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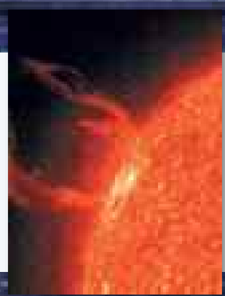
THE END-TO-END RELIABILITY FORUM

PUE VS PUE
HP Technology Services Strategy



Space Weather: A Brief Overview

A New Data Center That Will Hit Your Sweet Spot
Duffy Development Services

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Robert F. Kennedy, Jr.
2011 SPRING CONFERENCE
KEYNOTE SPEAKER

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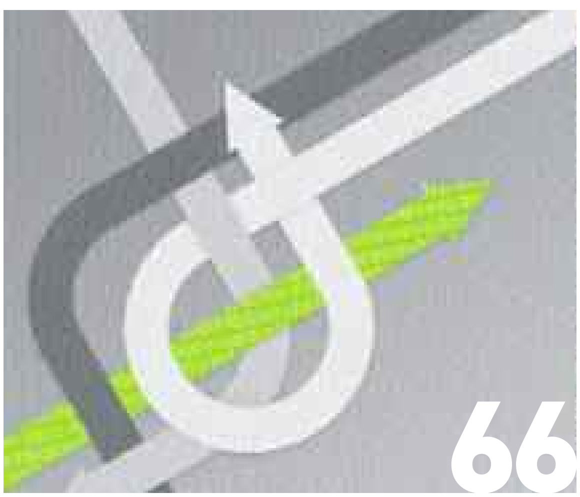

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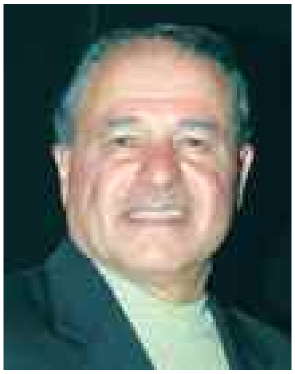


Robert J. Cassiliano

After "Digging Out" all winter I am sure everyone is looking forward to Spring!

Although economic uncertainty continues to prevail, 2011 is showing promise of increased business activity. Companies are slowly but steadily increasing hiring of employees and consultants to support business needs. Additionally, projects on hold and new initiatives are now getting reviewed for approval and implementation. These signs are very positive indicators for Mission Critical professionals as upgrading of information infrastructures and building new facilities are on the list of projects to be approved. A compelling business case needs to be made to senior management, however the time is right as capacity constraints and aging infrastructures become the driving factors. Companies supporting the Mission Critical Industry that are prepared to very quickly provide knowledge and resources as clients request will be successful and those that are slow to react will have missed opportunity.

The theme for the 2011 7x24 Exchange Spring Conference being held at the Hilton Bonnet Creek in Orlando, Florida June 12 – 15, 2011 is End to End Reliability: "Emerging Trends". Conference highlights are as follows:

- Conference Keynote: "Green Gold Rush: A Vision for Energy Independence, Jobs and National Wealth" presented by Robert F. Kennedy, Jr.
- Keynotes by Yahoo and Wells Fargo
- US Department of Energy (DOE) Data Center Practitioner Training & Certification
- Special presentation by NASA on Solar Flares
- Presentations by The Green Grid and the Uptime Institute
- Exchange Tables on specific topics at Monday breakfast and Tuesday lunch
- An End-User Exchange Forum Luncheon on Monday
- Vendor Knowledge Exchange on Monday afternoon

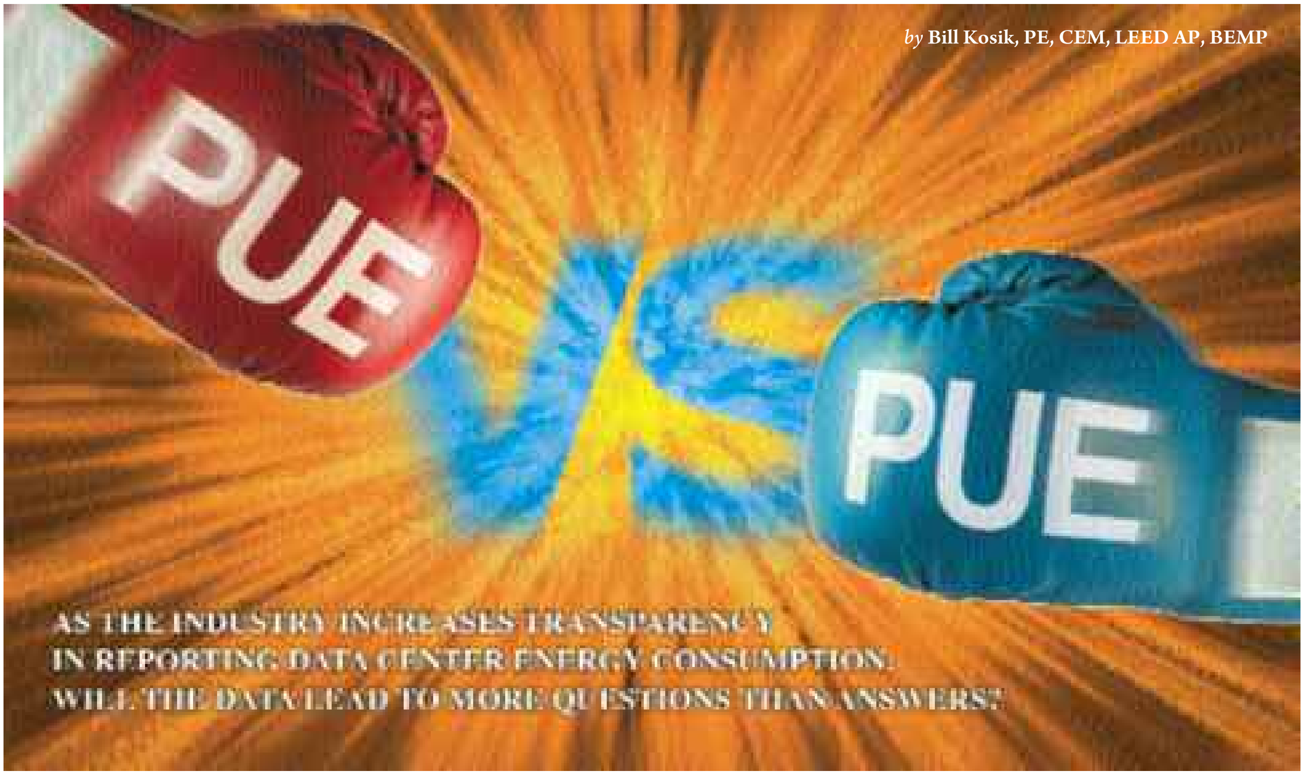
Sponsored Event: "An Evening at Sea World Orlando"

The program content is designed to provide value to conference participants and their companies by focusing on important topics of the day. Energy Efficiency, Data Center Design, and Reliability are highlighted at this year's Spring event.

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

Sincerely,

7x24 Exchange Chairman, Bob Cassiliano, presents the keynote speaker, NFL Legend Joe Theismann with a donation to St. Jude Children's Research Hospital on his behalf.



Reliability, resiliency, energy efficiency and sustainability are just a few of the many criteria used to judge the effectiveness of a data center. Now that energy efficiency strategies and metrics such as PUE/DCiE have been vetted for use in designing, monitoring and reporting, and other metrics such as carbon and water use effectiveness are right around the corner, the industry is now attempting to measure and publish data center energy consumption in a consistent and uniform manner. To enable this, organizations are working on revising or publishing new standards and guidelines on how, where and at what intervals readings should be taken.

