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Building a Culture of Efficiency

Google shares best practices

Mike Eruzione
2013 SPRING CONFERENCE
KEYNOTE SPEAKER

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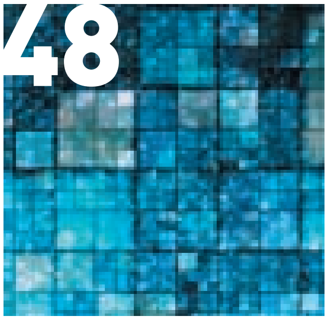

Correction

The graphic on page 40 of the Fall 2012 issue is the property of CH2M HILL | IDC Architects.

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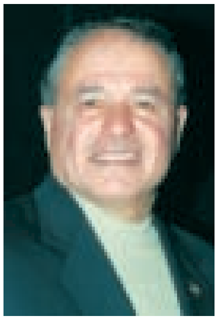
CHAIRMAN'S LETTER



Robert J. Cassiliano

We welcome in Spring with all the energy and newness that it brings!

As the economy continues its' sluggish recovery organizations look for creative ways to reduce expenses and increase profitability. In the mission critical industry that translates to clients performing cost benefit analysis on build vs. buy, cloud computing, utilizing container technology, site selection, etc. The analysis considers such factors as criticality of the application, redundancy and resiliency of the infrastructure, physical and logical security, environmental concerns, and of course the cost of the solution. As an example a critical application such as a trading or settlement and clearance system in a securities firm, a demand deposit account in a bank or a guidance system in an aerospace firm would require the highest level of robust infrastructure and security while less critical applications would not. The cost differential is significant! Today clients no longer look at cost as the price of the transaction but the total cost of ownership or "TCO". With the TCO model consideration is given to ongoing costs such as energy consumption, support, and maintenance. Once the client has completed this cost benefit analysis, it is presented to senior management for review and approval. This challenges manufacturers, service providers and consultants in the mission critical industry to focus their solutions to meet these new requirements. Companies that understand and react to new industry requirements will be successful and those that do not will face an uphill climb.

7x24 Exchange is committed to bringing awareness to the changing landscape of the mission critical industry!

The theme for the 2013 7x24 Exchange Spring Conference being held at the Boca Raton Resort & Club in Boca Raton, Florida June 2 – 5, 2013 is End to End Reliability: "Driving Performance". Conference highlights are as follows:

- Welcome Reception
- Sunday Tutorial by The Green Grid on the Data Center Maturity Model
- Conference Keynote: "Going for the Gold" by Michael Eruzione, Captain of the 1980 US Olympic Hockey Team and Subject of the Hit Film "Miracle"
- Keynotes by FIS and ViaWest
- Panel on Driving Data Center Performance – AOL/Google/IBM/Microsoft
- Tribute to an Industry Leader – Kenneth G. Brill
- Presentations by ASHRAE, EPA, HP, Intel, and the National Science Foundation
- Exchange Tables on specific topics at Tuesday breakfast and lunch
- An End-User Exchange Forum Luncheon

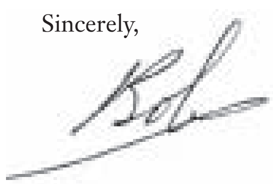
7x24 Exchange Chairman & CEO, Bob Cassiliano, presents the keynote speaker, Economic Editor for The Economist, Zanny Minton-Beddoes with a donation to the Leadership Public Schools on her behalf.

Sponsored Event: "7x24 Exchange Key West Dock Party"

The program content is designed to provide value to conference participants and their companies by focusing on important topics of the day. Performance, energy efficiency and developing trends are highlighted at this year's Spring event.

I look forward to seeing you at our Spring Conference in Boca Raton, Florida!

Sincerely,



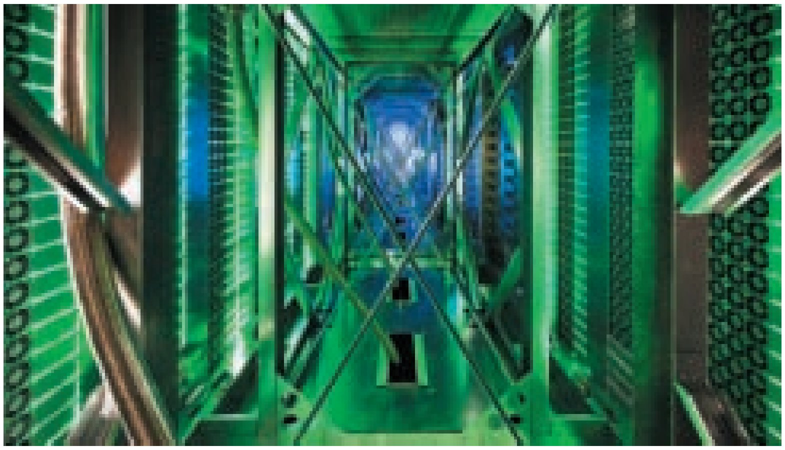
Building a Culture of Efficiency

Google shares best practices

by Joe Kava

In the far east of Finland, on the edge of an often frozen gulf, sits a large red brick building designed in the 1950s by Finnish architect Alvar Aalto. The building is unique because of the large tunnel that runs beneath it, a tunnel previously used to pump seawater to cool industrial paper manufacturing equipment. Today, this building is a Google data center—a warehouse full of tens of thousands of computer servers—and the seawater tunnel feeds an advanced cooling system that helps reduce energy use, making the facility one of the most energy efficient data centers in the world.

Colorful pipes used to pump seawater in Google's Hamina data center.



A look inside a Google Hot Hut.

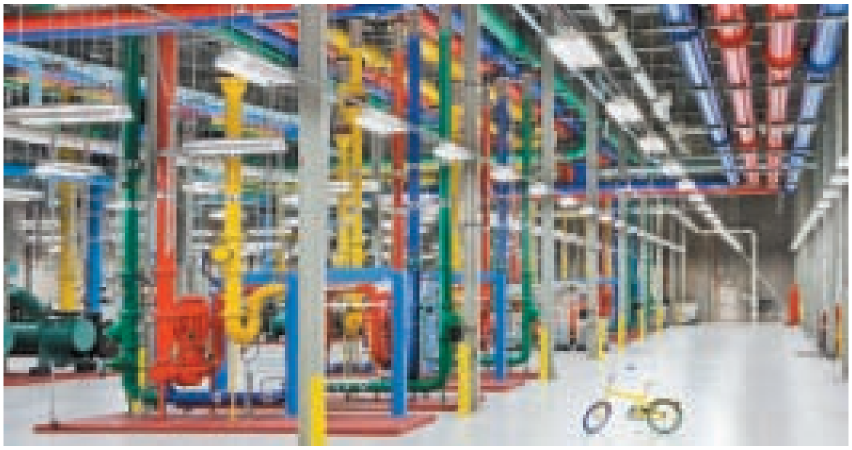
As the world depends more and more on the Internet and cloud computing, data centers have grown larger and more sophisticated in order to meet this growing demand. The tech industry has made significant progress in data center efficiency in the past few years and today, most large data centers achieve excellent performance levels and very high degrees of energy efficiency. Yet for Google, achieving a "high degree" of efficiency simply isn't good enough, and we've spent years optimizing the energy efficiency of our facilities. Efficiency and sustainability are key drivers in our overall goals as a company, and we foster this culture by empowering employees through rewarding their innovations.

Google still runs its data centers with the best practices we developed years ago, and these best practices are the foundation upon which we continue to improve efficiency gains. Cooling technologies are just one area in which we've made recent strides in efficiency gains. We've gone into great detail on our data center website about how we measure PUE in our data centers and continuously work to drive these numbers down *(http://www.google.com/about/datacenters/efficiency/internal/)*. Strategies we've found immensely effective in decreasing our energy consumption as related to cooling include increasing operating temperatures of our cold aisle to 80°F or higher and sealing hot air from the rest of the data center floor through the use of **"Hot Huts"** *(http://googlegreenblog.blogspot.com/2012/10/cooling-cloud-look-inside-googles-hot.html)*.

Google's efficiency strategy also focuses on designing cooling systems based upon the specifics of a particular geographic site. While our cooling system in Finland uses seawater cooling to capitalize upon location-tailored efficiency solutions, our South Carolina data center is experimenting with stormwater cooling, while our cooling infrastructure in Georgia uses a recycled water system.

Efficiency dictates constant refactoring and refreshing, which means that our teams regularly measure and meticulously fine tune the energy efficiency of our data centers. Remaining steady state is simply not good enough, and a culture of efficiency means that all of the players at Google contribute to the process of innovation. Some of these ideas roll out at the high level of infrastructure planning, but even common sense, ground-level innovations can have huge impacts. Even after Google achieved remarkably low PUE through the cooling strategies mentioned above, we weren't satisfied. We dug down to another level on which we could save energy—networking rooms, turning to meat locker curtains to isolate hot and cool air zones of the

Our Berkeley County, South Carolina data center is currently experimenting with stormwater cooling. This reservoir collects rainwater runoff.



Google's Georgia data center uses a recycled water cooling system.

data center—a simple tweak to our temperature control system that yields huge efficiencies. This is just one example of how rigorous application of some simple best practices that will work in almost any data center, large or small, contributes to the high level of efficiency we've achieved in our data centers.

Google's quest to increase efficiency extends beyond just cooling solutions—for instance, take our data center e-waste recycling program. When server parts break, we first try to repair them. If we can't repair the parts, we separate them into raw materials (steel, plastic, copper, etc.) and recycle the components. Since 2007, we've remanufactured and repurposed enough outdated servers to avoid buying over 300,000 new replacement machines.

So how does Google manage to instill a culture of efficiency across all levels of its data center organization? Google's organizational structure allows us to look at the picture holistically. The same organization designs, builds, operates, and pays all the bills for our data centers, meaning that we're all aligned in the goal to build and operate the most efficient data centers possible.

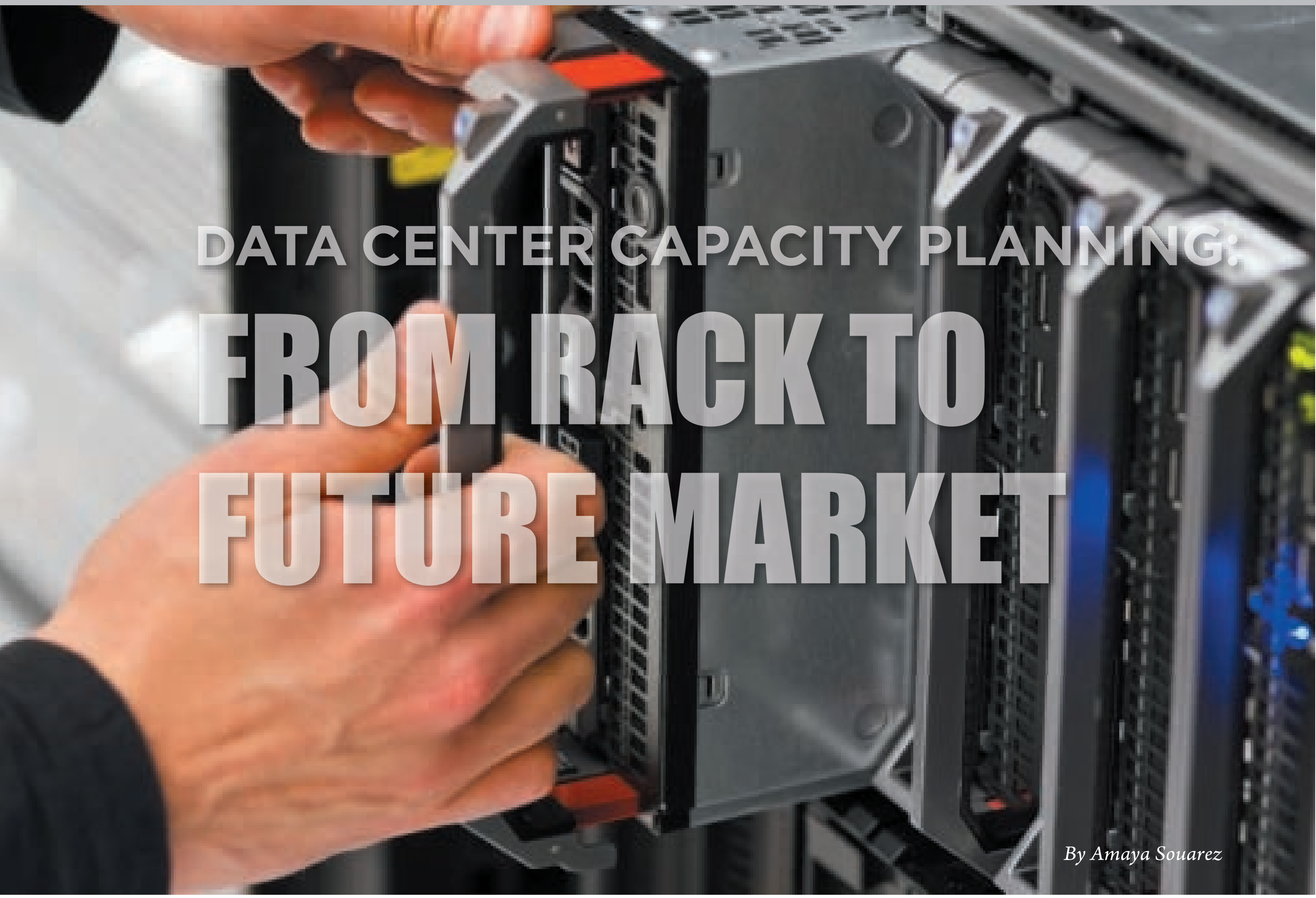
A culture of efficiency also mandates anticipating future needs and innovations—being thoughtful about the design of the conditions to which your data centers may need to adapt in the future. Google custom-builds its own server racks with the full knowledge that as technology advances, fleets of machines will need to be upgraded and swapped out. Implementing modular, swappable design means that we don't have to reinvent the wheel with every round of upgrades. A data center design plan that optimizes for flexibility up front can make it much easier to take advantage of efficiencies moving forward.

Google operates based upon a culture of efficiency for several reasons. Embracing this culture makes sound financial sense and delivers big cost savings, ensures that we can remain a carbon neutral company, and allows us to deliver services for our users at near magical speeds. But the truth is, there's no magic in data center efficiency. Our teams are constantly challenged to find new ways of delivering additional efficiencies to build sustainability practices into our operations, from simple onsite recycling to building greywater systems; and to do so as cost-effectively as possible. With a little time and effort, any data center facility can implement a culture of efficiency to create benefits both financial and environmental.

Joe Kava is Vice President of Google Data Center Operations. He can be reached at jkava@google.com.

Meat locker curtains provide a low-cost method of greatly improving our temperature control strategy in networking rooms.

By designing our own racks and servers to be highly modular, implementing a swappable design makes capitalizing upon efficiency gains easier moving forward.



DATA CENTER CAPACITY PLANNING: FROM RACK TO FUTURE MARKET

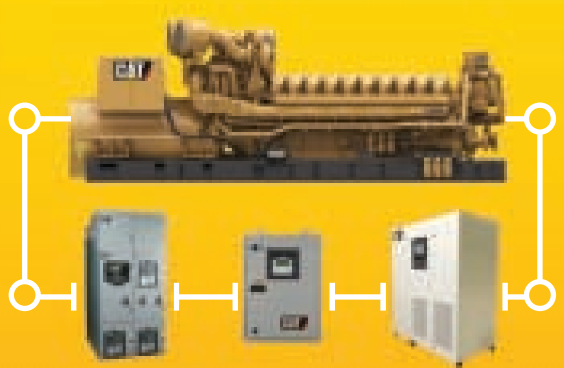
By Amaya Souarez

Capacity planning for data centers is a unique business challenge, and is not a one-size-fits-all problem. All data center owners, hosting providers, and cloud strategy planners will at some time deal with a capacity planning issue. The complexity of managing capacity is accelerated in the cloud services industry, due to volatile demand and rapidly changing market conditions.

This article provides simple methods for tracking data center capacity, and is based on processes developed during my time on the Microsoft data center capacity planning team. It covers how to approach future demand vs. supply matching starting at the rack/circuit level, moving to data center and colocation planning, and beyond to future market planning. The methods are based on a foundational understanding of data center engineering, combined with business planning and supply chain principles.

