the green data center 2.0

Energy-Efficient Computing in the 21st Century

BY MATT STANSBERRY

CHAPTER 4: A Step-by-Step Guide to Greening the Data Center

IN THE PREVIOUS three chapters of the *Green Data Center* e-book, we have laid out the case for going green in the data center and the tactics to achieve energy efficiency within server and infrastructure environments. This chapter summarizes strategies for going green in the data center and helps IT managers create a holistic strategy for a data center energy-efficiency project.

PHASE 1: Persuading the C suite to pursue energy efficiency

PHASE 2: Measuring data center energy consumption

PHASE 3: IT asset management and purchasing decisions

PHASE 4: Infrastructure optimization techniques

Data center energy efficiency begins with operations teams.

PHASE 1: Selling Energy Efficiency to the C Suite

DATA CENTER ENERGY efficiency begins with operations teams, but without executive buy-in, data center efficiency projects are doomed to fail.

Today's IT systems are so complex and fragile that IT staffers are often unwilling to re-engineer systems to run more efficiently. Rank-and-file data center admins are not motivated to audit and decommission unused servers.

IT departments need an executive mandate to pursue energy efficiency.

THE BIG-PICTURE SCENARIO. So how do you get a mandate to go green and unplug unnecessary servers (and other equipment)? For data center managers, the process begins with speaking an executive's language. Most executives do not relate to bits and BTUs. They look at the big picture. So you need to present your case from the big-picture perspective.

CORPORATE SUSTAINABILITY. C-level executives understand the concept of "going green." These days executives throw the term around more frequently than Al Gore does. So, for example, someone at the top of the chain writes in a press release, "We're going to be carbon neutral by 2010" but doesn't communicate that idea to the IT department. Only once it becomes clear that the company's data center is responsible for a huge chunk of the company's carbon footprint does IT get invited into the conversation.

When a company pledges carbon neutrality, it often means it has various

C-level executives understand the concept of going green. These days, in fact, executives throw the term around more frequently than Al Gore.

plans, including sponsoring public transportation and telecommuting options for employees to reduce gasoline consumption; pledging to reduce operational energy consumption; and/or buying carbon offsets. Silicon Valley giants like Dell, Hewlett-Packard, IBM, Yahoo, Google and Salesforce.com all have pursued one or more of these tactics to garner corporate goodwill.

Unfortunately, many companies don't plan to change much about their energy consumption and instead throw money at the problem rather than truly fix it, as is the case with carbon offsets. With carbon offsets, a corporation will pledge to pay a third-party company to invest in renewable energy or plant trees that will sequester carbon dioxide from the atmosphere. Examples include planting trees in Brazil or building wind turbines in India.

But carbon-offset companies are unregulated and often unaffiliated with official environmental agencies or standards. And even for companies that do due diligence on their carbon reparations, many experts say the whole scheme of carbon offsetting is misleading and, worse, ineffective because it doesn't fix the problem of consumption in the first place.

So rather than throw hundreds of thousands of dollars into the effort to offset the CO_2 your company pumps into the atmosphere (as Salesforce.com did in 2007), put that money toward a server refresh and purchase additional hardware or perform an analysis of computational fluid dynamics (CFD) to audit your data center's layout and improve cooling efficiency.

Learn which of your company's departments have embarked on going green and persuade them to sponsor your project. Now more than ever, as executive teams in various companies spout green rhetoric, this is the ideal time to present a data center project to management.

EXTENDING THE LIFE OF YOUR DATA CENTER IN LEAN TIMES. Despite the downturn in the economy, business

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demand for data center services continues to increase. And the cost of building data centers has skyrocketed.

During boom times, companies build new data center facilities because they have run out of power and cooling capacity and literally can't supply more power into their data center buildings. But in today's economic and credit climate, this isn't a workable solution.

"Take a look around you," said Chuck Goolsbee, a data center executive at Seattle-based hosting firm digital.forest. "What you have now is likely what you are going to have to work with going forward, at least until the economy picks up. If facility or operations staff has grandiose plans in process, expect them to get scaled back or shelved. Even projects in progress are at risk."

According to Goolsbee, executives aren't funding data center projects. And even if they were, outside financing in the form of debt would be almost impossible to find.

"Ironically, demand for data center services is not going to change that much," Goolsbee said. "In my 15 years in the business, data center demand has remained on a steady ramp and has hardly ever wavered."