Current Industry Resources and Analytics

Recommendations for Measuring and Reporting Overall Data Center Efficiency, unites many unrelated guidelines currently being used in the industry for the measurement of data center energy consumption. This document is unique in that it has been developed by an industry consortium: 7x24 Exchange, ASHRAE, The Green Grid, Silicon Valley Leadership Group, Energy Department's Save Energy Now and Federal Energy Management Programs, the Environmental Protection Agency's Energy Star program, the U.S. Green Building Council, and the Uptime Institute all participated. Other seminal programs include the US Green Building Council's LEED Data Center Adaptations and the EPA's Energy Star for Data Centers.

In all of these programs it is essential to understand that energy consumption and PUE should not be used as comparative metrics. It might be intuitive that a facility in a cold climate will have very different energy consumption compared to a facility in a hot climate. But this discussion becomes obscured when other operational parameters are thrown into the mix – what happens when we measure electrical consumption for a very lightly loaded data center? What is the impact of using different types of economizers (water, direct, indirect, evaporative)? Will a moderate and dry climate assist in lowering energy use? Or will a moderate and humid climate be better? How does an off-line UPS compare with a double-conversion UPS?

Now take these options and put them into a matrix to compare combinations of alternatives. The matrix gets very large, very quickly. Since there are so many nuances and subtleties in data center design and operation, it becomes obvious that comparing PUEs of different facilities becomes impracticable. However, it is possible to use these tools for data center design and benchmarking of existing facilities; tools that take into account all of the subtleties and create a platform for parametric analysis of the myriad options.

Geography and Climate

The location of the data center impacts the PUE and annual electricity usage. This primarily comes from the hourly outside dry bulb temperature and moisture content levels that vary based on location. During the preliminary design phase of a project, high-level decisions can be made by analyzing hourly weather data. This data includes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weather station number, latitude, longitude, elevation, hourly dry bulb and dew point temperatures, and relative humidities. Using standard psychrometric algorithms, additional information such as wet bulb temperature, enthalpy and moisture content can be generated for use in more detailed analysis. This data can also be used to create an annual profile of dry bulb and dew point temperatures. This data visualization technique helps both designers and end-users understand the basics of temperatures that can be expected in a particular climate, what the peak values are and when they occur, as well as the annual variation in temperatures. (Figures 1, 2)

Building Envelope Heat Transfer and Leakage

Maintaining the required temperature and humidity tolerances in a data center for 8760 hours per year is very energy-intensive. Rightfully so, much attention and research is currently aimed at HVAC system control strategies and system efficiencies to reduce energy usage. One area that is not being fully addressed is how the building that houses the computers affects the temperature, humidity and energy use. Building leakage will impact the internal temperature and moisture content by outside air infiltration and moisture migration. Depending on the climate, building leakage can negatively impact both the energy use of the facility as well as the indoor moisture content of the air. Interestingly, depending on the climate, building leakage may actually reduce energy consumption by providing supplemental cooling and/or humidification/dehumidification. (Using uncontrolled outside air infiltration, however, is not a recommended way of relying on outside air to reduce the mechanical cooling load).

Based on a number of studies from NIST, CIBSE and ASHRAE investigating leakage in building envelope components, it is clear that often times building leakage is underestimated by a significant amount. Also, there is not a consistent standard on which to base building air leakage. For example:

- CIBSE TM-23, **Testing Buildings for Air Leakage** and the Air Tightness Testing and Measurement Association (ATTMA) TS1 recommend building air leakage rates from 0.11 to 0.33 CFM/ft^2.

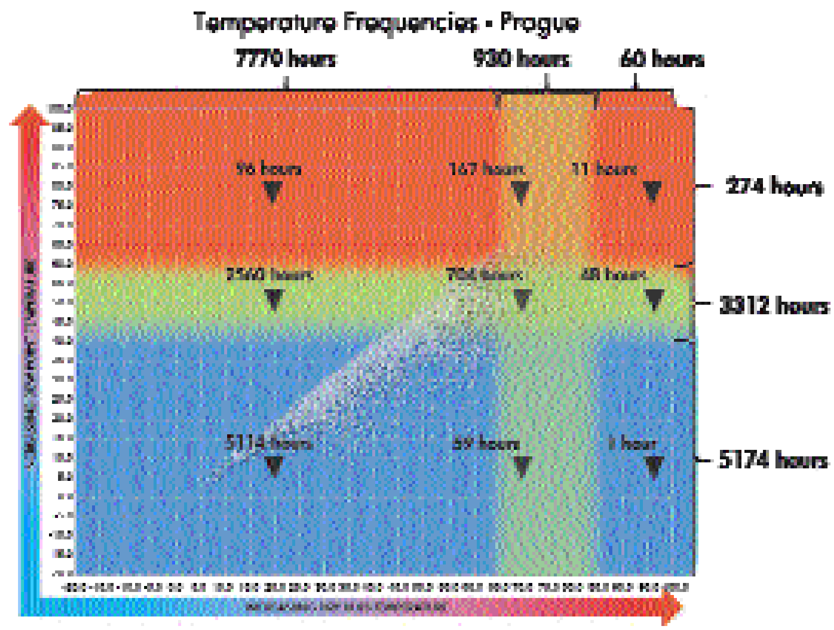


Figure 1 – Knowing the climate in which the data center is to be located is critical in the cooling system selection process.

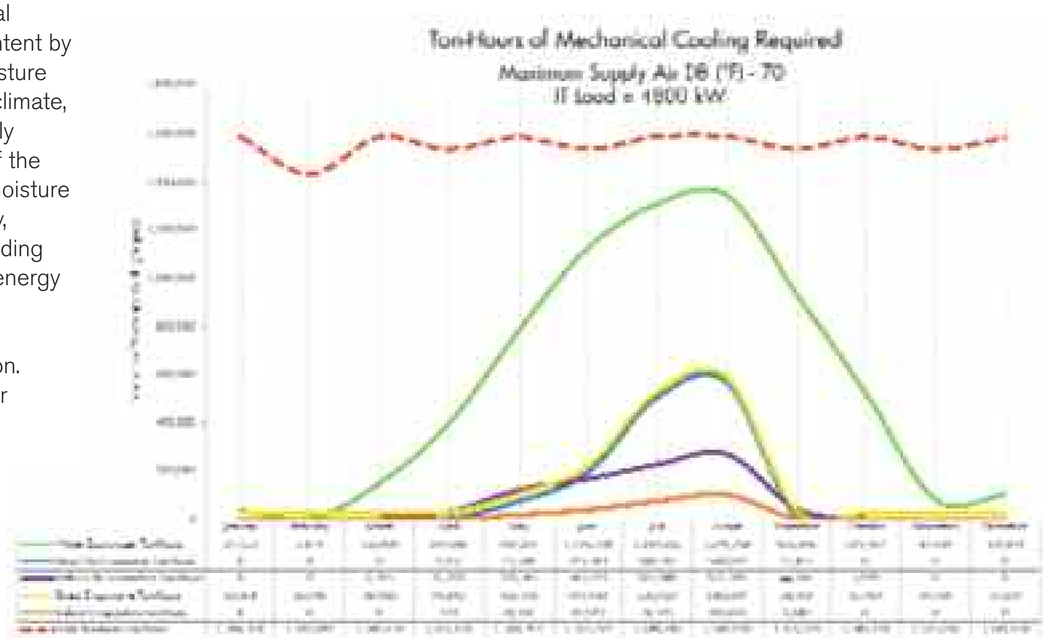


Figure 2 – Each cooling system will require a different amount of mechanical cooling based on air setpoints and climate.