The data center capacity planning team at Microsoft was established in March 2006 at the same time we built our first large-scale data center in Quincy, Washington. The team was tasked with improving communications with internal product and services teams, collecting demand input in terms of IT equipment, and developing future data center capacity plans. Today, the role of our data center capacity planning team has expanded greatly, and has several main responsibilities:

- Aggregate all data center demand from Microsoft's business teams and match it against supply to meet business requirements, and tightly integrated planning with online service application, networking, security, data center architecture, engineering, construction, and operations teams
- Provide signals for future data center expansion, consolidation, and decommission
- Provide data and analytics for total cost of ownership (TCO), financial planning, efficiency, and cost allocation to each cloud service



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- Analyze future markets and obtain approvals for market entry, working with legal, tax, trade, risk and compliance teams
- Communicate future data center roadmap to stakeholders across the company

The key goal of the data center capacity planning team at Microsoft is to ensure sufficient capacity is in place to meet the demand of our customers, while at the same time not wasting valuable data center capacity. In order to achieve this goal, I recommend adherence to the following principles:

1. Make data-driven decisions
2. Know your data center footprint - by tracking units of supply
3. Know your customers - by tracking future demand units

In many ways, the first principle is the foundation of success and supports the other two principles. Regular collection and tracking of supply and demand data is useful for much more than capacity planning, and enables analysis of the cost and efficiency of your data center footprint. The best approach is to simply collect the data that is initially available, and build from there. Once your management team sees the value of this basic data, it will become easier to obtain approval to invest, and implement advanced monitoring, data collection, and data warehousing systems. Getting started with the basics also allows you to gain knowledge of existing facilities' infrastructure, before attempting implementation of expensive systems. You could discover that circuit panels and other plant equipment, or connectivity to the equipment, is insufficient and requires significant investment in as-built documentation, equipment retrofit, or even complete replacement to support the telemetry required.

RACK-LEVEL CAPACITY PLANNING

Principle number two, "Know Your Footprint", starts at the rack level with documenting units of rack capacity in both physical rack units and in Kilowatts (kW), based upon the circuits provisioned to support the rack. Tracking your rack capacity in kW is also important to ensure that you are properly managing power distribution on the data center floor and not causing circuit overload. In addition, consider the concept of 'budgeted' rack capacity. Often additional racks and circuits are provisioned beyond the total room capacity, and therefore each rack is assigned a 'budgeted' limit.

When the capacity planning team first started, we used an Excel tool to manage data center capacity. This tool performed a nightly data pull against the asset database tracking all racks, servers, and other IT equipment. The tool used a simple table to correlate rack power capacity with the rack asset data pulled each night. This enabled us to view the total assets installed in a rack against the total allocated and budgeted power for the rack. Below is a sample rack capacity spreadsheet:

To further refine tracking of your rack footprint, data on the daily peak load on the circuits assigned to the rack can be collected. At Microsoft, we have installed branch circuit monitoring and currently focus on direct server power monitoring. Therefore, the data being collected varies depending upon the technology deployed at each site. Many companies will use a variety of power monitoring systems at each data center location. In the most rudimentary form, power load can be manually captured periodically by the facilities team onsite, without the use of automated power monitoring systems, and this can be a start to determining the peak circuit load by rack. This data can then be used to ensure that power allocation is appropriate and circuits will not be overloaded. Over time, automated data collection is extremely useful and can be used to help optimize the footprint.

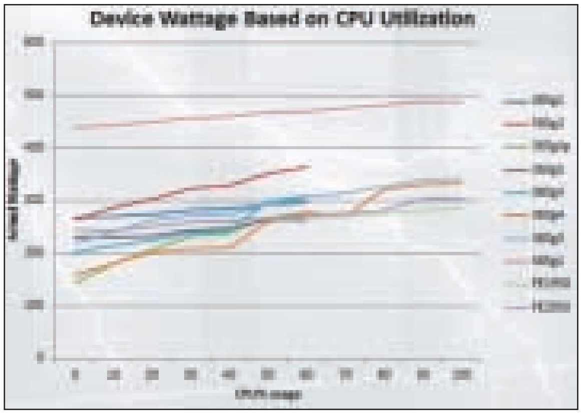
Finally, principle number three, "Know Your Customer," starts at the rack level with understanding demand units for rack capacity, which encompass the specifications of the IT equipment being deployed into the racks. The simplest methodology is to determine the average watts per server for your existing footprint as a basic unit of demand to help normalize all IT equipment power allocation against the server units. Each footprint needs to be analyzed to arrive at the appropriate number, which then you can apply to both the existing footprint and new demand. To determine the allocated watts per server for your footprint, track the

Rack Name	Electrical Limit	PDU Count	PDU Rating	RU Capacity	Budget Limit (Watts)	Allocated Power (Watts)	IT Consumed (Watts)
L1.AM109	14410	2	50	42	8277	8584	5097.55
L1.AH110	14410	2	50	42	9680	2762	1321.23
L1.AH111	14410	2	50	42	9680	2762	1980.6
L1.AM104	14410	2	50	42	9680	5202	3712.75
L8.AG012	14976	4	30	58	7987	7044	3396.58
L8.AG013	14976	4	30	58	7987	1702	1555.17
L8.AG014	14976	4	30	58	7987	1809	1495.18
L8.AG016	14976	4	30	58	7987	3729	3800.17
L8.AG017	14976	4	30	58	7987	8157	3418.58
L8.AG018	14976	4	30	58	7987	5577	2496.48
L8.AG020	14976	4	30	58	7987	1147	1238.92
L8.AG021	14976	4	30	58	7987	675	0

peak daily load of all IT equipment and total server count at each site, over the course of at least a month, and then calculate the average watts per server.

Next, to determine the device ratings for each type of device using the manufacturer nameplate rating, an intermediate methodology for determining the demand units of both your existing footprint and new IT equipment being deployed into your sites is needed. This requires documentation of all model types, whether network switch gear, server, drive bays, remote access devices or other peripheral devices, and the manufacturer ratings of each model. It is a best practice to store this data with the physical asset information in an asset repository. For future demand, collect this data prior to deployment and leverage it to determine whether new equipment can be accommodated in a given rack.

Beyond this, there are many ways to further refine the device ratings. After tracking IT equipment load for some time, it will become clear that the manufacturer nameplate ratings may not reflect actual peak wattage utilization, as some IT equipment is under-utilized and runs at much lower peak and average central processing unit (CPU) utilization. It is recommended to test all devices, using commonly available load tools to increase CPU utilization, while measuring the power load at various levels of CPU utilization. Once this information is collected, it is possible to apply a deeper understanding of application performance requirements against the entire device portfolio and refine the total allocation of rack capacity by device ratings. For example, a particular server model may utilize 200 watts at 50 percent CPU utilization, and 185 watts at 35 percent CPU utilization. Looking at the applications deployed on the particular model, one application may average between 20-30 percent CPU utilization, while another pushes the server up to 45 percent CPU utilization. Therefore, the device ratings can be applied at varying levels depending upon the planned application usage. Keep in mind, however, that both data center and device monitoring, including monitoring of circuit load, CPU, and storage utilization is required or you will run the risk of circuit overload as application usage can change dynamically.



Finally, it is critical to develop a deep relationship with all your customers, whether internal or external, by staying engaged and seeking to understand what IT equipment types are planned in the future, and what is the rhythm of business (ROB) for releasing and testing new hardware platforms to be implemented. In addition, data from power monitoring, as well as historical demand data can be provided to customers to inform their future IT equipment choices. A collaborative relationship with customers will drive the best infrastructure optimization of both data center and IT design.

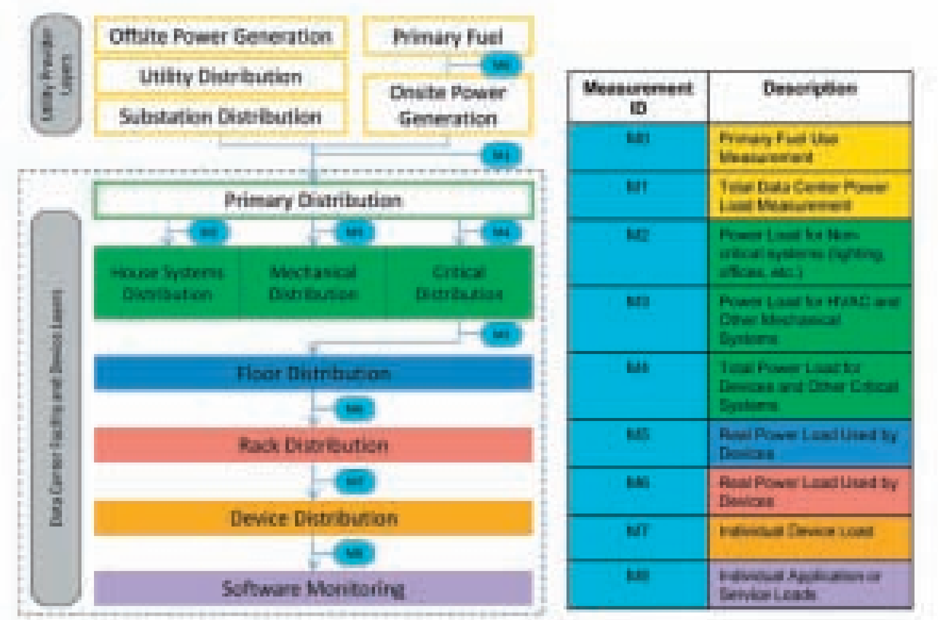
COLOCATION AND SITE CAPACITY PLANNING

Moving up to the colocation (room or cage within a data center) and site-level of capacity planning, longer term preparedness is required. At this level, data for the entire location is required to determine the supply units to "Know Your Footprint." The supply units must reflect an understanding of the total utility capacity and the power distribution within the site, even in cases where a company leases a small cage or room within an existing site. For any lease it is important to understand the backend infrastructure and review the available engineering diagrams from the lessor prior to entering into the lease. If a data center's electrical capacity of a room is overloaded an outage can impact multiple customers. Lastly, store documentation explaining the total useable capacity at each site, and track changes over time, for all sites in a portfolio.

In the early days of capacity planning, with little information about each site, we used a simple 90 percent rule to determine the useable IT equipment capacity at each site. For each site, we collected information about the nominal uninterruptible power supply (UPS) capacity. In the case of leased space, we also look at the total circuit capacity within the lease and set useable capacity at 90 percent of the total critical capacity. This is a basic rule of thumb still being used by many companies today and helps to account for distribution losses between the UPS and rack circuits.

Taking the next step to refine the supply units and document the useable capacity at each site, you will need to invest both time and money to refine the data, depending upon the plant equipment at each site. In addition, it is advisable to track peak load on the facility's mechanical and electrical equipment to further refine your site profile data. The diagram on the next page represents potential power metering points within a data center.

A simplified set of demand units is recommended, as the forecast will normally be longer-term, starting 12 months out at the earliest. Long-term forecasts tend to be less accurate, and therefore deep and ongoing customer engagement is required. Each customer will have a distinct ROB for determining their future cloud infrastructure needs. Knowing this ROB will allow you to collect the latest long-term forecast on a regular basis from each customer. Over time,

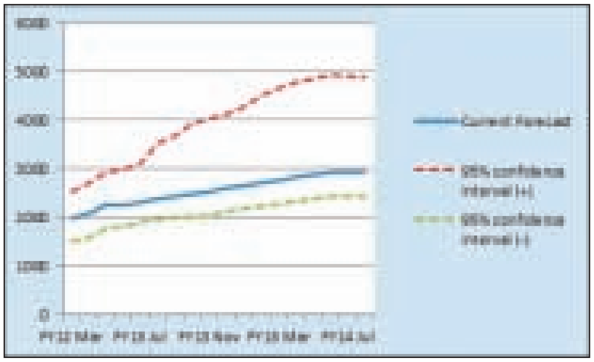


Potential power metering points within a typical data center

the accuracy of each customer's forecast can be tracked against their actual capacity allocation, and used to perform "Monte Carlo" simulations and adjust future forecasts.

Once demand and historical allocation of capacity for each customer has been collected regularly, quantitative analytics will be extremely helpful to develop predictive demand models since future forecasts tend to be extremely volatile in the cloud services industry. In future years, the forecast, historical data, and additional demand signals can be continuously studied and provided back to your customers to assist in the refinement of future demand signals.

A sample customer model output showing that they have been consistently under-forecasting.



FUTURE MARKETS CAPACITY PLANNING

Today, many data center providers are grappling with the need to serve additional global markets. From resource constraints to regulatory to political challenges in specific locations, making a decision to enter a new market can be risky and requires substantial research before making an investment. To determine beneficial data center locations that will satisfy the requirements of your current and potential customers, it is important to collect market growth data for each global market and engage your current customers to understand their market reach plans. Some customers will plan to serve all global markets from a few hosting locations, whereas other customers may have requirements for hosting in specific locations closer to end-users. At a minimum, you need to know your customer's future market plans, latency or round-trip time, and fault tolerance requirements, as well as the current market growth of each customer.

FINAL THOUGHTS

Data center capacity planning requires an in-depth understanding of your data center portfolio and customer demand. Collecting all possible footprint and customer data will enable strategic operational and business decisions. As the industry grows and expands globally, each company will need to prioritize the challenges of rack, colocation, and market capacity planning to meet their business goals. To learn more about Microsoft data centers, please visit our web site and data center team blogs at http://www.globalfoundationservices.com.

Amaya Souarez is Director of Strategy and Automation for Data Center Services at Microsoft Corporation.
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Elevate UPS Efficiency with "Intelligent" ECO Mode

by Peter Panfil

Budgets are tight for many businesses, and demands on infrastructure continue to multiply. This harsh landscape, coupled with increased data center energy costs and pressure from the C-suite, has created a formula for frustration for many data center managers. To combat this stress, data center managers are reviewing aspects of their data centers, including power distribution systems and UPS systems, to discover opportunities to increase efficiency.

There are many options to incrementally improve power system efficiency. These choices typically involve either moving components in the power path, changing an aspect of data center operations (such as raising the distribution voltage), or using more efficient components. One choice with which many data center and facility managers are familiar is the energy-saving mode of operation for UPS systems, or "eco-mode". This form of operation has long been promoted in the industry as a way to increase UPS energy efficiency and reduce the operating expenses experienced in the data center. It accomplishes this by switching the UPS to static bypass during normal operation. When power problems are detected, the UPS automatically switches back to double-conversion mode.

Despite the promise of efficiency gains, many data center managers have dismissed the technology because of availability concerns. However, the use of eco-mode recently has been gaining support in the industry. The Green Grid™, a global consortium of companies, government agencies and educational institutions dedicated to advancing resource efficiency in data centers and business computing ecosystems, included eco-mode in its Data Center Maturity Model.

The Environmental Protection Agency (EPA) also mentions eco-mode in its ENERGY STAR® for Uninterruptible Power Supplies specifications — which took effect in August 2012 — as one of the operating modes for efficiency improvements.

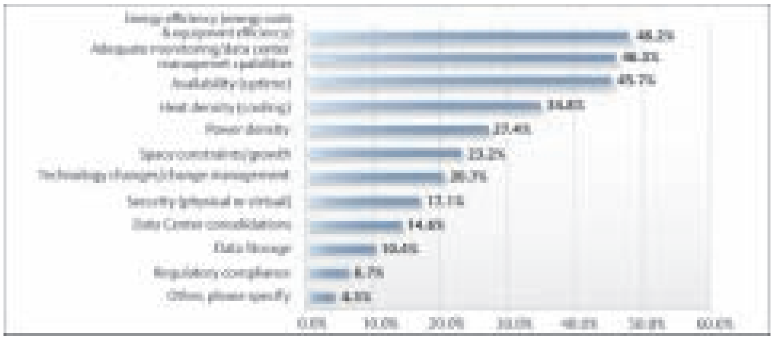

Figure 1. Data Center Users' Group members identified top facility/ network concerns.

Much of this support is a result of recent advances in technology that provide reasons why eco-mode deserves a second look. The key to any eco-mode evaluation is the performance it affords the user and whether that performance can meet the data center's particular requirements without experiencing downtime. A new "active inverter intelligent eco-mode" approach has emerged as a viable option for data center managers looking for big efficiency gains that do not compromise availability.

Spotlight on Energy Efficiency

Data centers are currently undergoing a period of great change. New technologies such as virtualization and cloud computing are transforming data centers into dynamic environments, optimizing the space in ways few could have predicted only a few short years ago. As a result, those responsible for their management are struggling to keep pace with growing capacity needs while also working under the constraints of tightened budgets and efficiency initiatives.

In fact, recent results of the fall 2012 Data Center Users' Group™ member survey, sponsored by Emerson Network Power™, show that data center managers are increasingly concerned with energy efficiency. The survey results show that data center energy costs and equipment efficiency has once again become the top-of-mind issue for data center professionals. When asked to identify their top three facility/network concerns, 48 percent of respondents cited energy efficiency, making it the leading response to the question. (See Figure 1.)


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The issue of energy consumption first emerged in the No. 3 slot in the 2007 Data Center Users' Group survey as data center power usage significantly increased and the U.S. economy entered a deep recession. IT organizations began to look seriously at energy efficiency in terms of cost savings as well as environmental responsibility. By spring of 2009, efficiency had moved to the second position.