If your company can scale back data center energy use, it can potentially forestall a nine-figure capital expenditure. Experts estimate that, with best practices and modern equipment, data

The potential cost of building a 30,000-square-foot data center today, compared with only $20 million a few years ago.

$300 million

center operators can realistically cut energy consumption by 50%. Bringing these CAPEX and OPEX scenarios to a CFO is a surefire way to get attention for your project.

"When profits are high, it may be hard for some organizations to justify spending much time on driving efficiency," said Christian Belady, a data center power and cooling architect at Microsoft. "In environments with little or no profits, the efficiency of your operations could make the difference between a profitable year and a loss. Efficient IT and operations are a competitive advantage in a growing economy, but in a down economy it is crucial for survival."

TALKING IN EXECUTIVES' LANGUAGE. Once you solidify the big-picture business case for a data center energy-efficiency project, you need to hone your presentation skills and learn to speak in the language of your audience. How do you package this project for a 30-second sound bite? You don't have two hours to present metrics.

"It's a challenge foreign to people in the technical field," said Robert Rosen, the former president of Share—an IBM mainframe user group—and the CIO of the National Institute of Arthritis and Musculoskeletal and Skin Diseases in Bethesda, Md. "You really have to give up the whole technical aspect of it and put your business hat on. At that level, they don't care about nuts and bolts. You have to come at this as a business problem," Rosen said.

If, for example, you want to present executives with a grand plan to save data center energy, don't approach the issue by talking about saving kilowatts. You have to say, "We are spending X dollars to provide this service today, and we can reduce that amount while providing the same level of service."

"You've got to put it into terms they're interested in, or their eyes are going to glaze over," Rosen said. "It's Salesmanship 101. You're a salesman, trying to sell your project. Why is it in the best interest of the person [to whom] you're selling to buy your project?" Usually the

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answer comes down to money.

Other tips include researching executives' pet projects. What would a C-level executive rather spend money on after you create major savings from a power bill? Executives want to know "What's in it for me?"

Rosen also recommends the training of IT staff on how to make a presentation. "Learn how to get your point across without falling into the techno trap," he counseled. "You have to understand the audience and have a pitch appropriate to that audience."

While it might sound cliché, Rosen suggests Dale Carnegie's classic self-improvement book *How to Win Friends and Influence People*. User groups like AFCOM, Share and the Uptime Institute also teach the soft skills necessary to sell a project to management as well.

THE THREE-STEP PROCESS FOR SELLING DATA CENTER EFFICIENCY. No matter how slick your PowerPoint presentation is, you won't get the green light on a project without taking the following steps:

1. Determine who pays the data center electric bill. What does it cost per month to keep servers running? Over, say, the past 24 months, what is the trend for data center power costs?

2. Work with your application teams to project your IT infrastructure growth. In the coming period, how much additional capacity will you need? Will any large projects affect data center demand in the future?

3. Determine a metric that you can use consistently. How efficient are your data centers? How efficient can they be? In the next section, we discuss how to measure data center energy consumption. ■

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PHASE 2: Measuring Data Center Energy Consumption

WHAT KINDS OF metrics do you need to manage data center energy consumption? You don't need a formula with an endless number of variables. Experts advise data center managers to pick a simple measurement, make a ratio and improve on it.

"Pick something—any metric—and get started," advised Pitt Turner, the principal, senior project leader and president of Santa Fe, N.M.-based ComputerSite Engineering Inc. "Even if you pick the wrong metric, as long as you improve it, you can drive tremendous change."

There are various potential variables to measure, which is where many data center managers get bogged down. But you don't need to swallow the ocean in your first attempt to gauge data center efficiency. Instead, take a simple approach to measure how much of the power in your data center actually goes to IT equipment (i.e., servers, storage and network gear) and how much is sucked up by air conditioners and lost in AC/DC (alternating current/direct current) conversions for power equipment.

This measurement is expressed as a ratio and is most commonly known as power usage effectiveness, or PUE.

