one reduced the Itanium 2’s power budget by about 25 percent. AMD did at least as well with its move to 90nm.

Of course, if simple power reduction is really what you’re after, CPU designers would need to resist the temptation to use the reduced transistor size to pack more transistors on a chip. They’d also need to leave the clock rate where it is. These two things almost never happen, but still, smaller is better. The road map for integrated circuit fabrication processes calls for 65nm and eventually 35nm. Intel and AMD will likely use these new processes to further enhance performance.

Dual-core processors from Intel and AMD represent the biggest advance in power efficiency in the past year. Not only has the processing power of a single chip more than doubled with the advent of dual-core processors in the data center, the dual-core chips ultimately consume less power than their single-core processor counterparts.

In the future, Intel and AMD are likely to follow a course pioneered by IBM. This calls for shutting off various parts of the CPU when not in use. For example, if they’re not needed, banks of cache memory or floating point units could be turned off. As the multicore strategy plays out, entire cores could be shut down when not needed.

It’s fair to say, however, that both companies realize that chip power budgets will remain approximately where they are—in the neighborhood of 100W per chip (see Figure 12, below).

Drive makers are also getting into the act by offering a variety of power-saving states on their devices. To save power, drive makers have a number of options at their disposal. Hitachi, for example, offers three lower-power states for its Serial ATA (SATA) drives. These include simply sending the heads to their rest position, and either slowing down or stopping the drive mechanism altogether (see Figure 13, page 18).

Originally intended for Energy Star-compliant desktop computers, these modes can also be useful in some data center applications. Typically, power-saving modes aren’t available on Fibre Channel or Serial-Attached SCSI (SAS) drives because such drives are intended to run constantly, whereas SATA

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**Figure 12 Sweating Out Components**

<table>
<thead>
<tr>
<th></th>
<th>Power</th>
<th>Speed</th>
<th>Cache</th>
</tr>
</thead>
<tbody>
<tr>
<td>Opteron 852</td>
<td>100 W</td>
<td>2.6 GHz</td>
<td>1 MB Layer 2 cache</td>
</tr>
<tr>
<td>Opteron 875 (dual core)</td>
<td>100 W</td>
<td>2.2 GHz</td>
<td>2 x 1 MB Layer 2 cache</td>
</tr>
<tr>
<td>Xeon MP 3.66</td>
<td>120 W</td>
<td>3.6 GHz</td>
<td>1 MB Layer 2 cache</td>
</tr>
<tr>
<td>Pentium EE 840</td>
<td>130 W</td>
<td>3.2 GHz</td>
<td>2 x 1 MB Layer 2 cache</td>
</tr>
<tr>
<td>Itanium 2 1.5G</td>
<td>130 W</td>
<td>1.5 GHz</td>
<td>6 MB Layer 3 cache</td>
</tr>
<tr>
<td>Itanium 2 (dual core)</td>
<td>100 W</td>
<td>1.6 GHz</td>
<td>2 x 12 MB Layer 3 cache</td>
</tr>
</tbody>
</table>

Source: IT Architect
drives were designed to be frequently powered on and off. By incorporating Hitachi’s or competing SATA drives with a similar power-saving technique, an enterprise could facilitate energy savings.

The storage industry is investigating storage models that will use dramatically less power for some applications. Massive Array of Idle Disks (MAID) systems are now offered by Copan Systems. Billed as an alternative to tape backup, these systems store data on high-capacity SATA drives, then shut off the drives until the data is accessed. The technology is specifically intended to save costs in terms of power and the amount of controller circuitry required.

If your data center is out of cooling capacity or can’t meet spot cooling demands, you need to do something about it. If it’s impractical to upgrade your data center or build a new one, an interim approach might be to use the power saving features of data center equipment.