- Data from Chapter 27, "Ventilation and Air Infiltration" from ASHRAE Fundamentals show rates of 0.10, 0.30 and 0.60 CFM/ft^2 for tight, average and leaky building envelopes.
- The NIST report of over 300 existing U.S., Canadian and UK buildings showed leakage rates ranging from 0.47 to 2.7 CFM/ft^2 of above-grade building envelope area.
- The ASHRAE Humidity Control Design Guide indicates typical commercial buildings have leakage rates of 0.33 to 2 air changes per hour and buildings constructed in the 1980s and 1990s are not significantly tighter than those constructed in the 1950s, 1960s and 1970s.

Cooling System Strategies

The energy use of the HVAC system (DX, chilled-water, air-cooled, water-cooled) will vary based on the outdoor air dry-bulb and wet-bulb temperatures, the chilled-water supply temperature (for chilled-water systems only), and the wet-bulb temperature entering the cooling coil (DX systems). The annual energy consumption of a particular HVAC system is determined by the use of algorithms developed to estimate electrical usage of vapor compression cooling equipment. Depending on the type of HVAC system being considered, the variables used in these algorithms represent temperatures for outdoor wet bulb, outdoor dry bulb, chilled-water supply, and condenser water supply.

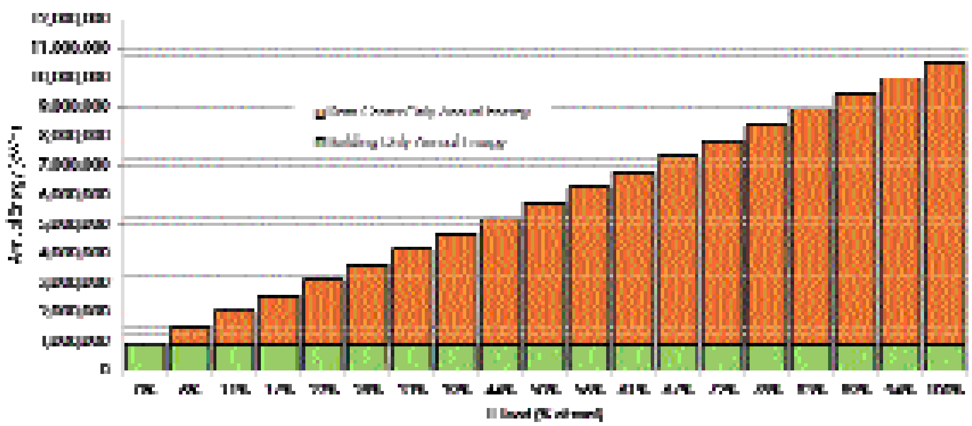


Figure 3 – The building that the data center is located in will consume a basic amount of energy annually. This energy can be significant in the early life of a data center relative to the IT load.

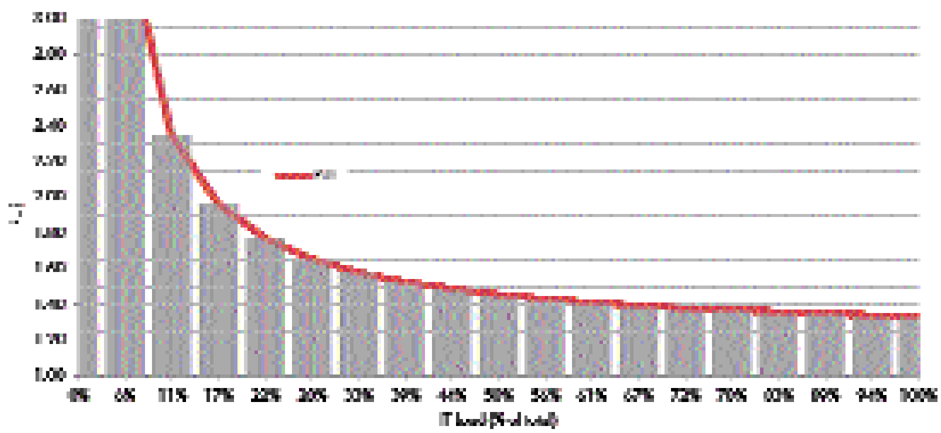


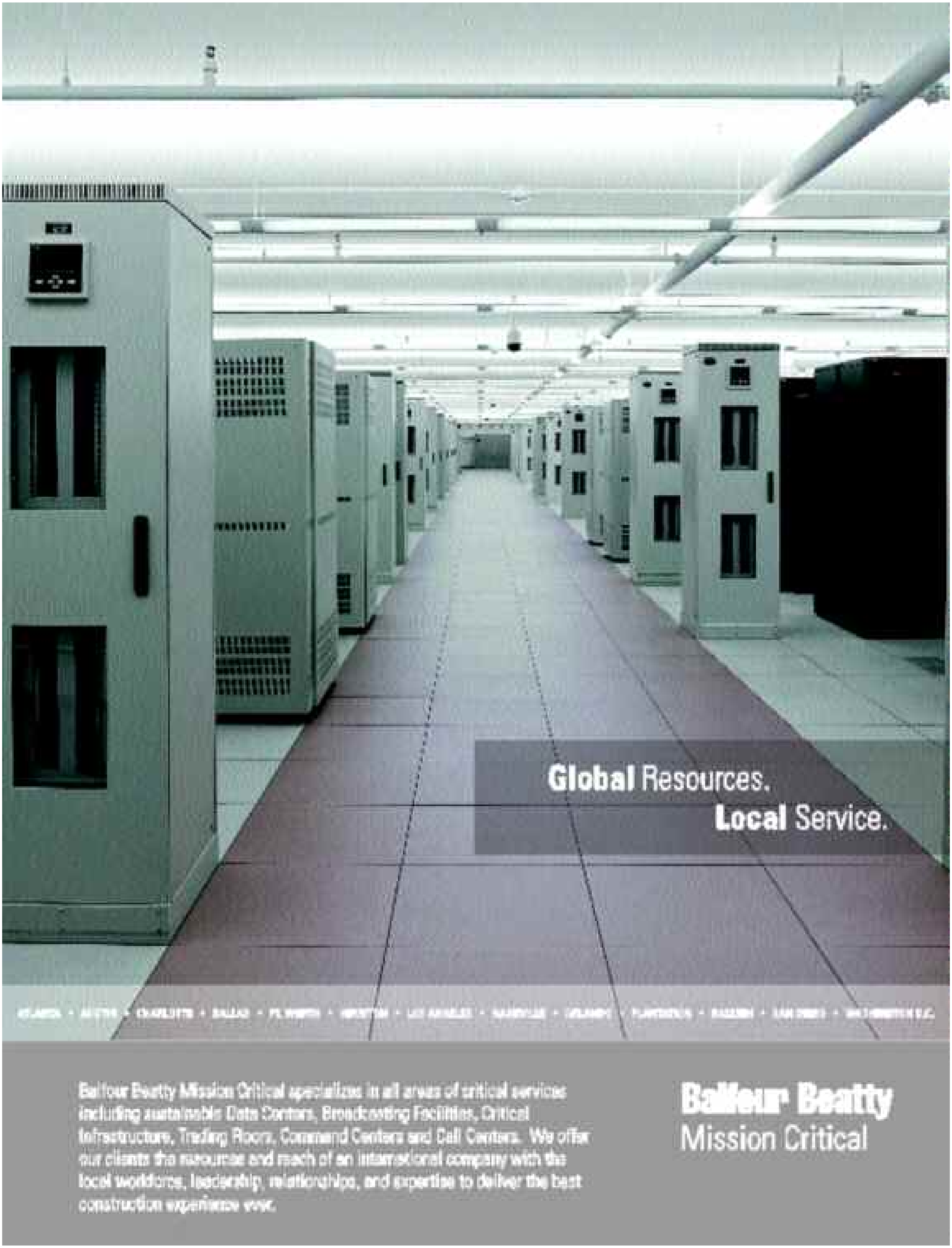
Figure 4 – The PUE of the data center can be significantly higher than the design specifications depending on the duration of the IT equipment ramp-up.