PUE is determined by measuring the power "taken in" to a data center (measured at the utility electric meter) and divided by the power "going out" used to run the IT equipment for computing needs. The equation looks like this:

$$\text{PUE} = \frac{\text{Total facility power}}{\text{IT equipment power}}$$

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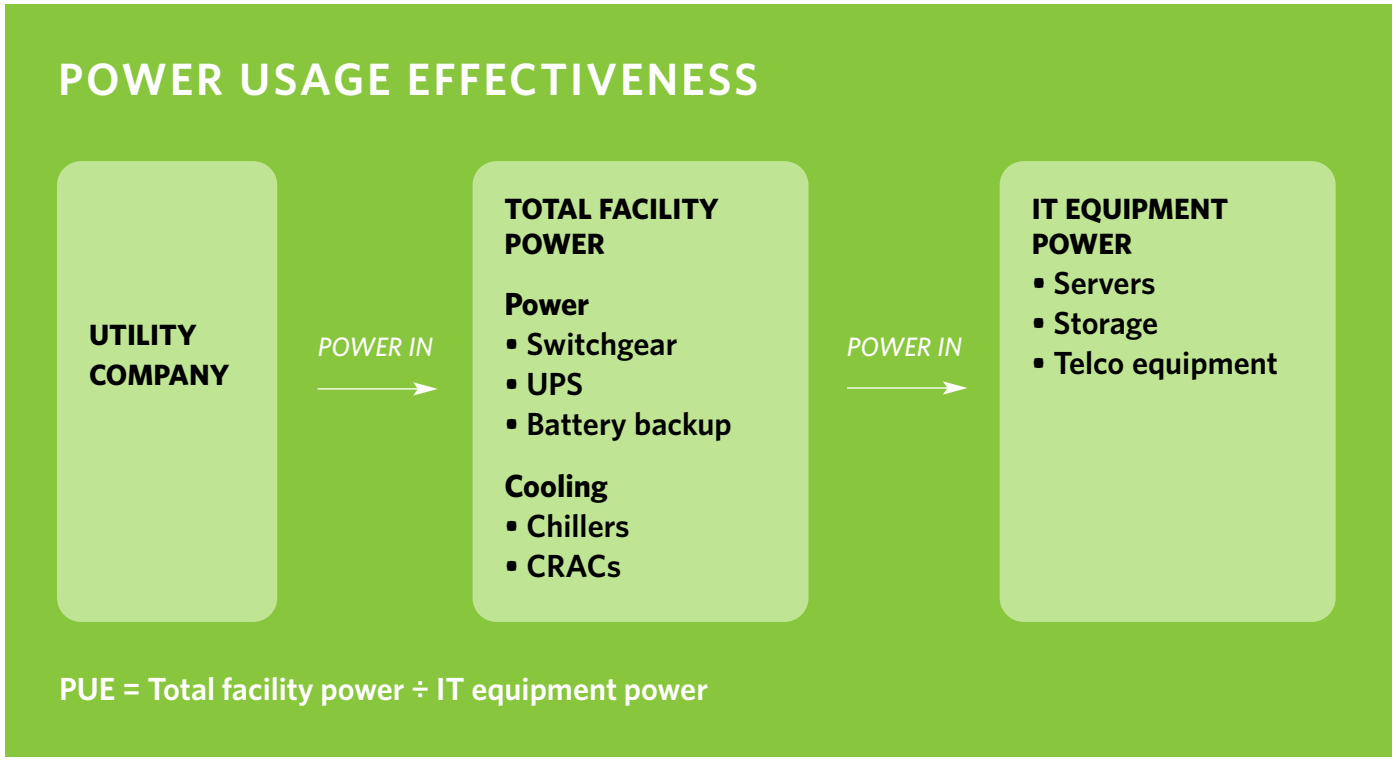
The measure has been accepted by vendor consortiums like the Green Grid as well as the Environmental Protection Agency (EPA) and ASHRAE to measure data center efficiency.

The first step in determining PUE is to take a measurement at or near the facility's utility meter. If your data center is in a mixed-use facility or office building, measure only at the meter that powers your data center facility. If power to your data center is not on a separate utility meter, estimate the amount of power being consumed by the non–data center portion of the building and remove it from your calculation. The next step is to



If your data center is in a mixed-use facility, measure only at the meter that powers your data center facility.

measure the IT equipment load, which should be measured after power conversion, switching and conditioning are completed.

According to the Green Grid, the most likely measurement point is at the output of the computer room power distribution units (PDUs). This measurement should represent the total power delivered to the compute equipment racks in a data center. While PDU is an accurate measurement of IT load, Turner said uninterruptible power supply (UPS) output may be a better option. "It's really important to have a consistent and predictable way to collect data to approximate the IT energy consumption," he said. "If you do it at the UPS output, there's only one place to measure. If you do it at the pure location, which is the PDU output, you would likely have to measure 600 to 700 locations to get the same information.