Energy efficiency dominated industry discussions until a rash of well-publicized data center outages in 2009 led to increased downtime. In the wake of those outages, respondents to the fall 2009 Data Center Users' Group survey showed a renewed respect for availability. It jumped from the fourth most important concern just six months earlier to the number one concern. Availability remained among the top three concerns in 2010 and 2011 while energy efficiency became the fourth concern of data center managers from fall 2009 to spring 2011. While efficiency rose to the top of the list with the fall 2012 survey results, availability remains a top concern. (Nearly 46 percent of respondents cite it as a top concern; placing it third on the list.) (See Figure 1.)

The UPS System: Availability vs. Efficiency

The Data Center Users' Group survey findings highlight one of the biggest dilemmas data center managers face today: increasing efficiency while maintaining or improving availability in increasingly dense computing environments. These sometimes conflicting objectives are one of the primary reasons some data center managers have been hesitant to implement eco-mode in their data centers.

The availability concern comes down to economics. The increasing reliance on IT systems to support business-critical applications has forged an even stronger connection between data center availability and total cost of ownership (TCO). One significant outage can be so costly that it wipes out years of savings achieved through incremental efficiency improvements. The actual costs associated with an unplanned outage are stunning. According to a Ponemon Institute study, an outage can cost an organization an average of about $5,000 per minute. That's $300,000 in just one hour.

Given these factors, it is easier to understand why eco-mode, while gaining a lot of attention in the industry, carries the stigma of providing less protection when compared with double conversion. Because the transfer of the eco-mode UPS from one operating mode to another may entail a momentary interruption and not all eco-mode UPSs provide the same performance with regard to transfer times, the eco-mode of choice must also meet the most demanding transfer times required by critical downstream loads, such as any surge protection or static transfer switches.

The internal design of a UPS system determines how the UPS processes incoming utility power and, ultimately, the effectiveness of the UPS at protecting against certain types of utility power disturbances. AC power UPS systems can have several modes of operation, the most ideal for mission-critical data centers being double-conversion mode. This mode is the only one that protects against the full range of power disturbances. (See Figure 2.)

Double-conversion mode is the most widely deployed UPS topology in mission-critical data center applications and is also known as voltage/frequency independent (VFI) mode as defined by IEC standard 62040-3. This mode is when the UPS provides a stable output voltage and stable frequency to the connected load(s) independently of the input AC voltage and frequency. Online double-conversion systems can tolerate wide power fluctuations without transferring to battery power. They also completely isolate mission-critical systems from the power source, preventing equipment-damaging power anomalies from passing through.

In double-conversion UPS systems, the rectifier and inverter are designed to run continuously with the rectifier directly powering the inverter. The incoming AC is rectified to DC, which is then converted back to AC by the UPS inverter, resulting in a low-distortion, regulated, stable AC output voltage waveform. This AC-DC-AC conversion process is about 93 to 95 percent efficient. This five to seven percent lost in the conversion process has traditionally been accepted as a reasonable price to pay for the protection provided by the UPS system.

With eco-mode, the double-conversion process can be bypassed, and efficiency increased when utility power is determined to be of acceptable quality. When the utility power quality is outside the voltage tolerance, the UPS will transition to a more protective mode and the efficiency could be lower than expected. Understanding the quality of the utility power is important for deploying UPS eco-mode in such a way that the data center will realize the expected energy efficiency improvements.

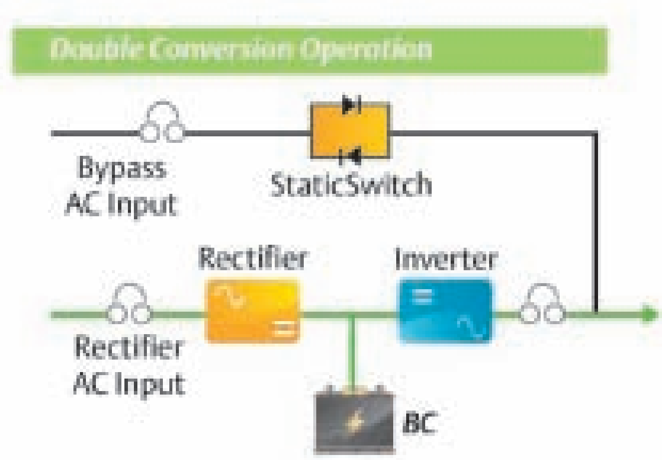

Figure 2. Double-conversion mode is most widely deployed UPS topology in mission-critical data center applications.

Is My Facility's Power Sufficient to Utilize Eco-mode?

To determine if facility's power is sufficient to operate a UPS in eco-mode, gather power quality data from the data center.

- Most data center sites should have power quality metering devices provided by their utility service. These power meters can measure and track the incoming utility power.
- Power quality meters can be programmed to track, over time, utility power quality disturbance events and duration relative to voltage immunity requirements.
- Data center operators can use standard voltage immunity curves programmed inside a power quality meter to accurately track the number of power quality events that occur and the duration of these events outside their voltage immunity requirements.
- This site-specific information needed to guide the eco-mode UPS application also can be obtained from a detailed power assessment from your UPS provider.

Eco-mode powers the critical load via the AC bypass path and is known as voltage/frequency dependent (VFD) mode. IEC standard 62040-3 defines eco-mode as the time when the UPS output voltage and output frequency are identical to the input voltage and frequency from the AC source. Should the bypass AC source exceed acceptable voltage or frequency limits, the UPS will instantaneously change over to double-conversion mode.

The primary reason data center managers have not implemented eco-mode is because, for conventional eco-mode systems, the critical output voltage goes to zero volts during a utility loss event until the static bypass can be turned off and the inverter and rectifier turned back on.

With many implementations of eco-mode (See Figure 3.), when the critical load is being powered through the bypass (i.e., eco-mode), the rectifier and the inverter are switched off, resulting in a delay and a notch in the output waveform when the critical load returned from eco-mode to double-conversion mode. (See Figure 4.) That notch appears as a zero current time in the supply and causes concern in the mind of the facility engineer because of the compromise to availability.

Conventional Eco-Mode Shortfalls

For most types of UPS systems, the inverter is not robust enough or controlled well enough to run in parallel with the static bypass utility source. This is where active inverter intelligent eco-mode improves upon the traditional eco-mode approaches. This innovative technology enables the UPS system to run its inverter in parallel with the static bypass source. It also helps provide superior output fault-clearing capability (i.e., the ten times current fault

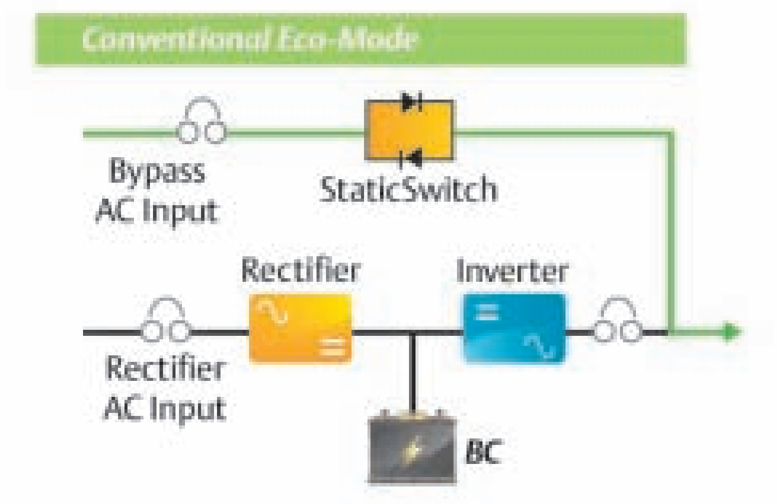

Figure 3. With conventional eco-mode, the rectifier and the inverter are switched off.

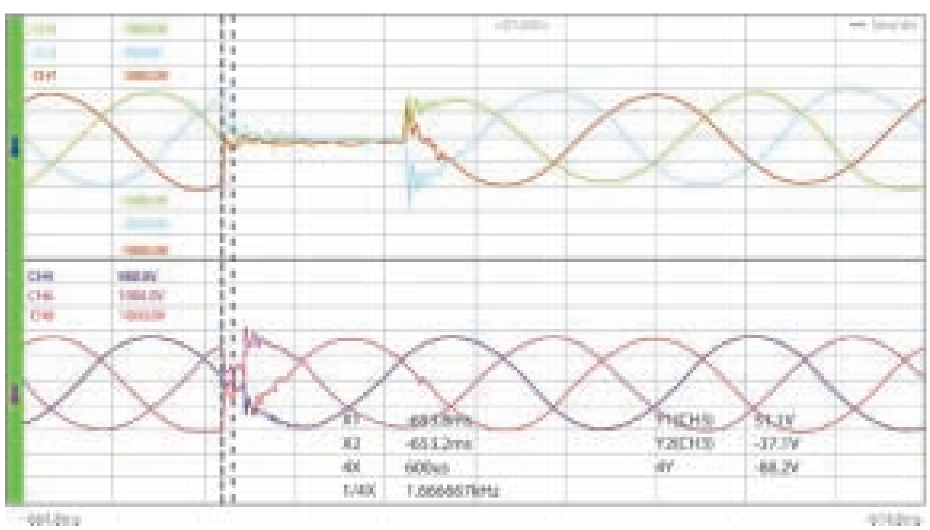

Figure 4. With conventional eco-mode, a notch in the output waveform occurs.

rating of a continuous duty bypass static switch paralleled with the two times fault current rating of the UPS inverter), allowing a downstream fault to be quickly cleared in order to achieve high levels of critical bus availability over dynamic conditions.

The active inverter intelligent eco-mode approach (See Figure 5.) eliminates traditional eco-mode issues by keeping the inverter and rectifier in an active state. Because the inverter is kept in an active state, and is providing an output that matches the bypass, it is ready to accept the load immediately. As a result, the transfer to the inverter can be accomplished almost seamlessly. (See Figure 6.) When the UPS senses bypass power quality falling outside accepted standards, the bypass opens and transfers power immediately back to the inverter until bypass anomalies are corrected. Once bypass power anomalies end, the critical load can be automatically returned to intelligent eco-mode.

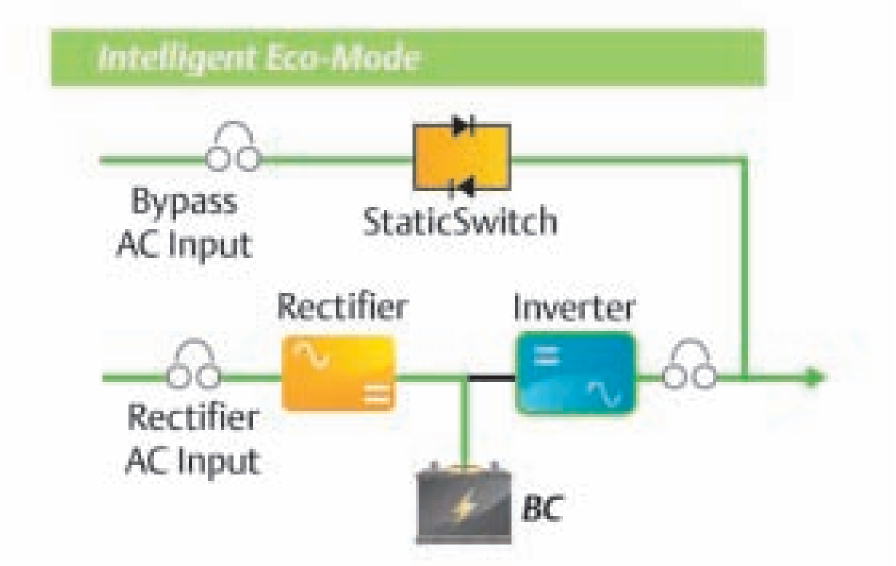

Figure 5. Active inverter intelligent eco-mode offers a more seamless transfer and possible UPS efficiency level of 98 to 99 percent.

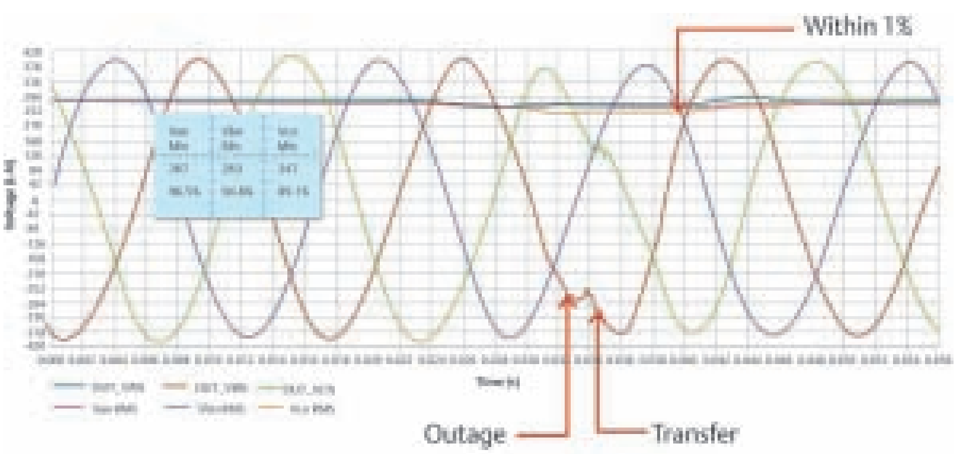

Figure 6. With active inverter intelligent eco-mode, the transfer can be accomplished almost seamlessly.

Keeping the inverter in a constant state of preparedness does require additional power; however, the power requirement is below one percent of the UPS-rated power, creating potential savings of four to five percent compared with traditional double-conversion operating modes. The result is a more continuous output wave form, a more seamless transfer and possible UPS efficiency levels above 98 percent.

Also, keeping the rectifier in an active state ensures a constant float charge across the UPS battery, which is shown to have a significant impact on battery life. Constant float charging is the recommended method of operation from battery manufacturers. Research has shown that not maintaining a constant float across the UPS battery can accelerate grid corrosion, which can result in a reduction in battery life up to four times faster. Also, with the rectifier available during the transfer back to dual conversion, cycling of the battery when changing modes is avoided.

Data center managers who may have dismissed energy-saving modes as a viable option because of availability concerns are encouraged to give the technology a second look. An active inverter intelligent eco-mode approach can increase efficiency levels and eliminate much of the compromise to availability experienced by conventional eco-mode approaches available in the past.

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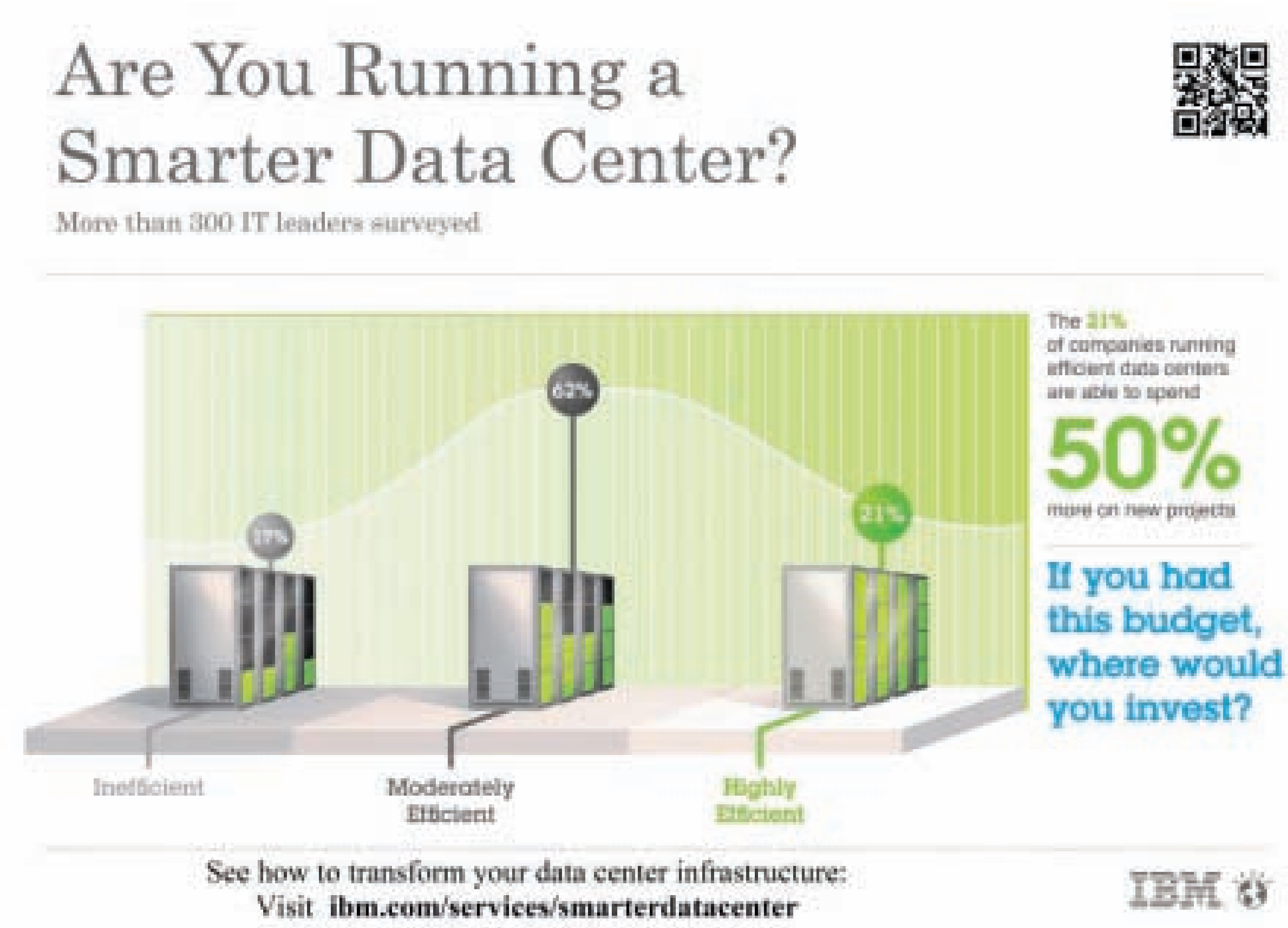
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Recovering from Disaster:

THE POWERFUL NEED FOR EVENT RECONSTRUCTION

The absolute necessity of reliable electric power in data centers is indisputable. Data center availability has become the Achilles' heel of a company's success due to the high economic impact of outages. According to a survey by the Aberdeen Group, businesses lose an average of $138,000 for every hour their data centers are down. Data center designers strive to optimize their reliability through redundancy and maintainability, two hallmarks of power systems. But, does that ensure complete reliability?

by Bill Brown, PE and Mark Kozlowski

The Reliability Paradox

The principles of reliability put a limiting factor on just how reliable any engineered system can be. No component or engineered system can operate indefinitely without failure, no matter how well designed. Even Tier IV systems are subject to this statement, as evidenced by representative site availability figures which are less than 100%.