One important energy reduction strategy specific to data centers is using high-temperature chilled water. (In other commercial building types where human comfort is the primary goal, colder water is necessary to achieve both indoor dry-bulb and wet-bulb temperatures as required by the standards on thermal comfort). Using higher water temperature also enables extended hours per year to use the economizer cycle. These savings can be achieved with both air and water economizer. This extension in hours comes from raising the air supply temperature from a typical 55°F to 70°F or even as high as 80°F. Since the compressor energy is the second highest energy consumer in a data center (next to the servers themselves), it is important to consider these ideas when designing or retrofitting a data center.

Part Load Efficiency

Most data centers have a prolonged ramp-up of IT equipment installation. This means that for a long period of time the data center will run at a fraction of its design load. Running the compressors and UPS systems at low loads generally will result in low efficiencies. To minimize the impact of low load conditions, designing modular data centers with expansion capability will maintain equipment efficiencies at optimal levels throughout the life of the data center.

At initial move-in, it is typical to see PUE values that are an order of magnitude higher that what the facility was designed to. Why does this happen? In addition to the inefficiencies of the power and cooling systems noted above, the data center relies on HVAC and electrical infrastructure and other support spaces. So the PUE must account for a very large "overhead" for a very small IT load. Since this "overhead" is in the numerator of the PUE calculation at the IT is in the denominator, the PUE increases commensurately. (Figures 3, 4)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Interplay with IT Equipment

The fact that the IT equipment is the primary "tenant" in a data center facility necessitates an on-going dialog to understand the needs of the "tenant". This interface arguably presents the greatest opportunities for overall energy use optimization in the data center. From a thermal standpoint the computer's main mission is to keep its internal components at a prescribed temperature to minimize risk of thermal shutdown, reduce electrical leakage and in extreme cases, mitigate any chances of physical damage to the equipment. The good news is that thermal engineers for the IT equipment understand the effects of wide temperature and humidity swings on the equipment and on the corresponding energy consumption. From a data center cooling perspective, it is essential to understand how the ambient temperature affects the power use of the computers. Based on the inlet temperature of the computer, the overall system power will change; assuming a constant workload, the server fan power will increase as the inlet temperature increases. The data center cooling strategy must account for the operation of the computers to avoid an unintentional increase in energy use by raising the inlet temperature too high. (Figure 5)

Overall Building Energy Consumption and PUE

In commercial buildings the outside conditions impact the energy use of the facility significantly. Passive design techniques to reduce energy consumption when choosing glazing type, insulation, building orientation, thermal mass, etc. are essential in minimizing unwanted heat transfer across the building envelope. Since most facilities such as offices, hotels and school have a cooling load that is predominantly externally loaded, the focus tends to be on how the climate affects the overall energy use. Data centers are predominantly internally loaded - the primary energy reduction strategies have mostly dealt with improving the efficiency of the power distribution and cooling systems by minimizing losses and improving air distribution effectiveness. Even though the internal load far exceeds the cooling load imposed by the climate conditions, climate impacts data center energy use in ways that are unique to this building type.

The HVAC system energy will change based on three main areas: outdoor conditions (temperature and humidity), the use of air and water economizers, and (when designing a new facility) using different types of HVAC system design. These items are detailed in the following.

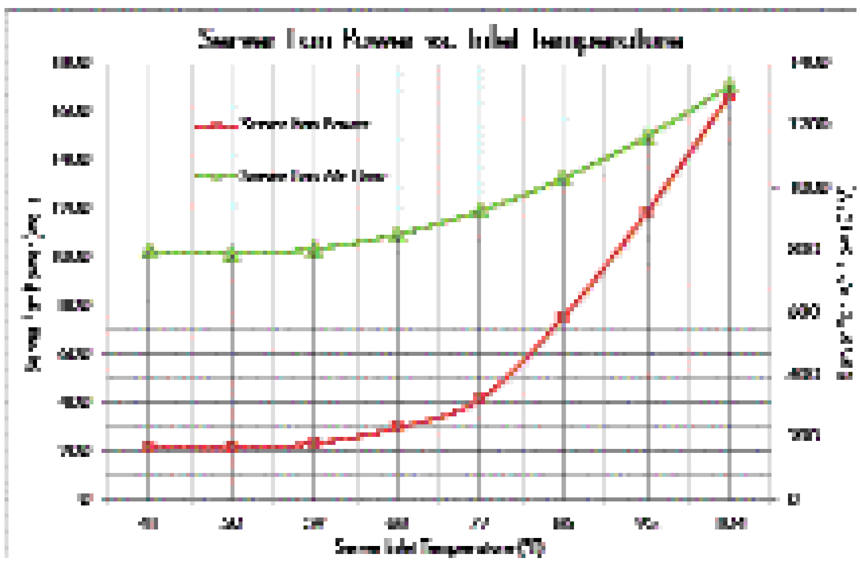


Figure 5 – An example of how fans in a server will increase airflow (and power) as the inlet temperature increases. Every computer will have different characteristics that must be considered in the overall data center cooling strategy.

1. The HVAC energy consumption is closely related to the outdoor temperature and humidity levels. This is because the HVAC equipment takes the heat from the data center and transfers it outdoors. The higher the outdoor air temperature is (and the higher the humidity level is for water-cooled systems) more work is required of the compressors to lower the air temperature back down to the required levels in the data center.
2. Economization for HVAC systems is a process in which the outdoor conditions allow for reduced compressor power (or even allowing for complete shutdown of the compressors). This is achieved by supplying cool air directly to the data center (direct air economizer) or, as in water-cooled systems, cooling the water and then using the cool water in place of chilled water that would normally be created using compressors.
3. Different HVAC system types have different levels of energy consumption. And the different types of systems will perform differently in different climates. As an example, in hot and dry climates water-cooled equipment generally consumes less energy than air-cooled systems. Conversely in cooled climates that have higher moisture levels, air-cooled equipment will use less energy. The design and operation of the systems will also impact energy (possibly the greatest impact). The supply air temperature and allowable humidity levels in the data center will have an influence on the annual energy consumption.

Using Energy Analytics for Making Decisions

In order to determine how each of these items influences PUE, it is necessary to develop a detailed parametric energy analysis for several climactic locations. These analyses will consider both HVAC system type and economizer type. Knowing that hourly weather data is available for over 2100 locations worldwide and knowing that it is not practical to generate such a high number of individual analyses, a technique called multivariate interpolation is used as a means to perform the analysis with an acceptable degree of accuracy. This technique, often used in agro-climatic studies, is a process to assign values to unknown points by using values from a scattered set of known points.

The first step in developing the PUE analysis is to determine the locations that will be used in the in the investigation of annual energy use. For the analysis illustrated here and to ensure that the analysis is based on a geographically diverse set of climatic data, 118 world-wide locations were selected based on the prevalence of data centers in the area.