The tradeoff, Turner explained, is accuracy versus ease of use. One is more pure but also much more difficult and risk oriented. The other is simple and straightforward." Whichever means users select, Turner said it's important to measure the same way consistently.

According to the Uptime Institute, the typical data center has an average PUE of 2.5. This means that for every 2.5 watts that goes "in" at the utility meter, only 1 watt is delivered out to the IT load. Uptime estimated that most facilities could achieve 1.6 PUE using the most efficient equipment and best practices and calculated that a large data center (of 30,000 square feet or more) could improve SI-EER—the Site Infrastructure Energy Efficiency Ratio—from 2.5 to 2.0 without building a new data center and actually increase cooling reliability. This project would save nearly a million dollars annually in high-utility-rate regions.

While in the future more granular measurement points will be necessary, understanding PUE is an important first step to managing data center energy consumption holistically, and experts agree that it is the key building block for any energy-efficiency project. ■

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PHASE 3: IT Asset Management and Purchasing Decisions

NOW THAT YOU have your CEO's blessing for a data center efficiency project and you've measured PUE, it's time to get down to the business of reducing data center energy consumption. There are hundreds of potential starting points, but to deal with the problem holistically, you need to have a strategy.

ROOT COMPONENTS. The logical starting point is with the root components (i.e., processors), then progress through the chain to the supporting facility infrastructure. HP uses the tagline "Chips to chillers" to describe this process; Emerson Network Power uses the phrase "Creating savings that cascade across systems." The idea is that savings on the most basic IT level adds up to exponential savings on big-ticket facility requirements.

APPLICATION CONSOLIDATION. An enterprise data center often supports and delivers thousands of applications, some of which are multiple versions of the same software, some of which are different products essentially doing the same thing, and an even greater number of which are forgotten or legacy programs just taking up space.

But application consolidation has received little attention in data center consolidation projects. Russ Daniels, the vice president and chief technology officer of HP Software and HP Adaptive Enterprise, stressed the importance of this step.

Daniels said that HP asked a series of questions to reduce its data center application portfolio in its data centers: "Do we have a business case for that application? Can we consolidate it with

Savings at the most basic IT level adds up to exponential savings on big-ticket facility requirements.

others? Do we have 10 applications all doing the same thing? Which one will we standardize on?"

Application consolidation saves costs in licensing, management resources and hardware support, according to Daniels. But it also lessens the load on servers, allowing data center managers to scale back computing resources.

ELIMINATING HARDWARE. The next step is to turn off unnecessary servers. Audit your hardware, decommission nonfunctional machines and get them off the grid. Too often, companies pull servers out of production, only to put them somewhere else (in test-and-development sandboxes, for example) or, worse, leave them running where they are. Decommissioned servers get lost in the shuffle.

So how do you get rid of them? According to Jack Pouchet, the director of energy initiatives at Emerson Network Power, it takes brute force. He recommends that IT managers take the following steps:

1. Round up all legacy servers in your data center and determine what they are supposed to do.

2. For servers with unknown purposes, take them through all the lines of business and ask, "Whose servers are these?"

3. If you end up with 30 orphans, offer 90 days for these servers to be claimed, then pull the plug. If no one screams, they're not being used.

4. If someone screams, they needed an application, not a server. You've shut that 5-year-old boat anchor off. Port the application to a more energy-efficient server and speed the process.

And indeed, said Pouchet, "the process isn't pretty, but people do it every day."

SERVER VIRTUALIZATION. Another way to reduce the number of servers in an environment is to use server virtualization from companies such as Microsoft, VMware Inc., Citrix Systems Inc. and others. We covered this topic in Chapter 2 ("Expert Tips For Energy-Efficient Rack Servers"); and according to survey data,

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most of you already experiment with or run virtualization in production, but the following information can provide a sense of what's achievable.

Five years ago, 80% of your servers ran at 5% to 15% utilization. Today, with VMware, you can collapse five to 10 operating systems onto a single machine, cluster them for failover protection and use fewer servers.

California utilities now pay customers 50% of the cost of a virtualization project (with a maximum contribution of $4 million). With VMware virtualization technology, one user in the pilot program reduced the number of servers from 1,000 to 270. Another virtualized 260 physical servers onto 11 VMware hosts. VMware and utility companies have estimated that direct annual energy savings for each server removed is between $300 and $600.