The cold reality implied is at odds with the reassuring reliability built into data center power systems. In well-designed systems with reliable components, the probability of an incident is quite low, but it is non-zero. A rigorous testing and maintenance program, if designed and executed successfully, will help to enhance the reliability of the individual system components.

However, taking reliability to the next level requires an incident mitigation strategy to properly deal with incidents as they happen. Simply stated, the two crucial goals of any incident mitigation strategy, in the aftermath of an incident, are:

1. *Determine what happened*
2. *Keep it from happening again*

In reality, both of these activities are challenging. Determining "what happened" requires a predesigned infrastructure for this purpose and has its own set of challenges. "Keeping it from happening again" implies a zero probability of the incident occurring in the future, which is not possible. Instead, the probability of reoccurrence is minimized. This may require system redesign or component replacement or both.

Why Worry About Event Reconstruction?

Any power system incident may be categorized into a series of events. The system starts in the pre-event steady state operating condition and changes after each event.

Each event may trigger another event or events, which in turn trigger other events. The intermediate states are non-stable or quasi-stable that cannot be maintained without causing another event. This cascading series of events will eventually stop, leaving the system in either an operating, partially operating, or non-operating condition.

This begs the question: "What caused the first event?" The answer could be one of two things: an occurrence external to the system or an occurrence internal to the system. In the case of an external occurrence, the initial operating condition could indeed be treated as a true steady state condition. In the case of an internal occurrence, the system is actually changing states very slowly — so slowly that the system appears to be in a steady state condition before the first recorded event.

In some cases, a single event causes the system to go into an operating state that triggers multiple events. Such multiple events add to the confusion as they may or may not be the root cause of the resulting system state, only a consequence of the system being in the previous state. Further, external occurrences, while a system is in a non-stable state, can cause complications.

Adding to the inherent complexity of the shifting system states is the fact that many of the events are not directly measurable with the human eye. In fact, many events are measurable only by their effects. Instrumentation is required to measure these events or their effects, and this instrumentation must be built into the infrastructure of the system, continuously monitoring specific quantities as designed. These are not limited to current and voltage, but also must include the states of over current protective devices and protective relay status.

The first part of reconstruction is accomplished via sequence-of-event recording (SER). A crucial complication is that the only way to sequentially order these events is through a record of the times at which they occur, and the timing of events in an electrical system is much faster than their counterparts in the mechanical world. Due to the number of events and the time-frames involved, this must be done automatically by power monitoring equipment built into the system infrastructure. This equipment must have the capability to make fast measurements of system parameters, usually in multiple pieces of equipment, and put them into time order.

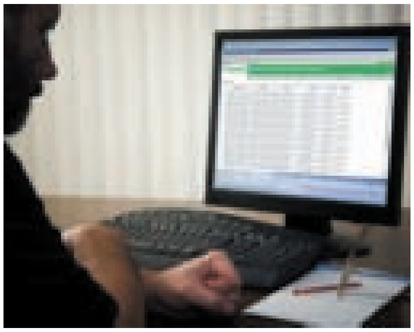
This time ordering of the recorded events from different pieces of equipment is the first part of event reconstruction. Once the measurements are ordered, the events themselves may be reconstructed and analyzed so as to arrive at a root cause of the incident. This second part uses knowledge of the system to describe the cause of the event sequence, and how one event led to another.

The measured parameters are coalesced into an ordered sequence of events and resulting system states, with each event leading to a new system state until the system reached a state which was maintainable for a relatively long period of time. In reality, there is really never such a thing as a true steady state, only states where changes are occurring slowly enough not to be noticed, such as aging equipment. Because some state changes are that minute, it is classified as a steady state.

The conclusion is inescapable: even a well designed system is in a constantly changing state. Ultimately, the net result of these state changes could be a sequence of events that has enough effect to be noticed. This highlights the need for event reconstruction if system reliability is to be optimized in the aftermath of an incident.

Time – The Crucial Factor

Just how fast is "fast enough" for measurements in the electrical environment? Most phenomena of interest in an electrical power system environment occur on timeframes that can be measured in milliseconds, while a few, such as lightning strikes, occur on timeframes measurable in microseconds. To account for more complex events which occur in different portions of the power system and incidents where multiple events are triggered at close to the same time, a time accuracy of 1 ms between different recording devices is the generally-accepted norm for SER.



Recording Hardware/ Software Considerations

In general, SER requires three specific data types for an effective system:

1. Measurements of specific system parameters such as current, voltage, and frequency, at predetermined thresholds
2. Status of devices which typically have a binary (on/off) state
3. Voltage and current waveform capture

The high-end digital power monitoring devices typically used for SER in data center power systems exhibits the following features:

- Instrumentation channels for three-phase current and voltage at the device location
- Current and voltage measurements with 0.1% accuracy or better
- Sampling of waveforms at up to 500 samples per cycle, with optional increased sampling rate for detection of medium-to-high duration of impulsive transients
- Calculation of almost all conceivable system quantities, including power quality indices, using the sampled data
- Data logging capability with 1 ms resolution, with a large on-board non-volatile memory for log storage
- Waveform capture capability, with adjustable pre- and post-cycle capture duration and sampling rate
- Discrete logic input capability, for sampling of status type events
- Capable of time synchronization via IRIG-B or other industry-standard serial time code

- Communications capability via industry-standard serial protocols, with optional Ethernet connectivity

Other sources of event data include microprocessor-based protective relays and low-voltage circuit breaker trip units. Although such devices do typically have metering, waveform-capture, and data logging functions, the metering functions are generally not as accurate as those available in a high-end power monitoring device. This data may be logged internally by the device, in which case the device would have on-board memory, time-synchronization and network communication requirements similar to those above. Alternatively, the data may be logged as a discrete input to a power monitoring device or discrete status input module.

No SER system would be complete without the proper software and operator interface. The software should be able to gather the events from the various recording devices and put them in time-order for ease of use. Typically, the same software used for general power monitoring can also serve as the software for the SER system, since the data is generated by the same physical devices and SER functionality is usually incorporated into the software. In larger systems, more than one computer workstation may access the recorded data to make the data access as convenient as possible; in this case a central server or servers would typically be used.

Where is SER Required in a Data Center Power System?

Unfortunately, there is no clear cut laundry list of locations that require SER in a typical data center power system. The cost of SER at each location must be weighed against the potential benefits to be gained for each particular case. The first step in identifying event recording locations is to identify the types of potential events to be recorded. Typical events that fall into this category are:

- Loss of utility voltage
- Generator start-up
- Frequency and voltage excursions while on generator power
- Automatic transfer switchgear/switch operation
- All UPS switchgear operations
- UPS input and output voltage abnormalities
- Cable faults

This list is by no means exhaustive. However, it gives emphasis to locations "higher" in the power system, closer to the utility service and generators, over locations "lower" in the system, downstream from UPS's. In most cases, the cost/benefit balance is achieved by including SER from the utility service and generators down to the UPS outputs only.

SER as the Hidden Key to Reliability

The reliability of a data center's electric power system is a critical part of the overall reliability of the facility. Because all electrical components, no matter how well designed, have non-zero failure rates, the electrical system as a whole will have an availability of less than 100%. Even if an incident does not lead to an outage, it can lead to an operating condition which is less reliable than desired. Therefore, it is critical to have the ability to diagnose past system incidents. SER technologies fulfill this requirement.

The basic requirements of electric power SER systems is that they be time-synchronized to 1 ms, have recording devices which are able to time-stamp events down to 1 ms resolution, and have a network architecture which allows data to be gathered from a central location. A good deal of the cost of such a system is typically built into the facility's power monitoring system, which provides additional benefits in addition to SER.

A carefully planned SER system, implemented with the proper placement of recording devices, will allow diagnosis of most power system incidents. This capability — the ability to "see into the past" with great accuracy and precision — is invaluable to keeping the data center's electric power system at peak reliability, minimizing the possibility of repeat incidents, and planning facility upgrades in the most reliable manner possible.

Bill Brown, PE and Mark Kozlowski are Principal Engineers at Schneider Electric. They can be reached at bill.brown@us.schneider-electric.com and mark.kozlowski@schneider-electric.com.

by John Collins and Paul Graves

A Standardized Approach to Energy Savings Yields Results

DOLLAR SAVINGS AND IMPROVED FACILITY RELIABILITY

Summary

When power reliability is a key measure of success, there is typically room to realize energy efficiencies, without adversely impacting operations. Reducing energy consumption in data centers is a key focus for operators, government organizations, utilities, and equipment and service providers alike. There are many ways to reduce energy consumption, however results can vary greatly. A standardized approach to evaluating energy savings helps data center owners better understand the range of opportunities to drive down costs and develop a long-term comprehensive energy management program.

This article hones in on what a standardized approach to energy management looks like and identifies specific methodologies that drive down costs and improve system reliability. Additionally, opportunities for financial support through utility rebates will be identified.

Introduction

Collectively, we expect immediate access to information. Businesses must deliver information to the consumers rapidly and reliably. Doing so requires a steady supply of electricity to power the ICT equipment that provides instantaneous access to information. Even short power outages and other anomalies can result in lost business, lost information and lengthy restart cycles. So, it is incumbent on organizations to design and operate their data centers to provide continuous power in accordance to desired Class or Tier[1] level.

In 2009, there were over 70,000 localized data centers and over a million server-room sized data centers in the United States. Overall, data centers consumed between 1.7 to 2.2 percent[2] of the total electricity use in the United States. Manufacturers, vendors, consultants, data center owners and managers, utilities, and the national laboratories have all become involved in looking for ways to help reduce energy costs in data centers.

Based on years of experience, data centers can achieve energy savings from five to fifty percent or more, with paybacks on projects ranging from less than one year to four years or longer. Typically, the problem is determining how much savings potential a specific data center can realize, and if it is worth pursuing those savings based on an organization's business requirements. This article discusses a standardized process that can be used to effectively determine the opportunities to significantly reduce energy consumption in data centers, while also yielding a host of additional benefits including:

- Improved system reliability
- Greater control of data center equipment and systems
- Improved working conditions
- Quality environments for data center equipment and systems
- Increased power capacity
- Improved planning tools

Fundamentally, the energy-savings methodology described is intended to provide a balanced approach to effectively managing all areas of data center operations – for improved operations and reduced energy consumption.

Why do energy results vary?

There are many ways to develop energy saving projects. Yet, some approaches to reducing energy costs can end up being counterproductive.

With many types of data centers, the savings potential of each facility can vary greatly. That said, there are typical savings opportunities that all data centers should consider as part of developing a comprehensive energy management program to improve energy efficiency and support power reliability.

Lawrence Berkeley National Laboratory (LBL) completed a study for the U.S. Department of Energy (DOE) to determine what could and should be done to improve data center energy management and drive efficiencies. As part of this process, energy management programs were reviewed in a sampling of data centers.

Based on the information provided by LBL, most of the data centers reviewed had all done something to reduce energy consumption. While there were similar projects, the approach to determine key energy savings initiatives was inconsistent – yielding projects with varying degrees of success. Projects focused on improvements to the IT equipment and systems, the mechanical systems that ventilated and cooled the IT equipment, and/or the electrical power chain that served the entire data center. Each approach could save energy, yet a comprehensive approach to identify and develop a prioritized set of energy management projects appeared to be lacking. Consequently, a key recommendation from the LBL study was to develop a program that would provide the consistent approach to identifying and evaluating energy saving opportunities in data center environments.

Identify energy (and cost) savings opportunities: zero in on the big picture

There are standard "big impact" savings opportunities that are already well understood and developed. Knowing the full range of potential opportunities is key to developing impactful projects that deliver substantial energy savings, and there are simple tools available to help focus energy saving efforts.

To obtain greater energy savings in data centers across the board, the DOE developed a training and certification program to identify energy savings opportunities – yielding a structured process with consistent results. The recommendations for energy savings are designed to cover all aspects of data center operations. Specific categories are identified in Table 1.

The DOE developed the Data Center Profiler (DC Pro) Software Tool Suite, Air-Management Tool, and Electrical Power Chain Assessment for data center owners and operators to help find and assess energy saving opportunities in their facilities. A DOE-trained Data Center Energy Practitioner (DCEP) can help data center owners and managers use these tools. While anyone can use these, optimal results are obtained from individuals that thoroughly understand all aspects of the data center and can apply the many opportunities to a particular site.

For in-house use, the DOE DC Pro tools are available for no charge. However, some of these tools do require a license for commercial use.

The DC Pro Tool is designed to be the first step of an energy management program that helps data centers to operate reliably, efficiently and adapt to evolving challenges. The software pulls together power and energy information about data center equipment and systems and historical utility consumption (if available). With the DC Pro software suite, data center owners and managers can identify energy-saving opportunities for their facility and estimate the potential energy savings.

Using historical utility data, the DC Pro software provides a detailed breakdown comparison of existing data center operations and projected energy use after the completion of a comprehensive energy management program. Figure 1 shows an example of the kind of information typically provided.

TABLE 1: CATEGORIES FOR DATA CENTER ENERGY SAVINGS EVALUATIONS

Category Number	Category Description
1	Energy Management (EM)
2	Informational Technology Equipment (IT)
3	Environmental Conditions (EC)
4	Air Management (AM)
5	Cooling Plant (CP)
6	IT Equipment Power Chain (ED)
7	Lighting (LT)

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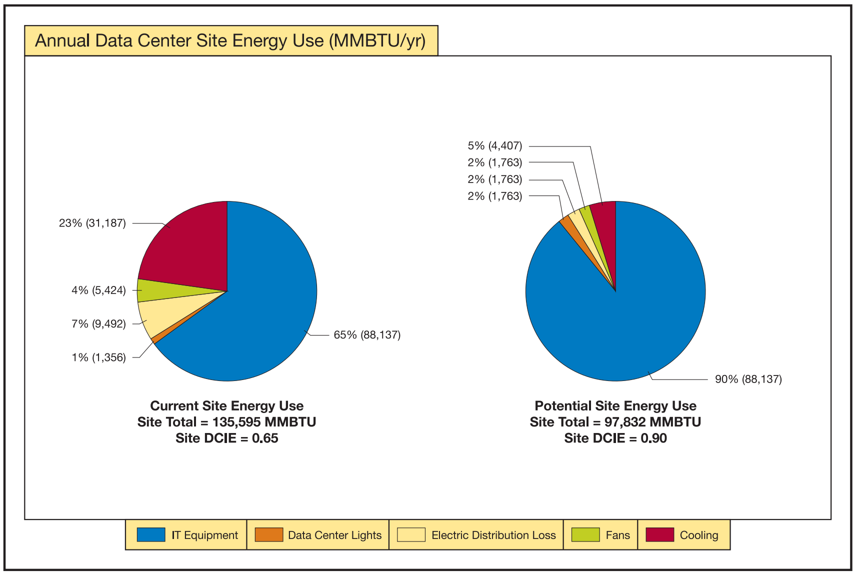

FIGURE 1: Rendering of annual energy use and breakout analysis report provided by DC Pro software.