Energy Simulation

Energy simulation is the foundational element determining data center energy consumption. A subset of the analysis is to investigate how climate affects PUE. In order to understand the degree to which the different system types are impacted in climatic variations, the analysis includes multiple system types:

1. Air-Cooled DX Direct Air Economizer
2. Air-Cooled DX Direct Evaporative Cooling
3. Air-Cooled DX Indirect Air Economizer
4. Air-Cooled DX Indirect Evaporative Cooling
5. Air-Cooled Chiller
6. Air-Cooled Chiller Direct Air Economizer
7. Air-Cooled Chiller Direct Evaporative Cooling
8. Air-Cooled Chiller Indirect Air Economizer
9. Air-Cooled Chiller Indirect Evaporative Cooling
10. Air-Cooled Chiller with Free Cooling Module
11. Air-Cooled Chiller with Water Economizer and OA Economizer
12. Water-Cooled Chiller
13. Water-Cooled Chiller - Closed Circuit Tower
14. Water Cooled Chiller Direct Air Economizer
15. Water-Cooled Chiller Water Economizer
16. Water-Cooled Chiller Direct Evaporative Cooling
17. Water-Cooled Chiller Indirect Evaporative Cooling

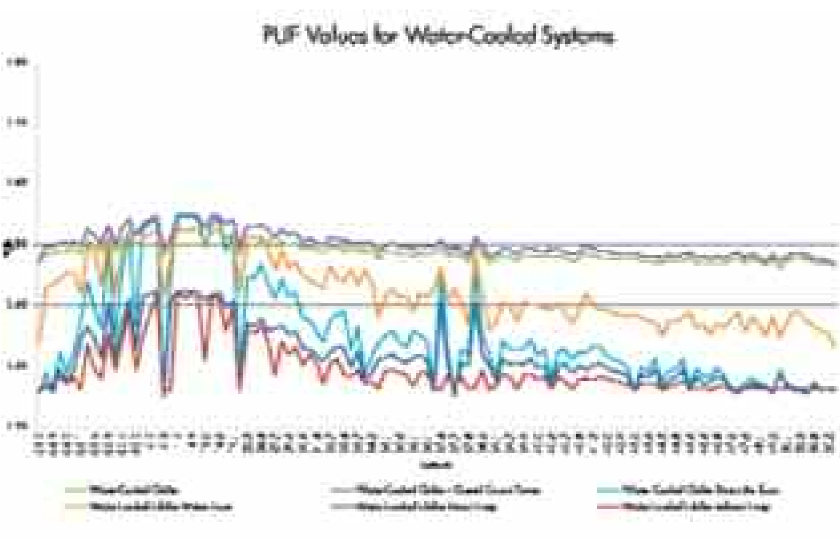


Figure 6a - Calculated PUE values for data centers with water-cooled cooling systems at different latitudes.

The analysis generates hourly energy use data in kWH for the following sub-systems (equipment varies based on system type):

- Information technology equipment (computers, servers, storage, networking gear)
- Cooling equipment (air-cooled and water-cooled chillers, air-cooled condensing unit)
- Fans (for CRAHs, AHUs, exhaust fans)
- Pumps (chilled and condenser water)
- Heat rejection (cooling towers, dry coolers, air-cooled condensers)
- Humidification (adiabatic, isothermal)

It is necessary to have this level of detail in the analysis since the energy use of many of the sub-systems is dependent on the climate in which the data center is located. As an example, the power demand of compressorized equipment (chillers, condensing units) is directly dependent on the outdoor temperature (dry-bulb or wet-bulb depending on the type of cooling equipment). Knowing that each climate will have a unique temperature profile over the course of a year, the power-per-unit-time, or energy, will also be unique. With the annual energy values for each of these sub-systems, the PUE can then be determined. (Figure 6)

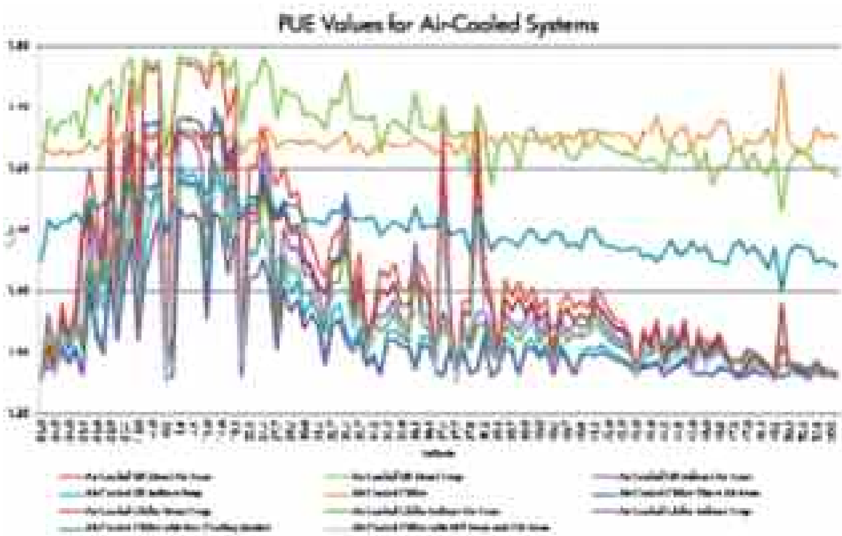


Figure 6b - Calculated PUE values for data centers with air-cooled cooling systems at different latitudes.

Multivariate Interpolation

Once the PUEs are established for the different systems, the values are used in a multivariate interpolation technique to determine PUE values that are not known (essentially "filling in the blanks").

This analysis yields an output that visualizes the PUE data; this will assist the user to more quickly understand the influence of climatic variation. (Figure 7) The overarching purpose of this analysis is to determine if climate has an effect on the PUE of a data center. Some of the systems exhibit modest percent variations in PUE across the range of climates (water-cooled chiller at 3%) but others show significant variation in energy use and PUE (air-cooled chiller with indirect air economizer at 22%).

Conclusion

Building design is a process with many contributors from many different disciplines. Buildings that house data centers have opportunities for energy savings, but to take advantage of these opportunities, there needs to be a seamless interface between the IT and facilities teams. This interface also needs to extend out to the IT equipment manufacturers to understand the capabilities and limits of operation prior to final design of the power and cooling systems. This data along with analysis on climate, building envelope, part load efficiency and cooling systems will provide a solid foundation for a robust and efficiency data center.

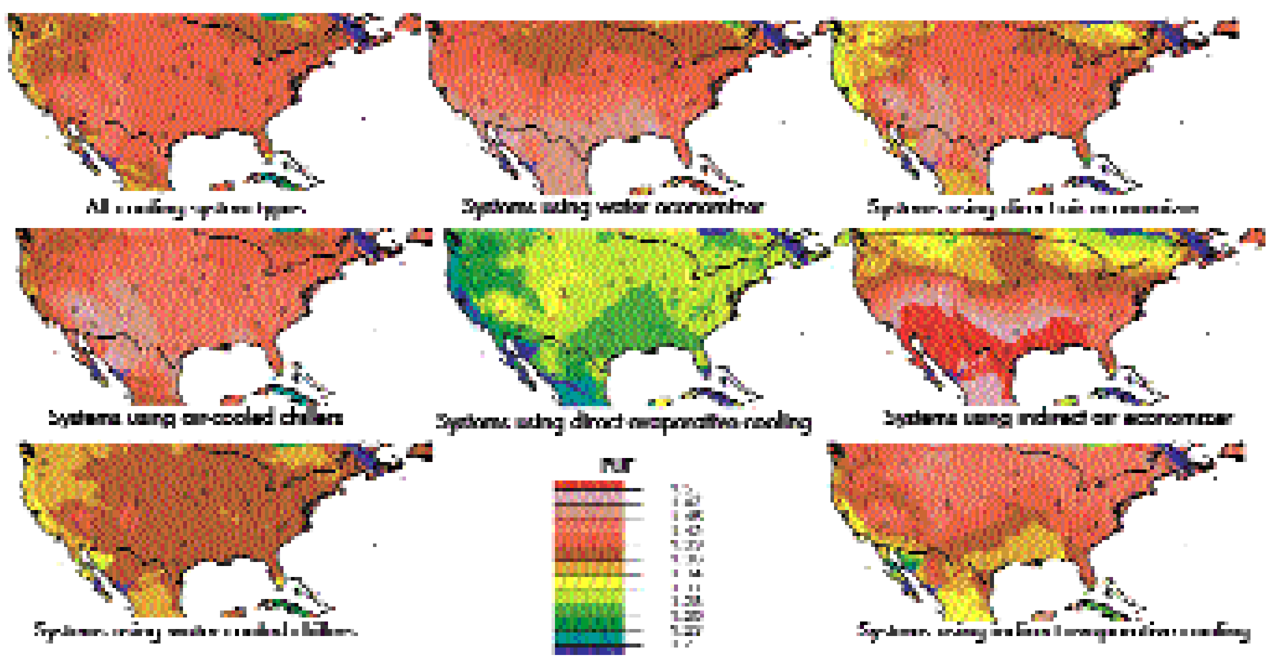


Figure 7 – Visualization of PUE data using multivariate interpolation will play a key role in understanding the effects of climate on data center energy consumption.