ACTIVE POWER MANAGEMENT. After you remove unused servers, how do you deal with the necessary servers that sit idle? Hewlett-Packard Co.'s Brad Kirby points users to the PowerSmart feature on Citrix XenApp, a program whose application delivery system enables users to identify and power down servers that are underutilized. Other tools in this vein include Cassatt Corp's Active Response.

Jay Fry, the vice president of marketing at Cassatt, cites the recommendations of such organizations as Gartner Inc., the EPA and the Uptime Institute on active power management. "A lot of vendors are pursing passive power management: more efficient processors and power supplies," Fry said. "While those efficiency gains can have a huge impact, active power management is the other half. Users can find idle servers and use policies to gracefully shut them down."

In addition to tools from Cassatt, VMware and Citrix Systems, server vendors offer homegrown tools to monitor, reduce and cap server power use. While these tools and settings work only among each manufacturer's equipment, they are often included in the price of the hardware, such as with IBM's Pow-

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erExecutive feature. The HP management tool is called HP Power Regulator, and it ships with its ProLiant machines. These tools often work in concert with the processor-scaling capabilities built into Intel Corp.- and Advanced Micro Devices (AMD)-based machines as well as with the operating system.

Many server vendors give users the option to turn on power-saving features. Many users previously left the power-saving features disabled, but today most vendors recommend using these features. "On the Intel Xeon, the Enhanced SpeedStep Technology [which increases or decreases clock speed based on usage] doesn't need a lot of application support," said Geffrey Noer, the senior director of product management at Rackable Systems Inc. "It's very safe and a very easy thing for customers to turn on."

AMD's new quad-core Dual Dynamic Power Management technology can power down individual cores on a processor. "A lot of applications may not be multithreaded enough to run on all of the processor cores at once," Noer said. "If you have a dual-socket server with

Active Power Myths

FOR NUMEROUS REASONS, users have been wary of active power tools, but Cassatt Corp. has set out to disprove some of the myths surrounding active power management.

For one, some users believe that turning servers on and off compromises hardware reliability. But Cassatt cites the website of the Energy Start Program at the Environmental Protection Agency (EPA) as saying, "Modern computers are designed to handle 40,000 on-off cycles before failure, and you're not likely to approach that number during the average computer's five- to seven-year life span. In fact, IBM Corp. and Hewlett-Packard Co. encourage their employees to turn off idle computers, and some studies indicate it would require on-off cycling every five minutes to harm a hard drive."

Another widespread myth: It takes more energy to turn a server off for a few hours and then back on rather than to just leave it running. Cassatt again cites the EPA Energy Star program: The small surge of power created when devices such as computers are turned on is vastly smaller than the energy used by running a device when it is not needed.

two quad-core processors, you may only have six cores running at a particular time. The processor would automatically shut down the cores that are not being used."

SPECIFYING EFFICIENT SERVERS. When it comes to buying servers, performance is still king, followed by price. But thanks to new specifications that allow users to quantitatively measure performance per watt, energy efficiency has gained ground in the conversation.

The EPA will soon release an Energy Star label for servers, just as it has created labels for desktop computers, clothing dryers and ceiling fans. Server energy consumption and performance would be measured and tested by third parties, and the top 25% of energy-efficient models would garner the Energy Star label. The determination would enable data center managers to weigh energy efficiency alongside other factors in purchasing decisions.

The upcoming Energy Star label is scheduled to appear on servers in May 2009, and the EPA uses three criteria to determine energy efficiency for 1U servers:

1. Energy Star servers must use a high-efficiency power supply.
2. Servers must implement power-saving features at the OS-firmware level.
3. Most important, the EPA will use a new Standard Performance Evaluation Corp. (SPEC) benchmark to calculate the amount of energy various servers require to perform a set unit of work.

The first workload that the new SPEC power metric will measure is server-side Java and is called SPECpower_ssj2008, and it is available from the SPEC website.

These Energy Star servers may command a slight premium over standard servers, but with the three-year cost of electricity expected to exceed the purchase cost of most servers by this year (at a conservative estimate of 7 cents per kilowatt-hour), up-front costs have become less of an issue. ■

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PHASE 4: Optimizing Data Denter Infrastructure

IN CHAPTER 3 ("Data Center Infrastructure Efficiency"), we explored how to prioritize data center facility improvements. In this chapter, we use a case study to illustrate how the process works.