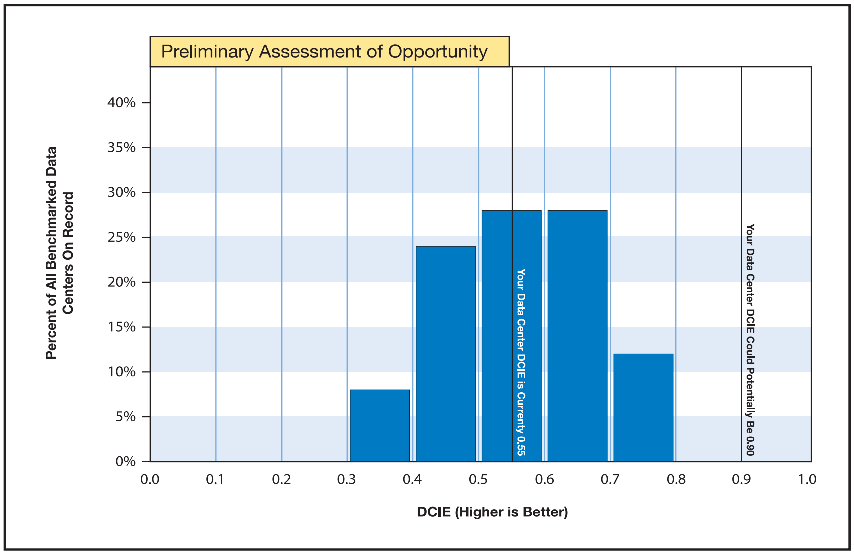

FIGURE 2: Example of Data Center Benchmark Comparison and DCiE Target.

TABLE 2: EXAMPLE OF POTENTIAL SAVINGS OPPORTUNITIES IDENTIFIED USING THE DC PRO PROFILER TOOL

Category Number	Category Description	Number of Potential Opportunities to Evaluate
1	Energy Management (EM)	9
2	Informational Technology Equipment (IT)	3
3	Environmental Conditions (EC)	6
4	Air Management (AM)	3
5	Cooling Plant (CP)	2
6	IT Equipment Power Chain (ED)	4
7	Lighting (LT)	1

Savings shown in Figure 1 are projected to result from changes to the cooling, fan, and electrical distribution systems; no savings are estimated to come from IT equipment. Also, the energy from the lighting equipment is actually projected to increase because existing lighting levels are inadequate. This type of analysis may result from a data center that has already accomplished savings from an IT equipment and systems efficiency project.

The DC Profiler also provides a preliminary assessment of opportunity – the potential for energy savings. Figure 2 shows an example of the estimated benchmark data from an existing data center compared to the potential goal. In this example, the existing data center infrastructure efficiency (DCiE) – the reciprocal of the Power Utilization Efficiency (PUE) – of 0.65 is compared to the ratings of the data centers used in the study, and compared to the software-based and assumed goal, which is 0.9. For this facility, energy savings of approximately 28 percent would achieve the goal. Note, currently the DOE software uses DCiE as the primary metric. However, since PUE has become the de facto standard, subsequent versions of the software are reportedly going to use PUE.

Estimated savings potential from the fan and chiller energy are also provided with the DC Pro Profiler tool. In addition, numerous potential energy savings opportunities are listed for each of the categories included in the analysis. For this example, the number of opportunities for each category is summarized in Table 2.

Overall, the Profiler report can identify over 150 energy efficiency actions for a data center, based on the information gathered and entered into the tool. Beyond the opportunities identified by the DC Pro software, an onsite energy team can identify additional energy efficiency actions, with added energy savings potential related to

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maintenance, operations, infrastructure upgrades, and monitoring. The entire package of opportunities can then be reviewed by the data center energy management team – with a holistic view of energy savings potential, management is better equipped to identify the most effective projects.

So, can a standardized approach to evaluating energy savings opportunities yield dramatic energy-savings recommendations? The answer depends on how a specific data center was designed, how it is being used now, and what the future demands on it will be. While the DOE approach can be applied across all data centers (and telecommunications centers), the results typically vary significantly. Consequently, the approach needs to be fine-tuned based on the project requirements. Overall, a robust energy management program that incorporates DOE tools has the potential to yield dramatic energy savings now and in the future.

Typical Energy Management Program Findings

A comprehensive energy program typically uncovers many unexpected opportunities for savings and problems that need to be corrected to support reliable operations. As lighting control, HVAC, controls, IT, monitoring and maintenance practices are analyzed, it is an excellent opportunity to find out if the designed operating parameters of the data center are being maintained.

Air-Management Savings

After IT optimization, fans and cooling equipment typically generate the biggest energy savings. Without sophisticated controls or analysis, it is difficult to know if airflow is adequate, and whether the temperature of the intake air to the IT equipment meets American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) or Network Equipment-Building System (NEBS) guidelines.

The DOE's Air-Management Tool provides a simple way to estimate savings for the fan and chiller. The Rack Cooling Index® (RCI)[3] and Return Temperature Index™ (RTI) metrics can be used to evaluate the performance of the supply air system and the ventilation conditions within the data center. The process requires multiple temperature measurements along each rack in the data center. Overall, this method provides feedback on whether temperatures are maintained in the data center, and how closely design requirements are met (see Figure 3).

For this sample data center, metrics indicate that some areas of the data center are not maintained to ASHRAE guidelines, but there is no opportunity to reduce fan power. At the same time, the analysis may show that there may be significant chiller savings from water-side (or air-side) economizers or other cooling plant improvements, which means there is an opportunity to reduce cooling energy - a savings upwards of 38 percent.

Maintenance and Operations Efficiencies

Many of the data centers analyzed have sophisticated equipment and systems. Yet it is often the simple or mundane facility maintenance requirements and mechanical equipment and systems that require attention.

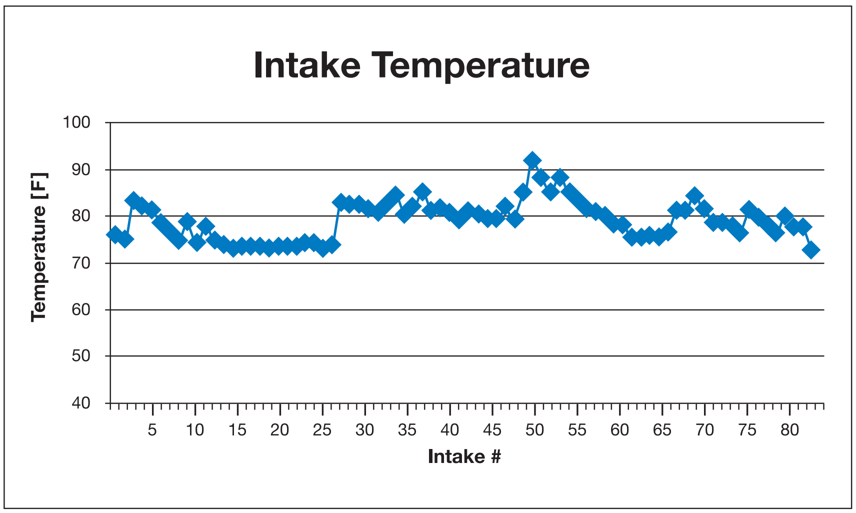

FIGURE 3: Sample equipment intake temperature in a sample data center.

TABLE 3: SAMPLE METRICS FROM AIR-MANAGEMENT TOOL. INTAKE TEMPERATURE INFORMATION CAN BE USED TO DETERMINE THE SAVINGS POTENTIAL FOR A DATA CENTER.

Metric or Measurement	Main Data Center
Return Temperature Index™	102 %
100/RTI (XX) vs. State of the Art (1.00)	0.98 / 1.00 (No savings potential)
Rack Cooling Index (HI)™	86.9 %
Rack Cooling Index (LO)™	100 %
Fan Energy Savings Potential*	0 %
Chiller Energy Savings Potential*	38 %

Typical M&O findings from data center analysis include: BUILDING ENVELOPE

Inadequate Roof Maintenance:
Many data centers have light colored roofs to minimize additional cooling loads placed on equipment because of the solar load on the roof. Roof inspections may show that the light coloring is compromised due to inadequate maintenance. In addition, roof drains may need to be maintained to prevent significant pooling of water on the roof that could create a disastrous situation.

Problems with Air-Cooled Condensing Unit Maintenance and Installation:
Mechanical equipment is often located in or behind enclosures so that data center owners can improve site aesthetics and/or avoid drawing attention to the fact that the facility is a data center. Air-cooled condensers are inspected during data center studies to determine if maintenance is adequate and if operating conditions are met. Some of the problems identified have included:

- Partially blocked condenser coils
- Failed condenser fans
- Small refrigerant leaks
- Short-cycling of fans and compressors
- Hail damage to cooling coil fins

Unassociated Findings:
A detailed analysis of a data center may uncover problems in areas not specifically included in the scope of work, but typically reported for the benefit of the owners and managers. For example, some of the issues that have been uncovered as part of a broad effort to drive energy efficiencies in data centers include:

- A broken connection in the lightening protection system
- Inoperable or improperly set-up irrigation controls
- Failed exterior lighting fixtures and systems
- Unintended openings in security fences
- Poor weather stripping
- Poor placement of security lighting that requires all lights to be on to enable the proper operation of security cameras
- Failed window walls
- Wasteful plumbing equipment and systems

Emergency Equipment Analysis:
A thorough analysis of the emergency power system and auxiliary equipment may identify problems that include:

- Failed damper actuators that leave dampers in an open position, requiring generator room heat to run continually
- Engine block heaters that are always energized

Support Room HVAC Equipment:
Most data centers have rooms located around the data center that contain offices, storage, and auxiliary equipment. Often a review of the operating conditions for the equipment that cool, and sometimes heat these areas can show a variety of potential problems. For example, the inside of enclosure of a rooftop air-conditioning unit can become exceedingly dirty because the external access panels to the unit are loose - allowing dirt and local pollution to enter the unit. Or, filters may not have been changed frequently enough or are poorly fitted, so the cooling coils have become dirty.

Computer Room Air-Conditioning/ Air-Handler Analysis:
Computer room air conditioning units (CRACs) may not be running according to plan. For example, the intent can be to have half of the units run at a time and on a regular basis, with unit controllers used to switch units, so equipment would have the same runtime. Operations do not always align with intent, and a problem with the control system set-up could cause all of the units to start and continue running each time the emergency power system is tested. Other problems encountered include:

- Scaled humidification pans (that can cause overflows and/or prevent proper operation)
- Temperature sensors that are out of calibration
- Dirty cooling coils
- Loose panels
- Constant flow fans (possibly due to older designs)
- Improper programming set-up
- Lack of sophisticated controls to coordinate unit operation

Data Center Power Usage:
Over time, there are a variety of opportunities to inadvertently develop a variety of inefficient practices. For example, non-essential electrical support equipment might be plugged into the power provided through the UPS – resulting in unnecessary load on the UPS and additional losses. Probably one of the best opportunities is to combine the need to replace UPS units (and the associated battery racks) at their end of life with new high efficiency units.

Energy Management Yields Savings, Improved Operations

A structured process to identify and analyze all potential energy management opportunities yields significant results in numerous areas of data center operations. With an in-depth analysis, wasteful energy practices are discovered and addressed to meet both energy management requirements and improve overall data center operations. The main goal of the analysis is to confirm that energy savings potential exists and can be obtained through:

- Maintenance and operations improvements
- Replacement of existing equipment/ systems with energy efficient alternatives
- Completion of retro-commissioning studies
- Installation of more sophisticated controls and monitoring systems

While each data center may have unique requirements to improve performance, a consistent approach can be used to uncover the opportunities and identify unexpected savings.

Timing, utility rebates, and budget impact the energy management master plan.

Data center age, various project priorities, equipment age, and management support fundamentally impact the energy plan. Availability of utility rebates and programs to offset certain costs will also influence the overall plan. Utility rebates may be found to address any or all of the following types of projects:

- Retro/re-commissioning (RCx) studies
- Energy efficient design requirements (some from custom programs)
- UPS replacements
- Lighting system replacements or upgrades
- Control system upgrades or replacement
- Variable speed drives for pumps and fans
- Energy efficient motors

The goal is to work with the local utility company to get pre-approval of your projects (utility rebates often require approval before the project starts).

Budget goals – in both the short and long term – also impact the overall energy management strategy. Yet, the benefits of a comprehensive energy management system include:

- Energy savings
- Infrastructure improvement
- Increased system reliability
- Decreased maintenance costs
- Improved data center operations

What many organizations find is that once they start “looking under the rocks” they might find many opportunities to reduce energy and in turn improve operations, reliability, working environments, and the environment as a whole. Identifying energy-savings opportunities can be accomplished simply and effectively, if the process is followed and the effort is made to see what the opportunities really are – yielding a real business advantage and more reliable operations.

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Paul Graves is Senior Management Consultant of Energy Solutions at Eaton.

1 Building Industry Consulting Service International (BICSI) and Uptime Institute categories.

2 U.S. Environmental Protection Agency data, “Understanding and designing energy-efficiency programs for data centers.” November 2011.

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by Robert H. Thompson, PE

THE EVOLUTION OF DATA CENTER WASTE HEAT RECOVERY

The paradox in IT is that while the technology we now have at our fingertips can make our world a far more efficient place, the facilities that support this platform have historically been energy intensive. As server densities increase, the cooling demand increases to handle the heat rejection of the servers. Historically, first generation data centers removed this heat from the servers and rejected it to the outside air through cooling towers and condensers. Over the years, facility engineers have recognized the potential to capture this waste heat and utilize it for other purposes. The concept is not new, having been proven in other high energy use facilities such as laboratories. One facility, the Energy Systems Integration Facility (ESIF) at the U.S. Department of Energy's National Renewable Energy Laboratory (NREL) marries these two energy intensive building types into a culmination of energy efficiency through waste heat transfer and water cooled IT servers.

The concept of computers and data centers began in earnest in the 1960s with the large mainframe systems used by NASA for the Apollo Space Program. Unlike laboratories that require large amounts of heating in winter and cooling in summer, data centers require large amounts of cooling year round (regardless of their location). The early mainframe computers utilized transistors, water-cooled intercoolers, and it was not uncommon for these systems to occupy whole rooms. Today a typical smart phone has the same or greater computing power.

Improvements in technology led to the development of the integrated circuits which use significantly less power and were much smaller. This reduction in scale allowed for a corresponding increase in circuit density. Computer technology soon progressed to the point that air cooling alone may provide sufficient cooling of the internal components, which made personal computing a reality. Early supercomputers still relied on internal water cooling, though for a brief period in the early 1990s the fastest supercomputer was air-cooled. Today a typical personal computer running Microsoft Office has similar computing power to that air-cooled supercomputer.

Computer performance increases, however, came with an increase in "waste heat". The expansion of the internet in the late 1990s and early 2000s led to the development of the traditional data center. Here large groups of servers are consolidated to a single location. Emergency power and UPS systems ensure continuous power service. Redundant cooling systems ensure continuous operation. Unlike the supercomputers which are predominantly water-cooled, however, traditional data centers continue to rely on air-based cooling.

Recent developments over the past 10+ years have led to significant improvements in data center efficiency. The typical air-cooled computer circuit is designed to operate with 75F entering air. Internal fans then circulate this air past heat sinks that transfer heat generated by computer chips to air, heating this air another 20F or so, then discharging the air at around 95F. Early data centers did not contain this heat. As a result, data center cooling systems had to supply 55F air to mix with the 95F "waste heat" to generate an average of 75F. Making 55F air year round is costly and inefficient.

Recognizing these inefficiencies, industry consortia developed metrics such as Power Usage Effectiveness (PUE), to measure and improve data center efficiency. PUE is a ratio, the sum of the total server energy plus energy for all supporting systems (cooling, lights, system losses, etc) divided by the server energy. The perfectly efficient data center with no losses or additional cooling required has a PUE of 1.0. It was not uncommon for mixing-type data centers described above to have a PUE of 2.0 or more. Significant energy savings, however, were found by simply isolating the cooling and waste heat.