Bill Kosik is Principal Data Center Energy Technologist for HP Enterprise Business, Technology Services. He can be reached at William.j.kosik@hp.com.

PERFORMANCE MEASUREMENT
A CALL TO ACTION

by Dennis Cronin

We work in an industry where timely accurate data is king, where processes and reports are delivered instantaneously and where, when you type a question you get an immediate response. So why is it then, that when we look for specifics, performance metrics and growth trends on our own industry we only find fragmented excerpts, grossly outdated data and projections based upon non-facts.

Let's start with the total energy consumed by data centers. Way back in February of 2007 Jonathan Koomey wrote a research paper revealing that:

1. *"Aggregate electricity use for servers doubled over the period 2000 to 2005…"*
2. *"Total power used by servers represented about 0.6% of total U.S. electricity consumption in 2005. When cooling and auxiliary infrastructure are included, that number grows to 1.2%, …"*

When this research was later incorporated into the August 2007 EPA Report To Congress with the now infamous graph below, it energized a our industry to develop new and more efficient ways of consuming energy. It inspired programs like the Silicon Valley Leadership's great "Chill-Off" competitions comparing various cooling technologies and continues to be the basis of many new data center designs.

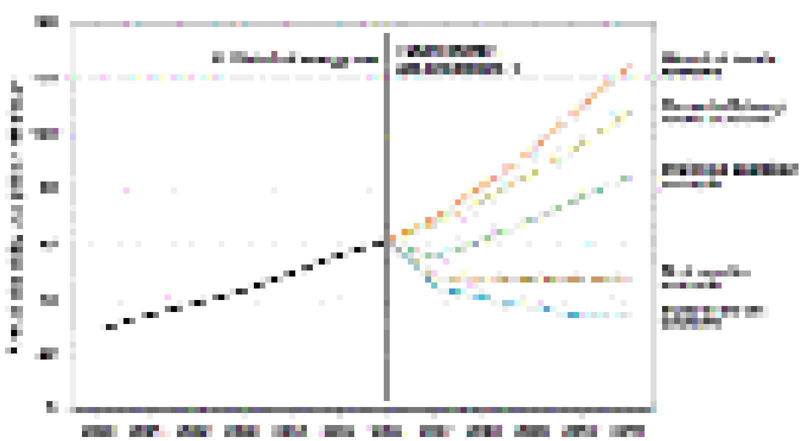
POWER REPORTING

This may all seem exceptional except that, what is shown as historical is really estimated. Now, I grant you, that to date it is the best estimate possible but it is still an estimate. With all our abilities to track information, with all our compute power, with all our databases and with the extensive improvements in data center power monitoring, it begs the question that why four years later we are no closer to getting accurate data than when Jonathan Koomey wrote his original report? Why, in a world where we get monthly reports on employment levels, where we know how many cars are sold weekly right down to the makes and models; Why can we not even get basic stats on data center power usage? Note: Koomey only estimated servers not data centers.

Taking this to the next level, the graph lays out five trend projections, yet in the four years that have followed, there has been no updating of the data, even on an estimated basis. How are we doing? Which performance curve are we trending against?

The Koomey research and the EPA report were at that time enlightening, inspiring and have since had a profound

Comparison of Projected Electricity Use, All Scenarios, 2007 to 2011



impact on our industry. Yet, for all the good that came out of them, without the development of accurate data to follow there is no way to measure our performance as an industry and without performance measurements we will not be able to manage growth.

The old saying "You cannot manage what you cannot measure" was never more applicable than it is here.

PERFORMANCE

Beyond just measuring raw consumption we need to gain insight into how the power is being consumed, what is considered good practice, what is the industry norm and is the industry getting better or worse?

This then brings us to the much maligned acronym "PUE". (Total data center power/IT power). PUE has established what is considered good practice – get as close to a PUE = 1 as possible.

Although this is not a perfect metric, it has established a sustainable industry standard so long as people do not try and game the system.

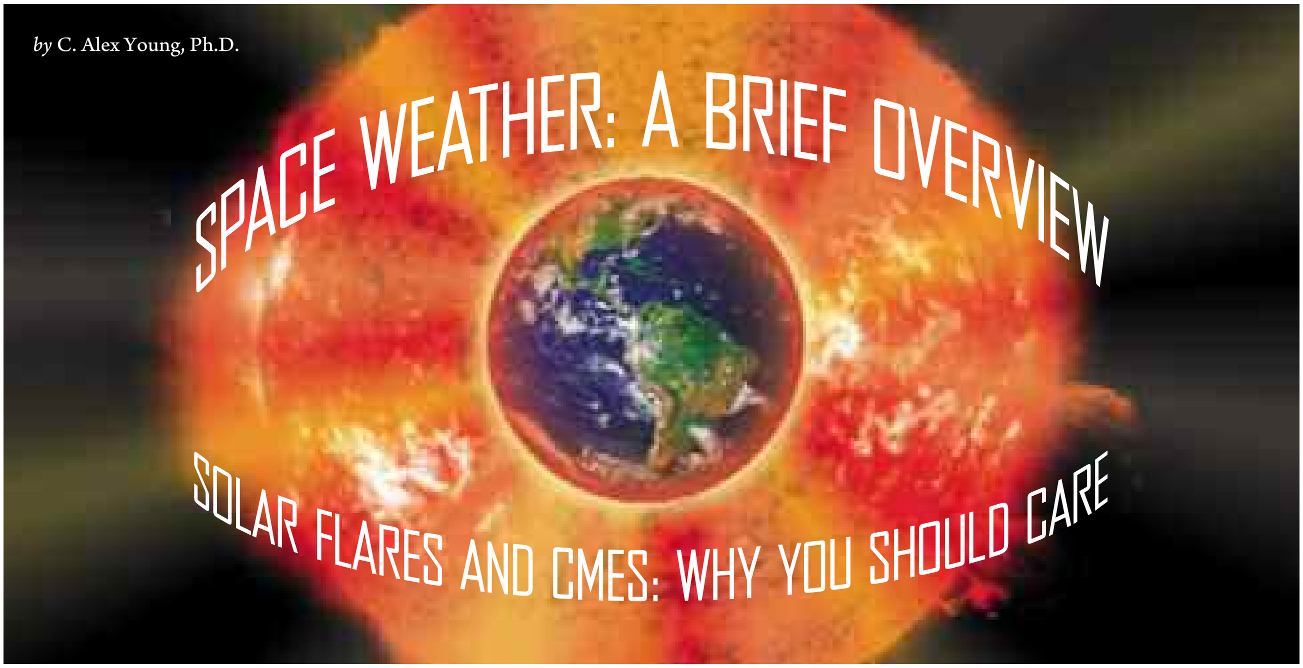
What we are still lacking is any understanding of what the industry norm is and is PUE getting better or worse? I read articles and listen at webinars I hear how data centers are operating at a PUE of 2.0 or greater yet when I talk to operators their PUE is always below 1.8 and designers are claiming designs of 1.4 or better. There seems to be a substantial disconnect here and it will never be resolved until we have definitive data from the majority of the industry.

With such data we could then gain insights such as year to year improvements and are there substantial differences between Collocation Vs. Enterprise operations. There are many things we could learn from having this data but we do not have it and as an industry we are not set up to even begin collecting it.