### Determining Actual Power Consumption

If you plan to upgrade your data center or build a new one, your facilities staff will likely want guidance as to the amount of power that will be needed. Unless you already monitor power consumption closely, you’ll probably be inclined to develop a response by looking at the equipment’s nameplate labels. This method involves adding up the wattage figures from the labels on each type of equipment to get a good idea of the amount of power being used now—and then estimate additional power required based on projected growth. But if you follow this script, you’re likely to overestimate your power requirements and spend more money than you need to. Why? Because the wattage data on the nameplate shows the amount of power the power supply can produce, not the amount of power required to run the equipment.

According to a recent APC study, a fully populated IBM BladeCenter running at 100 percent utilization consumes 25 percent less power than is indicated on the nameplate: 4,050 watts actual versus 5,400 watts listed. The listed power consumption will always be greater than the actual power consumption, but the amount of the difference will vary for each type of equipment. For all equipment, the disparity between the power value on the nameplate and the actual power consumed will be large, so the nameplate shouldn’t be used to estimate power requirements.

If a data center upgrade or redesign is still a year or more away, it might be a good idea to spend

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**Figure 13 SATA Power-Saving Techniques**

<table>
<thead>
<tr>
<th></th>
<th>Power savings</th>
<th>Recovery time</th>
<th>Application</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>0%</td>
<td>0 sec</td>
<td>Online</td>
<td>Rest head assembly</td>
</tr>
<tr>
<td>Unload</td>
<td>24%</td>
<td>0.7 sec</td>
<td>Near-line</td>
<td>Reduce spindle speed by 40%</td>
</tr>
<tr>
<td>Low RPM</td>
<td>51%</td>
<td>7 sec</td>
<td>Archiving</td>
<td>Turn off spindle motor</td>
</tr>
<tr>
<td>Standby</td>
<td>89%</td>
<td>15 sec</td>
<td>RAID sparing</td>
<td></td>
</tr>
</tbody>
</table>

Source: Hitachi Global Storage
some capital now on power usage monitoring equipment. Accurate reports on existing power consumption over time are the best indicator of actual needs and the best predictor of future growth requirements. Since electronic equipment power requirements spike on startup, it’s also important to factor in peak requirements during planning. Equipment vendors are slowly becoming aware of the need to provide actual power consumption figures to their customers, but, if power usage isn’t monitored on a day-to-day basis, good vendor contacts will be needed to help locate the information needed. Also, remember to insist on vendor-supplied actual power consumption on your next data center equipment RFP; the legwork you save will be your own.

**Future-Proof Through Modularity**

It isn’t likely that you’ll need to deliver 24 kW of power to every rack from day one in your new or redesigned data center. However, it is likely that you’ll need to deliver more power to a rack over time before you are able to again upgrade or redesign your data center, so it’s important to plan a power path that will enable you to respond to increased business computing needs in a timely fashion. If corporate management support a modular approach to data center design, as discussed earlier, the following methods will make sense for you.

Most data center-class PDU (Power Distribution Units) and UPS vendors offer systems with a modular capacity in rack-sized cabinets that can initially be outfitted to deliver 25 percent to 50 percent of total capacity. Using such systems, as power needs increase, additional power modules can be easily installed in the existing cabinets without additional floor space or downtime. You need to ensure that your power delivery chain, including circuits, emergency power generation and battery backup, are all up to supporting the additional power requirements in the data center, but a modular plan in the data center eliminates the need to scramble to redesign that space as needs grow.

Instead of installing a fully loaded PDU/UPS combo in a new data center from day one, consider deploying two or more sparsely configured combos with an eye toward future expansion. It will initially require more floor space and additional capital, but the upgrade path will be clearly defined and downtime will be minimized.