The most common form of this isolation is an enclosed "hot aisle". Server racks are grouped together, drawing air from the room and focusing the waste heat in one

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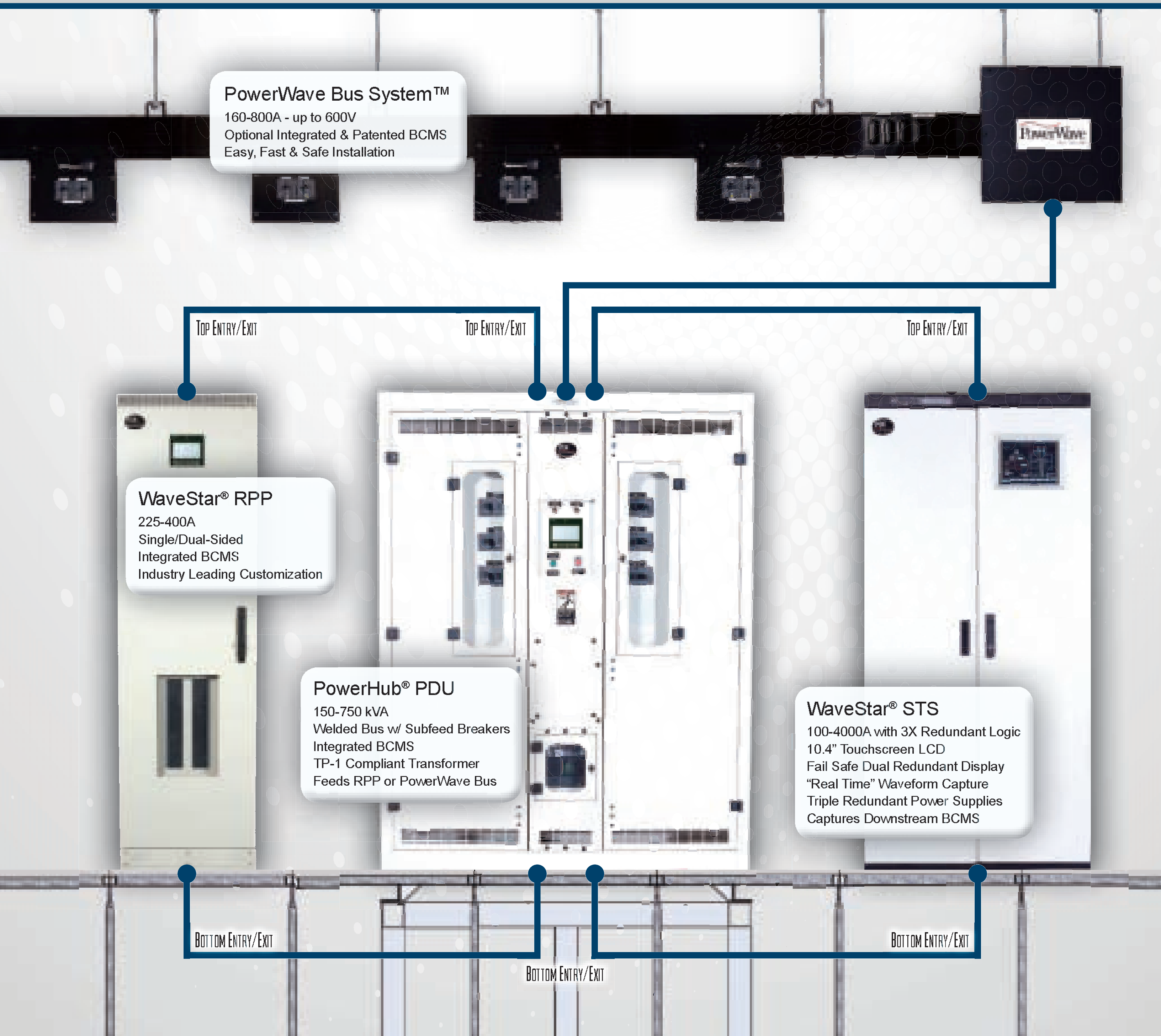


location. HVAC equipment then cools this air down to the 75F that the circuit is design for (colder air is not required as there is no mixing of waste heat). It requires much less energy for HVAC systems to produce 75F room air instead of 55F air. Depending on the location of the project, this can be done without the use of central chillers (evaporative-based cooling is sufficient) for a good portion of the year. Data centers using enclosed hot aisles and evaporative-based cooling (with chillers) now regularly achieve PUEs of 1.5 or less.

As the typical data center is air-cooled, the logical approach to employ waste heat recovery is for the data center to be collocated with another facility that requires a large amount of heating. Aside from the logistical concerns with this approach, air itself is not an efficient mechanism for transferring energy. Even if the perfect conditions allowed for the export of 95F air as waste heat, the resultant PUE improvement will be minimal. The reason for this is that the vast majority of energy savings described above were improvements to the cooling energy. Fan power and its associated energy remained constant. Any savings in cooling energy with this approach will likely be offset with the increased fan energy to transport warm air to other areas of the building.

Air has 3,500 times less heat capacity by volume than water. To put this in perspective, a typical hot air balloon with a volume of around 100,000 cubic feet of air has the same volumetric heat capacity as a 220 gallon aquarium of water. The convective heat transfer coefficient of air is also up to 50 times less than that of water, meaning that water can utilize a much smaller surface area to exchange the same amount of heat. If this weren't enough, air also has the penalty of a relatively high transport energy. It requires more energy to move air than to pump water.

One significant improvement to data center efficiency is the use of hydronic-based cooling at the server racks themselves. The air-cooled approach transferred server heat air, which is then transported to HVAC equipment to be cooled and returned back to the server. Hydronic-based cooling at the server brings the water close to the equipment (supplemental HVAC not required or are minimized). A heat pipe transfers the server heat to a metal plate in the adjacent rack, which is cooled by water. The now warmer water is then pumped to another heat exchanger where it can be cooled by the building cooling system. The biggest advantage of this approach is the marked reduction in fan energy. Central HVAC systems may still be provided, but serve only a small portion of the data center load.

Similar to the 75F design temperature for entering air at the circuit board, these water-cooled servers may also utilize up to 75F entering water. Using 75F entering water also results in additional energy savings at the central cooling systems. Depending on the location of the project, it is possible to create 75F water year-round without the use of chillers.

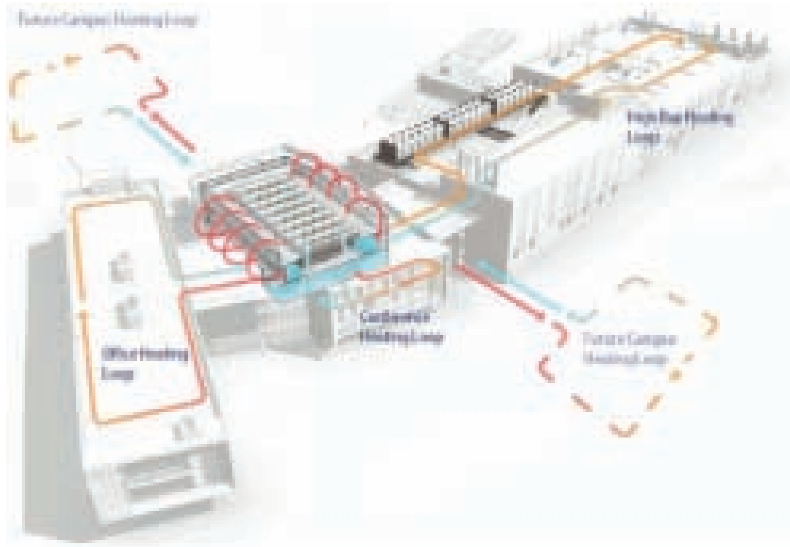
With 75F entering water to the server, the byproduct or waste heat, depending on the level of control, can be 95F or warmer water. With the heat now in the form of water, however, it is much more useful. With the transport energy being low, it is feasible to distribute this heat to other portions of the building. In a cold climate, this water can be used in other portions of the building for either radiant or air-based heating. It also works well for the preheating of outside air. The largest benefit to the data center in this mode is that the associated cooling equipment operates at a reduced level (or may be turned off) when the waste heat is needed elsewhere.

If 95F water is not sufficient for building heating, another method is to utilize a water-to-water heat pump to create warmer water temperatures for traditional building heating systems. The 95F waste heat is cooled back to 75F, while a heat pump provides up to 160F or more of heating water. Again, the data center cooling equipment will operate at a reduced level when the waste heat is needed. The building also sees a benefit in improved efficiencies for heating systems.

Two major obstacles to data center waste heat recovery are the scale of the installation as well as the physical separation (or isolation) of the data center to adjacent office and lab facilities which could utilize the rejected heat. Data centers can consume large amounts of power coupled with a tremendous amount of waste heat. Comparatively, a typical office building uses much less heat. The data center will always have a significant surplus in this case, which may not justify the increased cost of the distribution systems for waste heat recovery. The best approach is to couple the data center with other systems that have a high heating demand in the form of a laboratory or central campus heating system.

NREL in Golden, Colorado has taken steps to do just that. The ESIF building uses waste heat from the data center to provide heating throughout the building and its associated research laboratory. Waste heat from the servers is collected in the form of 95F degree water, which is then transferred to the building heating water system. The heating water system then

separates this water into low-temperature and high-temperature loops.



The low-temperature loop provides for air-based heating of offices, lobby, and conferencing center. The high-temperature loop serves high-bay laboratory spaces, building entries, and pretreatment of 100% outside air (or make-up air) systems. Campus heating water resets the temperature of the high-temperature heating loop to as high as 130F depending on the outdoor air temperature (95F water is not sufficient to provide heating at building entries and high-bay laboratories). The high-temperature loop is the largest user of heat in the building.

One initial concern with this approach was that at some point so much heat was added to the high temperature loop that we no longer recovered waste heat from the data center. Traditional hydronic heating systems operate at a 20F to 40F temperature differential, which is not sufficient to allow for heat transfer at design conditions (return water temperatures at 90F to 110F). To resolve this, we instead cascaded the high-temperature heating loop in the laboratory.

The high-bay laboratories need up to 130F heating water to maintain space temperatures in design conditions, but the make-up air systems only need around 100F heating water during those same periods. System optimization matched the heating water demand of the laboratories (at a 20F temperature differential) with that of the make-up air units (at around 100F). The high-temperature loop is distributed first to the laboratories. After serving the laboratories, the now 110F water is circulated to the make-up air units, where it is cooled to the upper 70s or low 80s. Using this approach, data center waste heat recovery continues even with the introduction of campus heating.

The building's demand for heating exceeds the data center waste heat available, but only during peak design conditions and with the initial data center load. As the data center grows, its volume of waste heat will eventually surpass that of the building needs. Even with the initial data center load, the building does not require the same level of heating year round. In summer months the primary user of heat is the laboratory (only 95F needed at that time), but at a much reduced level. To maximize the potential waste heat, the project made provision for connection to a campus heating system.

NREL's campus heating system operates at a 95F water temperature in the summer months, primarily serving other laboratories on campus. As the data center continues to grow, the goal is that data center will eventually become the campus heating water plant in summer months. A separate low-temperature campus distribution loop is also envisioned that can also be used to support slab-based radiant heating of offices during winter months. The combination of these approaches will allow for a further reduction in data center cooling energy.

The NREL ESIF project represents what is possible when data center waste heat is integrated into building & campus heating water systems. While it is not possible for all data centers to take advantage of this approach, note that this technique for heat recovery is not limited to data centers alone. Manufacturing facilities with large volumes of process "waste heat" may also benefit from a similar approach to provide supplemental heating for their buildings. In the end the goal is the same – to increase energy efficiency and recycle as much "waste heat" as possible.

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LOAD-ON DEMAND DELIVERY SYSTEMS AND INNOVATIVE DESIGN TECHNIQUES

by Dennis Julian, PE, ATD, DCEP

Design and engineering firms in the data center market builds must have a firm understanding of the ever-evolving needs of their clients. As the industry moves toward new trends in delivery systems and other innovative design techniques, the firms who have experience with this type of approach have begun to stand out above the competition. The buzzword in data center design today is “modular construction”. Unfortunately, the term has different meanings to different people. For that reason, at Integrated Design Group (ID) we prefer the term “load-on-demand” when discussing modular data center design. Load on demand is a strategy used in developing and implementing a data center design that provides IT, cooling and electrical load capacity on demand with a “just in time” philosophy. There are several ways to provide load on demand, each providing its own relative advantages. For the sake of discussion, ID breaks down load on demand concepts into four distinct design approaches.

1. **Master Planned Phased Construction**
2. **Skid or Container Based Component Modular**
3. **Repeatable “Kit of Parts” Modular**
4. **Modular Off-Site Constructed Data Center**

Each approach provides a solution to the challenges of delivering a data center expansion in a cost effective manner designed to fast-track the construction phase of a build. Each also offers unique advantages and disadvantages. During the early phase of every project we take on, ID leads a discussion of these various options as part of the overall project approach. Where appropriate, as guided by cost, schedule, availability, or client preference, one or more of them may be implemented.

Keep in mind, any of the load on demand options discussed in this article require the establishment of a standard growth increment that it must be adhered to unless a redesign is completed.

The final solution often includes a combination of the following strategies:

For over twenty years, ***master planned phased construction*** has been the most utilized and most basic method for providing load on demand. This method calls for designing a data center for the ultimate phased construction but installing only part of the system on the first day. During the first phase of construction, accommodations are made for the installation of the future equipment using strategies such as installing conduit and concrete pads for future equipment and sizing rooms large enough to accept the future gear. The obvious advantage to this approach is the time saved in construction during future phases. As a result, the team simply needs to order additional pre-specified equipment and have it set in place,

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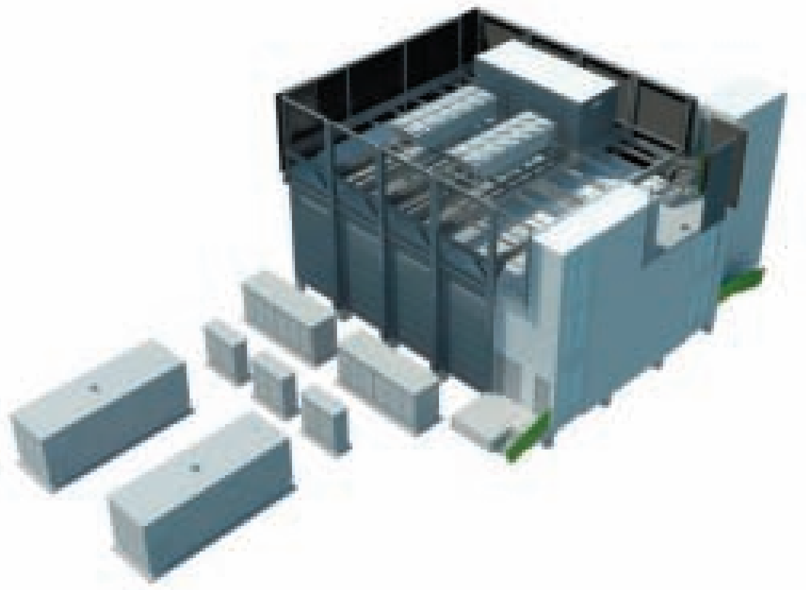
connected and tested. Be cautioned, however, that without careful planning, inefficiencies and stranded capacities may arise. Clients should be aware that certain parts of the system installed day one must be sized for the future builds, even when the growth may never be required. When using this phased construction model, pipe sizes, switchgear, electrical feeders and other systems, as well as the equipment spaces all need to be oversized day one to accommodate the future growth. If the growth does not happen, money is wasted. Additionally, if significant time elapses between phases, technology may change or equipment models evolve, resulting in preplanned and constructed accommodations that may no longer be appropriate. Furthermore, testing of the new equipment may be impossible without disruption to operations.



Skid and container based modular construction addresses the schedule and often space challenges associated with a particular component of the data center construction. With this approach, specific equipment or rooms/systems such as electrical rooms, pump rooms, chiller plants and even raised floor/rack space are standardized, built in a factory and installed as a complete system into a shell space. Examples include the use of the I/O container to replace traditional raised floor. The container can slide into a warehouse or even be installed outside and quickly attached to an existing infrastructure, making additional load immediately available. If existing infrastructure is not available, developing a modular electrical system with modular chiller plants and modular white space can result in a very fast build out. The challenge with this approach is twofold. Often each individual system is highly customized and unique to each particular vendor. Getting standard chiller plants with electrical skids, generators and IT containers sized at matching capacities takes careful planning and may not be feasible given project constraints in terms of budget, schedule and size. Secondly, the modular white space containers often restrict the IT vendor options available to the ultimate end users. With technology evolving so quickly, many don't want to risk having a facility solution that limits future technology choices. However, utilizing specific components, such as modular chillers within a traditional build out, can be effective in reducing space, lowering cost and improving time to market.