This is a call to action to all of you as industry leaders. There are over 1,100 collocation facilities in the US alone and at least as many enterprise data centers. With the extensive use of Power Monitoring and data collection, theses sites at best can analyze their own performance but lack comparative data with which to rank themselves against. We need cooperation, sharing and regular reporting of data. We need a central repository accessible by all those who contribute to the program and we need professional analysis of the data to help guide the future of our industry.

Let's hear your level of interest in this venture and together we can make great things happen.

Dennis Cronin is the Principal at Gilbane Mission Critical. He can be reached by dcronin@gilbaneco.com.



On Earth, we live inside an atmosphere that sustains life but also produces dynamic and often destructive phenomena to which we must adjust our lives. This includes hurricanes, tornadoes, torrential rains and powerful winds. An idea that is foreign to many is that we also live inside the atmosphere of a star, that is the entire solar system sits inside the atmosphere of a star, an active and dynamic star we call the Sun. This atmosphere consisting of ionized gas (plasma), particles and magnetic field interacts with the interplanetary environment producing different effects that we collectively call space weather. On Earth and in our local space around the Earth this space weather can produce beautiful (northern lights) and destructive results (power and communication blackouts). Here we will a brief overview of the type of phenomena that make up space weather, the effects we can experience on and near the Earth and some of the industries directly affected by it.

THE SUN HAS A CYCLE

Before we discuss the specifics of space weather it is important to mention the solar activity cycle or solar cycle. The types of solar activity that drive and make up what we call space weather follow a cycle of intensity that is roughly an 11-year cycle. A traditional measure of this activity is the number of sunspots visible on the Earthward side of the Sun. Sunspots are regions of intense magnetic field that suppress the flow of heat and light making them cooler than surrounding areas thus appearing darker. The solar cycle starts off at its minimum with few visible sunspots and low (called the quiet sun) activity. During this time the solar system is bathed in a steady flow of matter and energy mostly from the solar poles and cosmic rays from outside our solar system. The steady flow off the sun is the extended solar atmosphere called the solar wind. This wind is composed of energetic particles of mostly protons and electrons as well as magnetic fields. The solar wind and cosmic rays produce space weather effects that though generally smaller than effects during more active periods are still dangerous. As the solar cycle approaches its maximum, the number of visible sunspots increases as does the number of violent releases of energy and matter producing more intense magnetic and radiation storms at Earth. Figure 1 shows the sunspot number since 1700. The black curves are composed from yearly numbers and the red curves from monthly numbers.

Our current cycle (cycle 24) started in 2008. Figure 2 shows data from the previous solar cycle (23) along with the current cycle (24) up to April 2011. Also

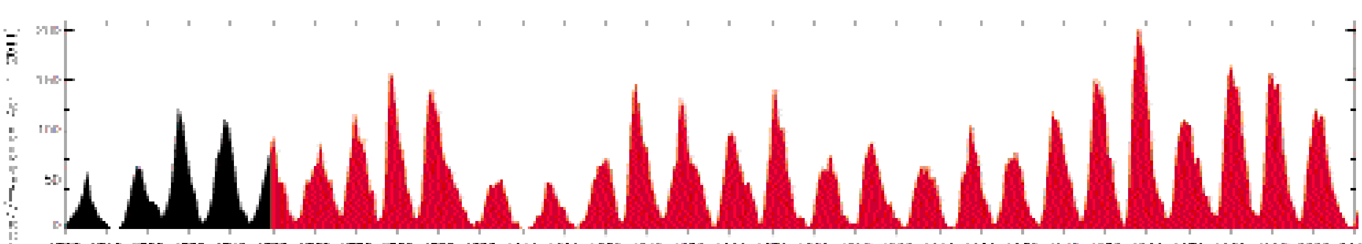


Figure 1 - Sunspot number from 1700 to the present. Black denotes yearly numbers and red denotes monthly numbers.

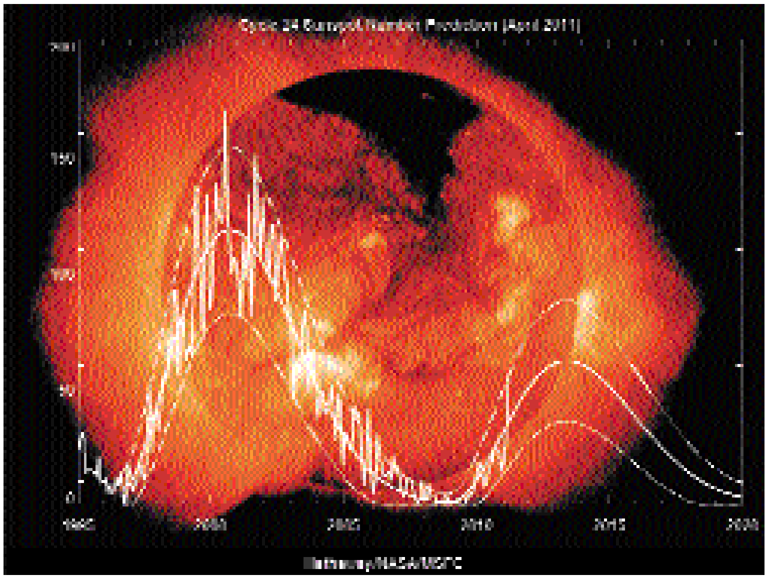


Figure 2 - Data for sunspot cycles 23 and 24 up to April 2011. Included is a prediction for the remainder of cycle 24, which estimates the next solar maximum around 2013-2014.

shown is the prediction for the remainder of cycle 24. The next solar maximum is estimated to be in 2013-2014.

THE SPACE WEATHER ZOO

The regions overlying sunspots are called active regions. Here the sun's magnetic field becomes concentrated and twisted because of the motions of the solar atmosphere at and below the solar surface. As these regions become more complex they can eventually become unstable causing the release of the magnetic energy. This is analogous to twisting a rubber band tighter and tighter until it snaps releasing energy in the form of heat and motion. The same thing happens in the solar atmosphere with the active region magnetic fields. This release of energy heats up and accelerates solar material. One form of this energy release is a flash of electromagnetic radiation over the entire spectrum (radio to gamma-rays) called a **solar flare**. Also during this energy release a high-speed blast of material can be ejected from the sun called a **coronal mass ejection or CME**. Both solar flares and CMEs can accelerate particles, mostly electrons and protons, to extremely high speeds close to the speed of light, creating a radiation storm called a **solar energetic particle event or SEP**. Solar flares and CMEs can each occur separately but the largest (and most dangerous) solar eruptions have both solar flares and CMEs associated with them. SEPs generally only occur in the largest solar eruptive events. Figure 3 shows an example of a very large solar eruptive event from the famous 2 week series of space weather storms from October-November 2003. This events are referred to as the Halloween Storms.

SPACE WEATHER EFFECTS

The solar wind fills the solar system and the Earth is constantly bombarded by this steady flow of particles and magnetic field. Normally, the Earth is well shielded from this matter by its self-generated magnetic field. Sometimes bursts of higher speed and density solar wind are able to create a disturbance in the Earth's magnetic field and these disturbances can create currents in the upper atmosphere that excite atoms creating the northern and southern lights. This is called a geomagnetic storm.