An interesting product from APC, the InfraStruXure Cooling Distribution Unit, brings the same modularity to data center cooling that these modular UPSs provide on the power side. The Cooling Distribution Unit provides from one to 12 balanced, chilled water feeds to half-rack-wide, 30-kVA cooling units. Piping between the Cooling Distribution Unit and APC’s InfraStruXure InRow RC data center cooling units is via seamless, flexible piping that is quick and easy to install. With this system you can start with 30 kVA of cooling in the data center and ramp up to 360 kVA of cooling by adding half-rack-wide cooling units. Of course, your chilled water plant would need to grow as your data center cooling needs grow, but the changes in the data center would be nondisruptive and easy to accomplish. Liebert provides a similar modular approach through its X-treme Density (XD) line of water or waterless data center cooling products. The XD line coolers can be mounted on the ceiling or on top of equipment racks to save valuable floor space.
AC vs. DC

There is considerable disagreement over the potential energy savings afforded by switching from AC- to DC-powered servers and storage in the data center. Estimates range anywhere from 10 percent to 25 percent. The telecom industry has been using DC-powered equipment for years so there is a precedent, but DC power will have to prove it can result in significant savings in order for it to be used in future enterprise data centers. The one driver behind the acceptance of DC-powered equipment is the inefficiency of AC power supplies.

The typical AC- to DC-power supply found in most servers is about 70 percent to 80 percent efficient, which means that 20 to 30 percent of every watt delivered to a piece of equipment produces nothing but heat. Not only do you pay for the wasted electricity to run the equipment, you also pay for the electricity to cool the heat produced by the wasted electricity. In a data center that uses DC power, the equipment that converts your utility’s AC grid power to DC power—known as a rectifier—typically operates in the 90 percent efficiency or better, and doesn’t need to be located in the data center.

In a conversion to DC power, you’ll need a rip-and-replace mentality to make the transition—all PDUs and UPSs would need to be replaced, for instance. And existing AC power cables would need to be replaced since they wouldn’t be large enough to carry lower-voltage, higher-amperage DC power. Racks would need to be retrofitted with large copper bus bars to distribute the DC power within the rack, and each system in the rack would need to be converted.

Even enterprises that are contemplating a new data center designed for DC power from the ground up need to be aware of potential pitfalls. There are fewer vendors for DC-based data center equipment, so the initial costs for the equipment will be higher than for comparable AC-based equipment. The added upfront costs might be offset through lower annual operating costs, but a careful cost/benefit analysis would need to be applied to determine the potential for long-term savings.

Finally, data center engineers and the IT professionals who staff those data centers are AC-savvy but know relatively little about DC power, so any enterprise planning to implement a DC-powered data center should factor in retraining costs for staff.

It’s also important to note that vendors are working to enhance the efficiency of their AC power supplies. For example, IBM claims that its BladeCenter power supplies are 90 percent efficient. Even if you have to pay more upfront for this increased efficiency, it is money well spent since your total cost of ownership will be significantly reduced when you consider power costs over the life of the equipment. If greater AC efficiency becomes a trend, and we think it will, DC’s primary competitive advantage would become much less compelling.

If you plan to install new power and cooling infrastructure during the next year or two, you’ll be on the bleeding edge by going the DC route. IBM, HP and Sun all supply DC-powered systems but not all of their models allow both AC and DC power, so choices for DC-powered hardware are limited compared with AC.
PHYSICAL SECURITY

Data center security increasingly is being incorporated into the infrastructure. Environmental sensors and rack-mounted monitoring cameras are common, and network access and physical access are being linked through two-factor authentication in the form of smart cards tied to back-end network directories that store both data and physical-plant authorization levels. The challenge: Combining physical and data security means integrating more than separate systems. It means merging two different professional cultures. Negotiations over where access databases should be stored and who may access and modify fields within those databases—not to mention discussions on the implementation of policies on switches, firewalls and other IT infrastructure components—have resulted in multiple, redundant, out-of-band control networks for different administrative functions. The amount of space within racks and cable trays that can be dedicated to administration will be determined by whether all the management networks are run through a single infrastructure that is separated into virtual LANs, or run on separate switching and cabling plants.