Let's face it: A lot of green data center case studies are pretty worthless. Vendors and customers pat one another on the back for buying green products and offer vague promises to save energy in data centers over a period of time.

But the folks at the United Parcel Service of America Inc.'s Alpharetta, Ga., site are about to save you a lot of money on your data center air-conditioning bill today. Joe Parrino, the data center manager at UPS' Windward data center also explains his organization's load-shedding process and proves that using outside air to cool a data center can work—even in the hot temperatures of the southeastern U.S.

BROWN GOES GREEN IN ITS DATA CENTER. UPS' Windward data center bucks the conventional wisdom. Old data center facilities are supposed to be inefficient, and outdated mechanical systems are primarily to blame. Even worse, considering the amount of redundancy designed into the facility to prevent downtime, an Uptime Institute Tier 4-rated data center would have to be a real energy hog.

But somehow the 15-year-old, Tier 4 facility in Alpharetta scores a PUE as low as 1.9. As mentioned, this ratio represents the measure of the power going into the facility at the utility meter divided by the power going to the IT load, measured either at the power distribution unit, or PDU, or at the uninterrupt-

UPS' Windward data center bucks the conventional wisdom.

ible power supply, or UPS.

In the case of the Windward data center, PUE was measured at the output of the PDU. If measuring PUE at the output of the uninterruptible power supply, UPS' PUE would shrink to 1.90 because PDU feeder and transformer losses do not get taken into account.

According to the most recent EPA Energy Star results released in November 2008, the average PUE of 37 participating Tier 3 data centers is 2.41, and the 13 Tier 4 sites scored 2.44. This means that for every 2.44 watts going "in" at the utility meter, only 1 watt is delivered to the output of the UPS.

In this regard, United Parcel Service's Windward data center is way ahead of the curve. But how did the company do it?

CUTTING OUT THE CRAC UNITS. Forced-air cooling is one of the least efficient systems in data center infrastructure, and wasting cold air is the most common mistake in data center management. You can set up hot aisle/cold aisle, install blanking panels, and seal gaps in the floor, but you've probably still wasted cold air in a place you wouldn't expect: the perforated top of power distribution units.

Parrino's staff learned this by chance. The team noticed the perforated roof on

Windward Data Center Specs

- United Parcel Service of America Inc. has two data centers, the Windward facility in Alpharetta, Ga. , and the other in Mahwah, N.J.
- Together, the two facilities house 15 mainframes, 2.9 PB of storage and nearly 3,000 servers.
- These data center handle the logistics for the eighth largest airline in the world, plus nearly 100,000 ground vehicles.
- The Windward facility was completed in 1995 and has 50,400 square feet of raised floor.
- Windward achieved the Uptime Institute's Tier 4 rating for availability: It has multiple active power and cooling distribution paths, concurrent maintainability and System + System, N+1 redundant components.

a PDU as it sat in a hallway waiting for installation. They took airflow measurements on several installed units using a velometer and calculated the cubic-feet-per minute (CFM) loss (i.e., the velocity of the air multiplied by square footage of the opening). United Parcel Service determined the units lost 2,000 CFM per PDU.

"What heats up inside a PDU that would require 2,000 CFM of cooling?" Parrino wondered. The only component possibility was transformers, which have a high temperature tolerance. So the facilities team conducted an experiment. It ran a PDU with a solid Lexan cover at full load (i.e., 180 kW) using a load bank for one hour in an outside location on an 85-degree Fahrenheit day. Measurements of the transformer temperatures were taken with an infrared camera. The transformer temperatures increased 20 degrees from the nominal 115 degrees on the conditioned raised-floor space to about 135 degrees in a non-air-conditioned location. This was well within the manufacturer's stated 300 degrees-plus Fahrenheit operating range. "We didn't even come close to the shutdown temperature," Parrino said.

The next step was to seal the top of PDUs with Lexan covers. The covers have a 3-inch opening to ensure that the transformers get airflow but also block 90% of undesirable bypass airflow. Following the installation of the Lexan covers, average transformer temperature increase was about 10 to 20 degrees Fahrenheit.

"After we installed the covers, we looked at the under-floor static pressure and we were amazed at what we got back," Parrino said.

To date, Windward has shut off 26 of the original 65 computer room air handlers that were installed. This has saved more than 1.5 million kWh of annual energy usage and avoided carbon dioxide emissions by at least 1,077 tons per year.