The ***kit of parts modular solution*** includes selecting standard readily available components and component sizes for generators or chiller plants and utilizing them to create multiple combinations to achieve a variety of data center solutions. An excellent example of the kit of parts in action is Digital Realty's (DLR) POD™ architecture. DLR utilizes a standard components study in a variety of combinations to provide data centers that achieve a desired Tier rating. Their design allows for loads ranging from 1.125 MW to virtually any multiple of that size. Using this approach, DLR is able to preorder components prior to the final determination of installation details and ultimately ship them to the build site. They take this a step further by integrating modular components such as electrical and pump skids into the mix providing an additional advantage. Furthermore, DLR has developed multiple cooling options to enable alternate solutions by geography to take advantage of "free" cooling in certain environments. By taking these steps, a team can leverage buying power, streamline provisioning and reduce overall construction time.

Limitations to this approach are that it is most applicable to a company building multiple data centers simultaneously. Additionally, when constructing much larger facilities, the deployment of multiple smaller systems will use many more components and be less cost effective. Cost issues, however, may be offset by the increased buying power that this approach enables. In addition, the time value of money or the need to reduce initial costs can be considerations.

The ***off-site constructed data center*** is similar to any modular structure. Whether it's a house, school or dormitory the entire building may be constructed in a factory and shipped to the site and assembled. The modular data center is self-contained and incorporates its own power and cooling infrastructure as well as network room and IT whitespace. All that is required prior to commissioning are basic utilities such as network, water and power that any traditional data center would need.

This approach is described in detail in the 451 Research Long Format Report titled **"Market Monitor: Datacenter Technologies – Prefabricated Modular Datacenters"** dated May 10, 2012. To date, utilization of this approach has been limited and therefore cost remains higher than traditional construction. As more of these projects are implemented, the cost should come down quickly.

It can be argued that the modular off-site data center is in fact equipment, and not a building at all. If this is the case, the depreciation schedule will drastically reduce actual total cost of ownership and make this approach very cost competitive.

A recently commissioned off-site constructed data center consisting of a 500kW prototypical Tier IV modular data center, Centercore, is located at Research Triangle Park, Raleigh, North Carolina. A financial services company sought to explore the feasibility for a modular data center product. The result is a fully modular data center which allows for scalable growth in 500kW increments. The power and cooling infrastructure is designed as a fault-tolerant and concurrently maintainable system. Centercore is constructed of a robust steel frame module wrapped in a weather resistive insulated metal panel envelope and Miami-Dade rated louvers. The prototype offers end users significant flexibility in IT deployment with over 2800 sq ft of 36" raised floor. The space is vendor neutral and can accommodate virtually any IT equipment type with power densities as high as 10kW/cabinet. The cooling system uses outside air economization for all CRAH units as well as hot aisle containment for increased efficiencies. Generators and substations are located directly outside of the modules on equipment pads.

Ultimately, many projects may incorporate a combination of these approaches. The Equinix data center in North Bergen, New Jersey was also master planned for phased construction. The initial build made provisions for the installation of equipment in multiple future phases. Additionally, two modular chiller plants were utilized to save space and reduce overall schedule. To date, three phases of this project have been implemented with no disruption to service. In order to determine the most successful solutions for your project, evaluation of all load on demand options should be evaluated according to the criteria set forth above. Each provides benefits for short- and long-term growth, expansion and cost efficiency. The key is determining the unique solution that is a fit for your project needs.

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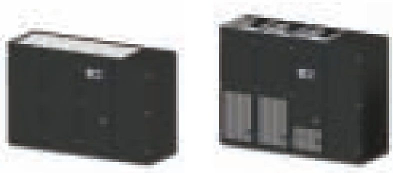

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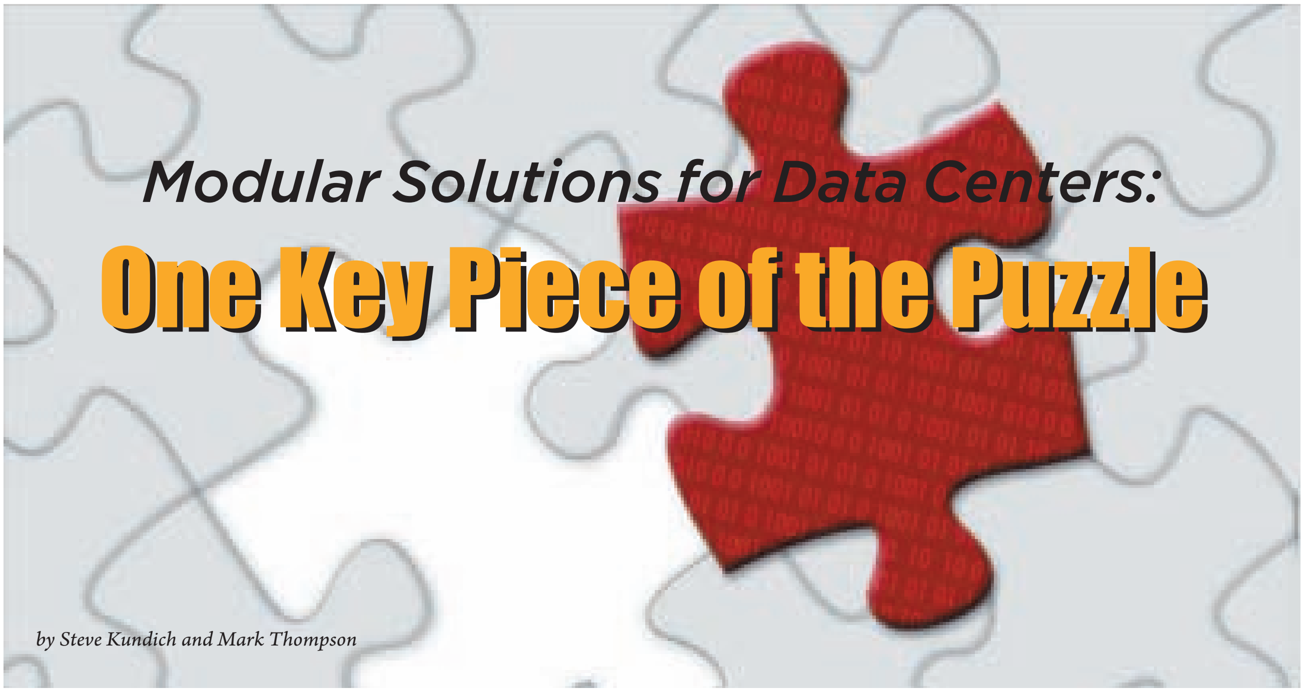


Modular Solutions for Data Centers:
One Key Piece of the Puzzle

by Steve Kundich and Mark Thompson

In the high stakes, rapidly changing market of mission critical data center design, construction and deployment, owners and operators are constantly looking for ways to reduce costs, minimize risk and improve the speed and reliability of their data center facilities.

One area garnering increasing interest and growing market share is modular data center deployment. As an alternative or supplement to traditional "stick-built" data center facilities (constructed onsite with conventional materials), these self-contained units incorporate a variety of components within a pre-fabricated, often times container framework and can include servers and other data center equipment, as well as power and cooling skids/units. The customized containers are pre-manufactured and pre-assembled, then shipped to the site for relatively quick set-up and commissioning.

As advances have been made in modular data center technologies and forms in recent years, and the buzz surrounding them has grown, more companies have begun to explore the potential advantages they offer due to their perceived lower cost, speed of deployment and tailored solutions designed to meet owners' diverse program needs.

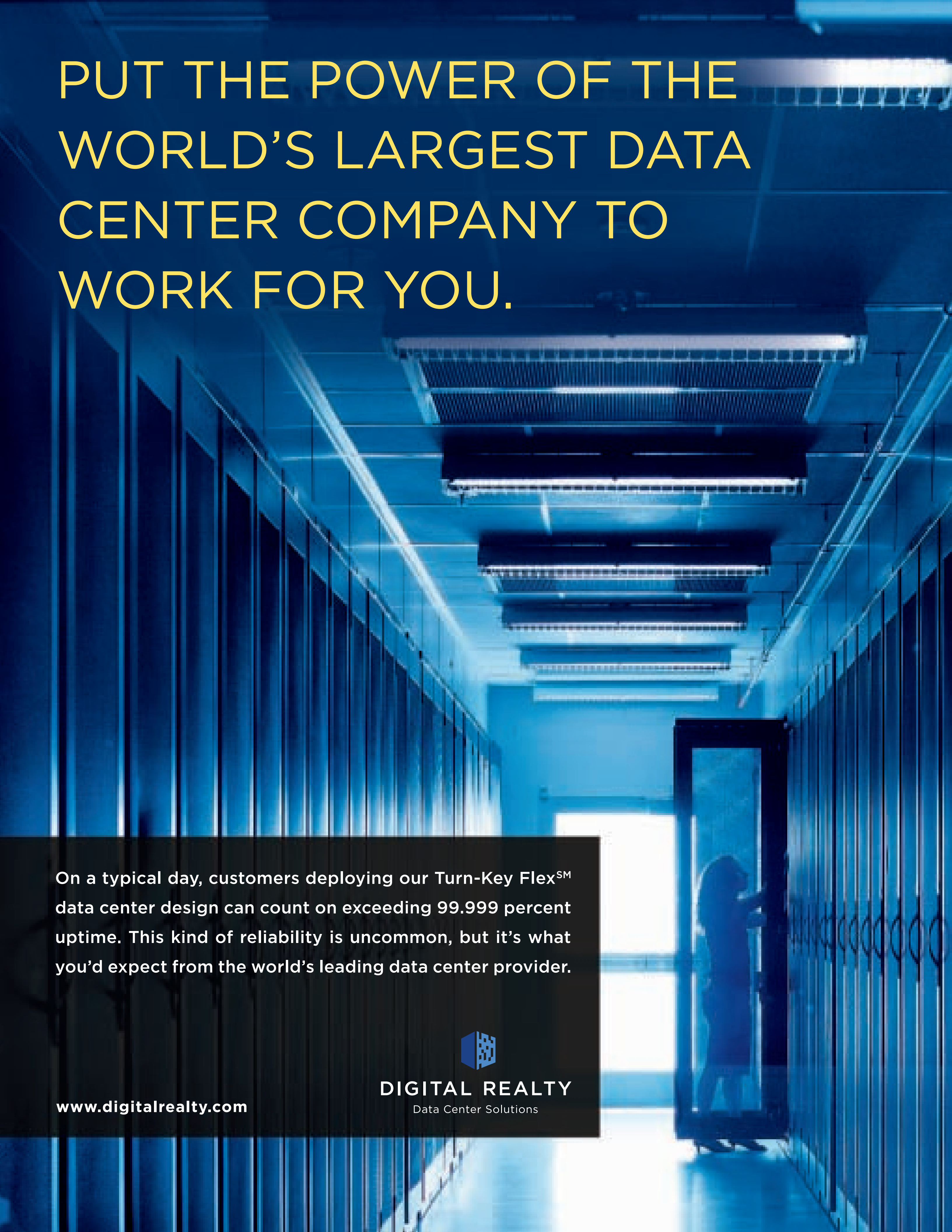
Modular data centers, in some instances, have clearly delivered measurable efficiencies that translate into savings, for example the use of pre-fabricated skids on a series of data center projects for Digital Realty have cut two weeks out of its standard, aggressive delivery schedule. But it is also important to understand that modular pre-fabricated methodologies are just one piece of the puzzle. Modular solutions should be evaluated within the context of an overall data center delivery strategy. Many other factors must be navigated to leverage the full advantages of modular data center deployment, including effectively managing the supply chain, the design process and site entitlement, to name just a few.

Think of modularization as the "arrow in the quiver" for the design and construction team seeking to deliver the most effective and efficient data center possible. It can help them hit the target, but there must be a solid, experienced team with a committed design in place and a plan for quality control pulling back the bow and aiming the arrow to get it there effectively.

Putting Together the Right Team

Whether building a modular data center or a traditional brick-and-mortar facility, assembling a highly experienced, knowledgeable and integrated project team with the necessary core competencies and know-how is arguably the single most important factor in the success of the data center project. The team should have a strong mastery of the supply chain, an understanding of quality control processes and hands-on experience with every phase of data center design, construction and commissioning.

The team's involvement should start during the site selection process. Their expertise is essential to investigate critical factors such as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power and fiber availability, local geographic conditions and more that could impact performance. The high performance design and construction team will know what questions to ask and how to obtain the right answers to help the owner make critical decisions, beginning with site selection and design through construction and commissioning. In a recent example of the benefit of early involvement, the team on a confidential modular data center project uncovered a conflict between the over-head power distribution and the clearance space available. Caught during schematic design, the team was able to redesign the space for under-floor distribution.

A region's climate is one of the factors that should be weighed, for example, as the owner makes decisions on the data center's design and location. Currently one of the key metrics for evaluating energy efficiency in data centers is Power Usage Effectiveness (PUE). While the facility's mechanical system selection and design play a major role in improving, or lowering, the PUE of a data center — containerized or brick-and-mortar — other important factors including the owner's acceptable data center environmental temperature ranges and humidity levels also come into play. At Facebook's data center in Forest City, NC, humidity was a chief concern. By modifying the high desert design of the Prineville, OR facility to include a direct expansion (DX) cooling system with humidity sensors, the team was able to make the facility as efficient as possible, utilizing outside air whenever possible. A knowledgeable project team understands the importance of evaluating the range of factors impacting data center performance and will work in partnership with the owner to carefully evaluate sites, providing all the information required for informed decision making.

It is clear, then, that bringing the team on-board early during the site selection and project definition phases is an important strategy that contributes greatly to the ultimate success of the project, including on-time and on-budget delivery of a quality product.

Early Procurement, Early Design are Critical

Early equipment procurement and an early commitment to the design are both essential to successful modular data center deployment. To gain the most value from modular solutions, owners must be willing to commit capital up-front and to make decisions early on and then stick with them, particularly regarding the design. As illustrated in Figure 1, time savings can be seen when the customer commits earlier on in that process. This allows design, procurement and modular fabrication to occur prior to project site identification, allowing for a streamlined process to follow site commitment.

Once the team is in place, it is critical to immediately put "pencil to paper" to develop a reliable design for the modular data center facility. A standardized design utilized across multiple facilities can greatly increase the overall efficiency of the modular data center fabrication and installation processes, particularly on each subsequent project. Similarly, economies of scale advantages can be achieved by using and optimizing the same cohesive team across modular data center jobs. For example in a series of eight replicable projects for Digital Realty in Northern Virginia, productivity improved with

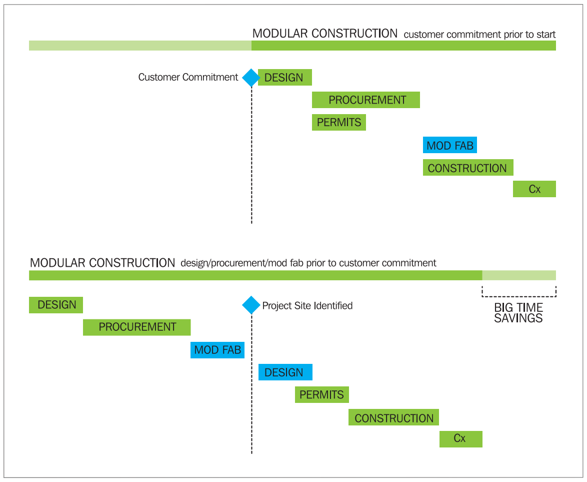

Figure 1 illustrates two approaches to modular construction. The first waits for customer commitment to begin the process where the second begins design, procurement and modular fabrication prior to site identification, resulting in time savings.

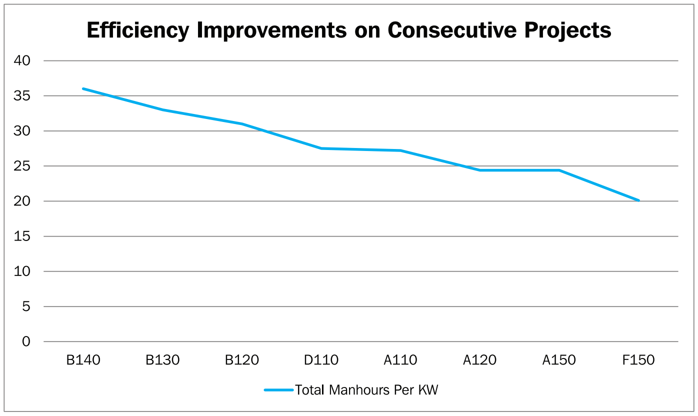

Figure 2 illustrates the manhour reductions on a series of consecutive and replicable projects using the same team and specifications.

each new project. Total man hours per kW decreased from 36 to 20.1 hours between the first and last project as illustrated in Figure 2 and the total cost decreased incrementally.

As a word of caution, a modular prefabrication approach requires the appropriate size operation; otherwise, scale can be a barrier to success.