Security considerations also dictate how video and environmental signals are distributed from server rooms and remote wiring closets. The way IT and security responsibilities are usually split, information from cameras and sensors on equipment racks goes over a dedicated coaxial-cable network to the network operations center, while information from cameras in the parking lot and halls is routed to security guards, again over a dedicated coax network. In the new model, video signals and instrumentation data are routed across an IP network to as many locations as have security responsibility for the area. Within the data center this creates another dedicated network that must be racked and managed, but that’s really the story of the entire data center infrastructure: Individual components are smaller and perform a wider range of functions, but the range of tasks and the number of components continues to grow.
DATA CENTER BEST PRACTICES

1. Watch for equipment with side-to-side or top-to-bottom airflow requirements. Devices that require loads of back-panel connections sometimes use side-to-side airflow for cooling. These devices will have special rack space requirements.

2. Deploy rack rows in “hot aisle” and “cool aisle” configurations. That means equipment exhaust sides should face one another, as should equipment front panels in adjacent rows. This prevents equipment from pulling in air already warmed by other gear.

3. Unless the rack is equipped with its own air-handling equipment, don’t use racks with solid doors. Air must be allowed to enter to cool the equipment. Glass doors look cool, but they turn racks into ovens.

4. Use racks with plenty of room for cable runs. Cables can obstruct airflow, so keep them neat and bundled to the side.

5. Use panel blanks in the front of the rack. Panel blanks prevent hot air from being sucked through the rack and back to the front side of the equipment.

6. Oversize cooling capacity by 10 percent to 15 percent per rack. You need enough capacity to lower the temperature of the equipment, not just maintain it.

7. Cut floor tiles carefully. Lopping an oversized hole in your floor tile for cable runs seems benign enough, but it can easily impair local airflow. Thus, cut with caution and use brushes or other airflow obstructers around wiring holes.

8. Leave enough room between racks. You need to be able to walk down both cold and warm aisles. More space means better airflow, too.

9. Buy a thermometer. Better yet, buy some sensors and deploy them so airflow and temperature can be tracked. A fried server shouldn’t be your first indication of trouble.

10. Get an audit. Particularly if you’re planning for a pile of new high-density servers, you’ll need an audit to determine the remaining power and cooling capacity.
APPENDIX

The following figures provide a profile of respondents to our data center surveys, NETWORK COMPUTING March 2005 This Old Data Center Survey (Figures 14 and 15) and NETWORK COMPUTING March 2006 Enterprise Data Center Survey (Figures 16 and 17).

Figure 14 Organization Size

Estimate your organization’s total sales revenue for the past 12 months.

- $1 billion or more: 15.5%
- $500 million to $999 million: 7.9%
- $100 million to $499 million: 10.9%
- $10 million to $99.9 million: 21.1%
- $1 million to $9.9 million: 18.1%
- Less than $1 million: 12.5%
- Government or nonprofit organization: 14.0%

Source: NWC 2005 This Old Data Center Survey, 684 respondents

Figure 15 Respondent’s Role

Which of the following best describes your role in your organization?

- Corporate officer: 19.6%
- Management: 37.4%
- Team leader: 7.8%
- Technology staff: 30.4%
- Other: 4.8%

Source: NWC 2005 This Old Data Center Survey, 684 respondents
Figure 16 Organization Size

Estimate your organization’s total sales revenue for the past 12 months.

- $1 billion or more: 16.4%
- $500 million to $999 million: 5.9%
- $100 million to $499 million: 10.5%
- $10 million to $99.9 million: 19.5%
- $1 million to $9.9 million: 13.2%
- Less than $1 million: 15.0%
- Government or nonprofit organization: 19.5%

Source: NWC 2006 Enterprise Data Center Survey, 228 respondents

Figure 17 Respondent’s Role

Which of the following best describes your role in your organization?

- Chief information officer (CIO): 8.0%
- Chief technology officer (CTO): 4.9%
- Corporate officer (VP): 2.7%
- Director: 13.8%
- IT consultant: 7.1%
- IT staff: 21.3%
- Manager/supervisor: 23.1%
- Owner/partner: 9.3%
- Other: 9.8%

Source: NWC 2006 Enterprise Data Center Survey, 228 respondents