The cost of covering PDUs was about $6,000, and United Parcel Service estimated that payback would take about 4.3 months. Instead the project paid for

To date, Windward has shut off 40% of the originally installed computer room air handlers and thus saved more than 1.5 million kWh of annual energy usage.

itself in a month and a half.

The Windward team's next objective is to experiment with variable-air volume floor grates controlled by intake temperatures of the racks. "This will slow the consumption of CRAC [computer room air conditioning] fan energy even further by delivering the CFM that's needed for each rack instead of delivering based on the worst-case IT load," Parrino said.

FREE DATA CENTER COOLING IN GEORGIA.

The Windward data center has two 1,000-ton centrifugal chillers and two 800-ton absorption chillers. The data center also has a 650,000-gallon thermal storage tank with redundant water sources (a well and city water for back-up). The thermal storage tank was designed to provide about 20 hours of emergency cooling, but Windward's data center team also uses it for energy cost management.

In 2000, United Parcel Service installed a plate-and-frame heat exchanger to take advantage of outside air temperatures to cool its chilled water. Also known as water-side economizing, the practice saves energy by allowing data centers to turn off chillers, and lately green data center experts have given it a lot of attention.

Unfortunately, most people don't take advantage of free cooling because they aren't in a region that stays cold long enough for the system to pay for itself or lack the automation to manage going on and off a plate-and-frame heat exchanger. But UPS has solved both of these problems.

For starters, Parrino's staff raised the temperature of the chilled-water loops from the designed temperature of 44 degrees Fahrenheit. It now modulates between 48 degrees and 61 degrees Fahrenheit. The lower temperatures are needed during high-humidity days (i.e., 100% humidity when it rains) to maintain the interior relative humidity between the nominal 40% to 55%. During the winter months when the outside air is drier, Windward can use higher temperatures.

Further, moving on and off the plate-

Water-side economizing saves energy by allowing data centers to turn off chillers.

and-frame heat exchanger is easier with a thermal storage tank. As the chiller shuts down and a condenser water loop is lowered, the thermal storage tank provides uninterruptible cooling to the data processing equipment.

The Windward data center can do so because it is a standalone data center rather than a mixed-use facility with office space that needs to run cooler chilled-water temps for latent cooling.

Higher chilled-water temperatures enable United Parcel Service to extend its use of free cooling dramatically. In 2008 the data center used the plate-and-frame heat exchanger for the last time on May 17 and switched free cooling on for the first time on Sept. 26. During this seasonal transition period, nighttime temperatures get low enough, but the days are warm. To extend time on the plate-and-frame heat exchanger even further during the seasonal transition periods, the thermal storage tank provides ride-through during the warm afternoons and is then re-charged during cool evenings. The entire process is automated; no human intervention is required.

By November, Windward is on plate about 90% of the time and remains that way through the better part of April. That's five months of free cooling—in Atlanta, no less. Northern latitudes can enjoy even longer free cooling periods.

In mid-2008, the plate-and-frame heat exchanger was expanded from 1,200 tons to 2,000 tons. The objective was to shorten the evening recharge time of the thermal storage tank and expand the usage window two to four weeks per year. Annually the plate-and-frame heat exchanger saves United Parcel Service 1.45 million kWh of energy. This is equivalent to an additional 1,040 tons of carbon dioxide emissions avoided.

According to Parrino, switching on and off a plate-and-frame heat exchanger would be a messy job without thermal storage tank and solid automation software. He says using the Windward building automation system from Kennesaw, Ga.-based Automated Logic Corp. is a story in itself.

United Parcel Service's thermal storage tank provides ride-through during the warm afternoons and is then re-charged during cool evenings.

In 1995 the system was installed with the building, and the plan was to bring all building systems under a single interface. "It was a pretty advanced system in 1995, even more so today," Parrino said. "Manufacturers want to give you a PC for your UPS system, one for the generator or a chiller. Our system interfaces with all of these third-party devices."

The system provides chiller, pumps, and cooling-tower rotations and manages the thermal storage tank. It also gives Windward visibility into outside air temperature and humidity conditions to determine when a data center can use outside cooling.

HOW PEAK-LOAD SHEDDING GETS DONE. Automated Logic's system also helps United Parcel Service shed its power load during high-demand peaks in the summer. United Parcel Service is on a real-time pricing plan with its utility Georgia Power. The price can range from 4 cents per kWh in the morning and jump to 8 cents in the afternoon when there are moderate summertime temperatures. Costs for afternoon peak-load times in the month of August exceeded 30 cents per kWh on days when the outside temperature surpassed 100 degrees Fahrenheit.