It is also important to secure early involvement from major subcontractors and vendors, including the mechanical and electrical contractors during the design phase. They should work collaboratively with the architect, engineer and general contractor to provide constructability input and help design and develop the building information model (BIM). The model is used to communicate the prefabricated components that will go into the modular units. The earlier the design is finalized and "you pick up the pencil," the sooner the owner can move forward with equipment procurement, which must occur as early as possible to take full advantage of the potential pre-fabrication opportunities and ensuing schedule benefits.

The Importance of Quality Control

One prevalent myth about modular data center solutions is the assumed improvement in quality when components are prefabricated in a factory compared to those that are "stick-built" onsite. While certainly there can be quality advantages assembling components in a controlled factory setting, where factors like weather damage or site congestion are taken out of the equation, those advantages, including speed, consistency and predictability, are by no means guaranteed. It is vital, therefore, to utilize a fabricator that is knowledgeable and experienced with data center projects and has solid quality control and production control systems in place.

In addition, the prefabricated components will only be as good as the information provided to the fabricator. It is imperative that the owner's project team first and foremost have a complete design (again "pencils up" is critical!), then submit highly accurate drawings and specifications, optimally based on BIM, to the fabricator, and finally follow through with the owner's project team actively monitoring the production process to make sure what is being produced is correct and complete.

How Modular Can Deliver Real Savings

Another myth surrounding modular data centers is that modular systems are always less expensive than more traditional building approaches. Our experience shows modular pre-fabricated approaches may not always be the absolutely cheapest route.

Major mechanical and electrical equipment costs, whether modular or traditional, don't vary and tend to consume a full third of the total data center cost. The most significant opportunity to save with modular data centers stems from reductions in the electrical and mechanical labor costs. Prefabrication and installation of these systems within the modular container in a factory setting, rather than installed on-site, saves considerable time and labor costs in the field. The costs do not entirely disappear; instead they are shifted to the factory, which in turn shaves time off the schedule.

Also from a schedule standpoint, major savings can be achieved through early equipment procurement. Typically, the earlier an owner commits to equipment purchases up-front, the greater the savings will be achieved, as this will allow for more pre-fabrication and bulk procurement. The capital commitment can be daunting, but savings per unit will increase as well.

In addition, the more standardized or repeatable the design of the modular data center, the greater the efficiencies and savings. The more time spent up-front by the owner and the project team planning how the project will be designed, procured, delivered and commissioned, setting milestones and sequences and utilizing tools such as lean processes and procedures to eliminate waste and rework, often the better the ultimate outcome.

No Magic Bullet – But Modular Adds Value

Taken in the context of the overall data center project delivery, modular solutions clearly can have positive impacts on the speed, cost, reliability and efficiency of a project – but they are not a magic bullet. There are a number of other fundamentals that must be in place, including a solid, experienced project team working collaboratively to design, construct and deliver the data center facility, as well as an owner who is willing to make decisions and commitments early on about equipment procurement and design choices.

With those factors in play, the data center project will be able to leverage the potential cost and schedule savings that modular solutions can offer to improve the project's efficiency and achieve a successful outcome.

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Mark Thompson is National Advanced Tech/ Mission Critical Leader for DPR Construction.
He can be reached at MarkT@dpr.com.

ENERGY MANAGEMENT

by Hendrik Van Hemert

Rising energy costs, increased stakeholder attention, and unforeseen capacity constraints are setting the stage for a new era of energy management in data centers. Energy management programs can help a company recover power and cooling capacity, increase overall system resiliency and drive core business functions. Concurrently, they can reduce operating costs and increase asset value.

Despite pressures to improve, many firms lack the organizational resources and energy expertise to effectively manage their energy consumption. Good intentions often fail to deliver the anticipated savings because they lack a proven process. For many firms, the most significant barriers to achieving best-in-class efficiency are organizational, not technical.

Each firm has unique operating conditions and unique goals, but following a simple process will allow every organization to maximize their potential savings while managing risk and uncertainty. The following steps are a great starting point to designing an effective energy management strategy for your facility.

1. CREATE A VISION AND SET GOALS

The first step towards successful energy management must include the creation or adaption of an overall vision. Determining organizational goals sets the stage for a tailored program to deliver exactly what the organization needs. Many possible objectives may exist for your firm including risk reduction,

sustainability objectives, cost savings (CapEx and OpEx), capacity utilization (cooling or power), uptime improvement, or increased asset value. Using an established framework such as the SMART (Specific, Measurable, Attainable, Relevant, Timely) approach to set appropriate goals is an excellent means of moving strategy into action.

Setting a vision has many advantages. It demonstrates leadership's commitment to changing current energy management approaches, which is vital to driving new processes and behaviors throughout the organization. Vision is not, however, sufficient for success. Many initiatives lose momentum when high-level strategy fails to translate into achievable tasks. The vision must be translated into clear goals and commitments. Individual contributors must be incentivized and overall goals must trickle down into individual performance plans.

2. MEASURE CURRENT PERFORMANCE AND BENCHMARK

Understanding current performance and comparing against peers gives decision makers a context for decisions to invest in physical and operational improvements. Industry benchmarks allow you to compare yourself to similar firms and also provide easy to measure means of understanding your baseline and tracking improvement.

It is important to note that no single measurement can effectively capture the overall performance of a data center. PUE is often touted as the best data center metric available but it has limitations. PUE can be made to look better or worse without overall energy efficiency changing based on timing of measurement, server optimization, server virtualization, rack configuration, etc. To avoid making decisions based on incomplete metrics, each organization must recognize the limitations of the metrics and adjust accordingly.

It is also important to note that your specific challenges require a tailored approach. The ENERGY STAR® Energy Management program is a good guide for commercial and industrial facilities but lacks some important considerations for data centers. For example, tenant behavior in data centers is not a significant energy concern. However, IT vendor management can have significant impacts on facility optimization over time. Data centers that fail to manage IT vendors and partners often suffer from IT equipment installed incorrectly, resulting in bypass air, re-circulation, and hot spots that lower cooling efficiency.

3. IDENTIFY OPPORTUNITIES

Once goals have been set and commitments made, the next step is to find the savings. Every facility has some opportunity for improvement. The lowest performing data centers can waste more than half of the energy they use. The following sample list includes some of the most common areas for savings:

1. Airflow optimization
2. Controls and set point changes
3. Hot/cold aisle containment
4. Lighting controls
5. Economizers
6. UPS optimization
7. Power conversion simplification
8. Standby generator strategy
9. Cooling central plant efficiencies
10. IT virtualization and optimization

4. FOLLOW A PROCESS

The long-term success of any energy management program is dependent on having a clear yet flexible process in place, such as a Key Performance Indicator process. There must be a program that facility and IT staff can follow to identify, prioritize, execute, and review improvement measures. The best programs include feedback loops to allow for continuous improvement.

Conclusion

Data centers are dynamic and uniquely challenging facilities, but they also represent enormous opportunities for businesses to cut costs and increase margins. While this task can seem daunting as a whole, it can be simplified by breaking it down into the four steps provided in this article. Your organization is most likely doing some version of each of these four steps today. Focusing your organization's efforts and attention on these steps will allow you to realize the full potential of your data center assets.

Hendrik Van Hemert is Program Manager at McKinstry. He can be reached at hendrikv@McKinstry.com

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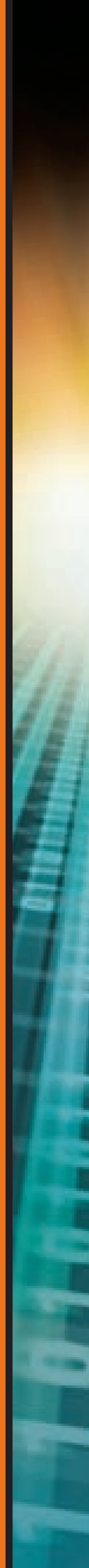


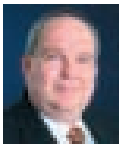
The Spring Conference themed **"End-to-End Reliability – Driving Performance"** will be held June 2-5 at the Boca Raton Resort & Club in Boca Raton, FL. The Conference will feature compelling keynotes, high level speakers, concurrent sessions, an end user only forum, a spectacular sponsored event, and more...

Mike Eruzione, Captain of the 1980 US Olympic Hockey Team, and Subject of the Hit Film, ***Miracle***, will kick off the conference with a session entitled **"Going for the Gold"**.

Mike Eruzione shares how to overcome any obstacle and go for the gold. When the 1980 US Olympic Men's hockey team, led by Coach Herb Brooks and captained by Mike Eruzione, defeated the mighty USSR team in the semifinals and went on to beat Finland for the gold medal, it truly shocked the world. This stunning achievement, which was captured in the popular 2004 Disney movie *Miracle*, is considered by many to be the "greatest sports moment of the 20th century." Drawing from his experiences in the 1980 Olympics, Eruzione reveals to audiences how true commitment is at the heart of super achievements.

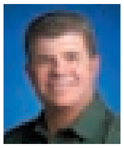
A panel of industry leaders will discuss the attributes of data center performance and how they measure them in their respective organization to drive continuous improvement into their operations at a session entitled **"Driving Data Center Performance"**.

MODERATOR:

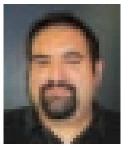


David Schirmacher
Senior Vice President of Operations, Digital Realty, and President, 7x24 Exchange International

PANELISTS:



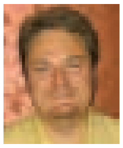
Joe Kava
Vice President, Google Data Center Operations



Nicholas Bustamante
Manager of Global Data Center Operations Engineering, Microsoft

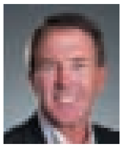
Todd Traver, CDCDP, PMP
Data Center Strategy and Energy Efficiency Executive, IBM Global Technology Services

Michael J. Manos
Chief Technology Officer, AOL



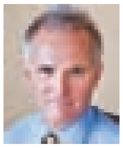
Kevin Kealy, Senior Vice President of Enterprise Networking at FIS Global, will open the second day with a keynote presentation entitled **"How to Stop Hackers Affecting Your Performance – The Blue Pill for Data Centers"**.

The closing keynote is entitled **"Performance Challenge – Tier IV PUE 1.2 Modular Build Out"** and will be delivered by Dave Leonard of ViaWest and Gary Orazio and Robert Yester of Swanson Rink.



Dave Leonard
Senior Vice President
ViaWest

Robert Yester, PE ATD
Executive Vice President
Swanson Rink



Gary Orazio, PE
President
Swanson Rink

In keeping with the theme, additional presentations will be delivered on topics such as:

- Driving Data Center Performance by Minimizing Latency
- Fuel Cell Pioneer: The First National Technology Center
- The Cleveland Clinic Data Center: Challenges & Solutions
- Intel - High Density Data Center: An Operational Review
- HP - How the Warmest Year Ever Affects the Data Center
- Optical Trends in the Data Center
- Cloud Energy Storage for the Grid
- National Science Foundation – The Digital Utility
- Quenching the Thirst for Future Growth
- Using the ASHRAE Guidelines for IT Equipment Thermal Management and Control: A Big Opportunity
- Network Virtualization and its Impact on the WLAN
- Ten Steps to Maximizing Efficiency in the Data Center
- Fire Protection in the 2015 Data Center
- Green Grid - Using the Data Center Maturity Model

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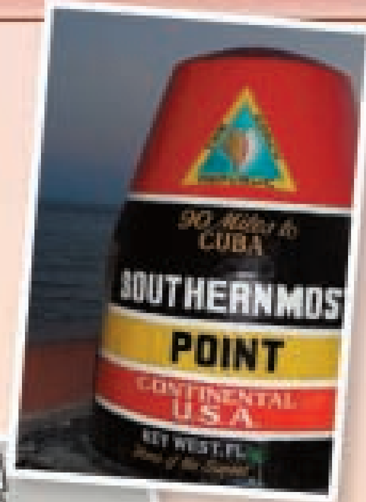

We realize that Key West is a long way from Boca Raton... that is why we chose to bring it to you! Join 7x24 Exchange and our Sponsors for this event on the Yacht Club dock for an evening of fun filled networking!

If you travel south on A1A to the very end of the road you will find yourself at the "Southernmost Point" in the United States – the magical town of Key West, Florida. Take in the breathtaking beauty of the blue waters that surround you and walk along tree-lined sidewalks filled with unique architecture from the turn of the century.

At "The Conch Republic" 7x24 Exchange guests can treat themselves to a photo opportunity with Ernest Hemmingway or take a shot at a record catch on "Mile Marker One" in a virtual reality fishing experience set up complete with a first mate, without even getting wet.

The famous sunset ceremony will be re-enacted with the famous Key West Cats. A Key West cigar factory comes alive as the cigar master rolls his favorite blends right before your eyes. Tight rope walkers, both human and feline, will thrill the audience as jugglers and stilt walkers eat fire and blow the conch shell to herald the setting of the sun.

Enjoy the tropical atmosphere, while vendor carts display the vast array of delicacies local to the Island cuisine.

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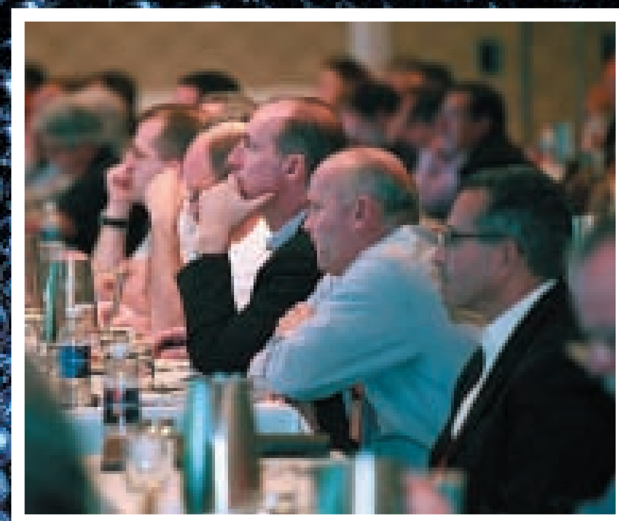
CAROLINAS CHAPTER

MISSION CRITICAL OPERATIONS CURRICULUM

The Carolinas Chapter Educational Committee, led by Paul Marcoux, developed a most impressive and impactful program that has gained support, both by endorsement and monetary, from a number of parties. The foundation of the program, now renamed, "The Bob Cashner Memorial Fund", recognizes the fact that on a national basis, over the past 15 years, there has been a steady decline in people entering fundamental trades that support mission critical operations. The average electrician or mechanic is in the mid- to late-50's. For the last decade training was over-weighted toward programming and engineering. Now the pendulum has returned to value technical training. Through the formation of the Educational Committee, the Carolinas Chapter has taken a pro-active position, which includes:

- Raising awareness about the need for the Mission Critical Operations Curriculum;
- Promote awareness that Mission Critical Operation is not just about data centers but can be found in 911 call centers, hospitals, and critical manufacturing process etc.;
- Raised $10, 000 to support MCO education and scholarships related program development;
- Gathered college involvement from Cleveland College, Isothermal Community College, Catawba Valley Community College, and Caldwell Community College and Technical Institution;
- Built a strong relationship for MCO with Dr. Ralls, President, NC Technical Schools;
- Dr. Ralls in concert with school administration has committed to providing $200,000 to seed development of an MCO training curriculum;
- The Education Committee worked with these institutions to develop a grant application to the National Science Foundation for $600,000 to develop an MCO curriculum;
- Published the Mission Critical Curriculum course white paper which became the basis for the NSF Grant and NC Technical School program development.

By creating the program, the Chapter has charted a Mission Critical Career Ladder that allows young people to embark upon a career and continue to grow through programmatic learning, moving from a general maintenance position to a Mission Critical Technical or Business Executive.



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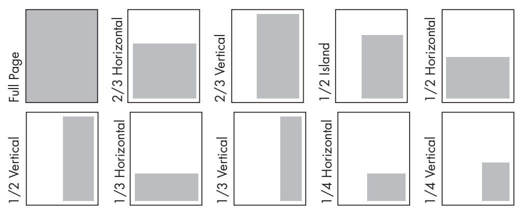

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Bylines: All articles should include a brief (1-2 sentence) author biographical sketch at the end of the article, that includes the author's name, title, affiliation, address, and phone number. Photos of authors are never used. We do not pay authors for contributions.

Visuals: Authors are encouraged to submit photographs and charts, graphs, or other illustration that will help readers understand the process being described, though it does not guarantee that visuals will be used with the article. Submit all charts, graphs, and other artwork separately; do not incorporate them in the body of the article. Indicate caption material separately. We reserve the right to publish submitted visuals.

Editorial procedures

All articles are reviewed for suitability. Accepted materials are then edited for grammar and to conform with our editorial style. All attempts are made to preserve the author's writing style, however, we have the right to edit for style, clarity, and to fit space allotments, and to make final selection on headlines, subheads, and graphic treatment. Manuscript submission implies author agreement with 7x24 Exchange's Editorial Policies.

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