To minimize costs, Windward switches to "plant economy" mode during the summer peak-load periods. Plant-economy mode effectively shuts down the 630 kW chiller plant (including chillers, cooling tower fans, primary pumps, tower pumps) and cools the data center using the stored 45 degrees Fahrenheit of thermal energy in its 650,000-gallon thermal storage tank. The facility then runs chillers at night when the cost per kilowatt-hour is around 4 cents—recharging the tank during off-peak hours.

Running the chillers at night is an effective energy reduction strategy as well, since outside wet-bulb temperatures are typically lower than they are during daytime hours. A lower wet-bulb temperature allows more efficient removal of heat via cooling towers. This reduces the condenser water temperature, also reducing "lift" in the chiller and

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enabling it to run more efficiently.

In 2008, between 9:00 a.m. until 8:30 p.m., Windward started using plant-economy mode in the winter while on its plate-and-frame heat exchanger. This reduces the mechanical plant consumption (cooling tower pumps and fans, and primary pumps) from 230 kW to about 20 kW for half the day. The plate-and-frame heat exchanger then uses the cool nighttime winter air to recharge the thermal storage tank.

One unexpected outcome is that water usage has reduced significantly. "I don't completely understand why" says Parrino. "Yes, the duty cycle of makeup water in the condenser water loop is halved, but tonnage is tonnage, and it would seem you'd have to pay the piper at night. [But] not so." Less makeup water usage means fewer chemicals injected into the condenser water, which equals savings multiplication.

The thermal storage tank used to provide only six to eight hours of cooling capacity on a 95-degree day, with 40% thermal capacity remaining. Raising the chilled-water set point has increased the ton-hours capacity to approximately 12 hours of cooling with 50% thermal capacity remaining. The tank is never completely discharged, so it can continue to provide thermal backup in case of a chiller problem. Finally, it removes stress on Georgia Power's peak power capacity infrastructure.

ECO-AWARENESS AT UNITED PARCEL SERVICE. It's not clear that companies are in a green mood. In "IT priorities in 2008: A truly new year," SearchDataCenter.com reported that in 2008, green computing remains a minor initiative. For the moment, many companies have simply fed the energy-consumption beast by building new data centers to provide additional raw power for an increasing number of servers.

United Parcel Service is a notable exception. According to Parrino, the company's founder, James Casey, embedded the principle to always be "constructively dissatisfied" and constantly to seek opportunities to improve

United Parcel Service equates energy efficiency with increasing the useful life of the data center.

efficiency. United Parcel Service has actively gone green in its data center and views its efforts with a broader impact on the environment.

"When you look at electrical costs of $155,000 a month in our $51 billion company, it's not a lot of money for one building," Parrino said. "But going beyond that, as a good corporate citizen, UPS has learned to manage the consumption of energy in all aspects of their business. The data center is no exception. Energy capacity in the Southeast is plentiful, and there are no strains on the grid compared with the West Coast and the Northeast. But if we can begin to get people thinking about the environmental impact of waste, rather than cost, they will start to care more. Generating sources in Georgia are 64% coal, 23% nuclear, 7% natural gas, and 5% hydroelectric and biomass. Unfortunately, 0% comes from renewables." ■

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Chapter Summary Steps

1. **Build the business case** for data center energy efficiency. How much do you spend on energy now? How soon will you need to build a new data center to keep pace with company growth? Use this information to get a mandate to pursue efficiency from C-level executives.

2. **Determine a simple metric** such as power usage effectiveness to create a baseline for how much power goes to servers and how much is lost on cooling and infrastructure. Set goals to improve the ratio.

3. **Tackle IT inefficiencies** by consolidating applications, deleting deadweight servers, implementing active power-saving features and specifying energy-efficient hardware.

4. **Address facility fundamentals** by implementing hot aisle/cold aisle, sealing your data center's floor, raising the voltage on PDUs from 120 volts to 208 volts and by exploiting, when available, free cooling.

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HP is among the world's largest IT companies; with revenue totaling $118.4 billion for the four fiscal quarters ended October 31, 2008. In 2008, HP was number 14 on the Fortune 500 list. The company's corporate headquarters are located in Palo Alto, California.

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