CMEs are the most dangerous and destructive space weather events. When the Sun produces CMEs that travel to the Earth they can carry magnetic field of opposite polarity to that of the Earth. This in combination with a solar wind enhanced by the CME weakens the Earth's magnetic field allowing energy to reach the Earth. This creates rapid changes in the Earth's

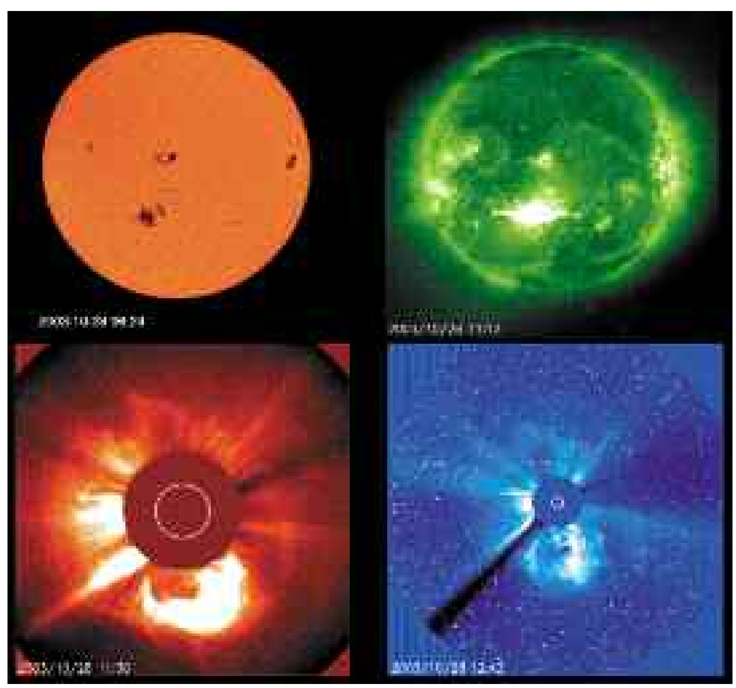


Figure 3 - On the morning of Tuesday October 28, 2003 a large sunspot group, labelled NOAA Active region 10486 (dark patch on the bottom right of the solar disk seen in the image in the upper left), erupted around 11:12 UT with a fast CME (observed first in the lower left SOHO LASCO image) and the second largest solar flare observed from space (seen in the upper right SOHO EIT image). The flare and CME produced a strong high-energy particle event that was observed hitting the SOHO spacecraft 1-2 hours later (creating the "snow" in the lower right LASCO image). This CME triggered powerful magnetic storms that caused problems for the electric grid and in-orbit satellite anomalies and failures. credit: NASA/SOHO

magnetic field causing a strong magnetic storm. These magnetic storms induce currents on the ground in power grids, pipelines, railway signaling and magnetic fluctuations that effect surveying and drilling for oil and gas.

Another consequence of magnetic storms is heating of the upper atmosphere. This changes the density in the ionosphere disrupting radio signals, in particular satellite navigation systems.

Solar flares, though visually dramatic and first to effect us (light takes 8 minutes to travel from the Sun to the Earth), have a few limited effects on radio based systems. Solar flares produce a 10-20 minute change to the atmosphere that absorbs high frequency (HF) radio waves producing an HF radio blackout on the Sun facing side of the Earth. Also, this change to the atmosphere slows down GPS signals producing location errors of many meters in GPS receivers.

SEPs created by solar flares and CMEs are very energetic bursts of particles that pose a major threat to the electronics and power systems of satellites. The Earth's atmosphere is normally a very good shield against energetic particles but during the strongest of these events particles can disrupt electronics in airplanes and even electronics on the ground. These particles can pose a significant health risk to airline crew and passengers. Particle storms can create the same atmospheric absorption effects as solar flares causing HF blackouts near the poles.

Solar flares and CMEs can create bursts of radio waves aptly called solar radio bursts. These intense bursts of radio can potentially disrupt wireless and short-range devices so they are now of growing concern as the use of this technology increases (e.g. Wifi).

INDUSTRIES AT RISK

The effects of space weather are of huge concern to power and satellite companies, the airline and transportation industries as well as oil and gas pipeline and survey/drilling companies. Even the financial sector is becoming aware of space weather's impact. The awareness of these industries to space weather varies with the satellite and power industries most aware because of their previous exposure to its effects.

EXAMPLES AND COST OF MAJOR SPACE WEATHER EVENTS

- **September 1859** - Aurora bright enough to read by seen extremely far south (Cuba). Telegraph systems ran without being powered. Some caught on fire and operators were electrocuted. Considered to be the largest solar storm on record (estimates for an event of this magnitude today are up to $2 trillion).
- **May 1921** - Entire New York Central Rail switching system knocked out. Telegraph and telephone disruptions worldwide.
- **March 1989** - Huge magnetic storm caused the Quebec power grid to fail in 90 seconds leaving millions without power for up to 9 hours (total cost not just to the Quebec power grid estimated at over $2 billion).
- **October/November 2003** - Major loss of GPS accuracy with errors over 50 meters, transformer failures in South Africa, major HF radio blackouts, 30 satellite anomalies including one satellite loss (many billions of $s).

CONCLUSIONS

The effects of space weather events and their effects on modern technologies are well understood and well documented. This does not make them any less important because the broader impact on our socioeconomic infrastructure is less understood. Our society and its dependence upon modern technologies is constantly evolving and becoming more complex and interdependent. Though we have experience and have learned from many episodes of space weather over the years we have yet to see the impact of major space weather events upon our current technological society. The current state of technology in our society has evolved greatly since the last solar maximum. The next solar maximum is several years away and the effects of space weather will become more apparent as activity begins to increase. At the same time our advancing society will increase our vulnerability to space weather. The current solar cycle is not expected to be as intense as recent ones in the past but this does not mean we can afford be complacent. In fact, the largest space weather event in modern times (perhaps in the last 5000 years) occurred in September 1859 during a low activity period of a relatively small solar cycle. The good news is that the most severe effects of space weather can be mitigated with proper precautions and preparations.

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Public Outreach Sites, http:www.spaceweather.com and http://www.thesuntoday.org
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Royal Observatory of Belgium, Solar Influences Data Analysis Center, http://sidc.oma.be/

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HIGH EFFICIENCY UPS SYSTEMS

FOR A POWER HUNGRY WORLD

Learn why energy efficiency for uninterruptible power supply (UPS) equipment is so important, what can influence UPS energy efficiency and how it can directly impact energy costs. This paper will compare the differences in energy efficiencies among various UPS topologies available today through laboratory testing. These studies demonstrate flywheel based UPS technology achieves much higher efficiency ratings as compared to legacy battery based UPS systems, resulting in substantial cost savings over the life of the system.

by **Todd Kiehn**

UPS systems provide power conditioning and backup power to mission critical facilities such as datacenters, broadcast sites and hospitals. UPS systems protect these sites from voltage fluctuations such as surges and sags or frequency fluctuations and also provide ride-through or temporary power to bridge the gap between a power outage and the restoration of utility power or the transfer to a backup generator. The UPS uses a form of short-term (seconds to minutes) energy storage to assist in power conditioning and power bridging in the event of a complete outage. The most common and practical DC energy storage forms are chemical batteries (i.e., lead acid, NiCd, NiMH, etc.), flywheels and ultra-capacitors. To perform its two functions, a UPS requires energy – in this case electricity.

The industry measures UPS efficiency as power out divided by power in with the UPS consuming a portion of the input power. The amount of energy consumed by the UPS represents energy lost or inefficiency. UPS inefficiency can waste 10 percent or more of utility input within the UPS itself and is a significant concern for datacenter operators, utilities and policy makers. UPS inefficiency amounts to hundreds of thousands of kilowatt hours per year wasted in the process of protecting even a medium sized mission critical load.

More efficient UPS systems such as Active Power's CleanSource UPS can help reduce electrical waste and cost. Proven in the lab to reach at least 96 percent efficiency at loads as low as 40 percent, CleanSource UPS can reduce datacenter energy losses by multiple megawatts and hundreds of thousands of dollars annually compared to double conversion UPS systems, while meeting or exceeding the power quality and system reliability of other topologies.

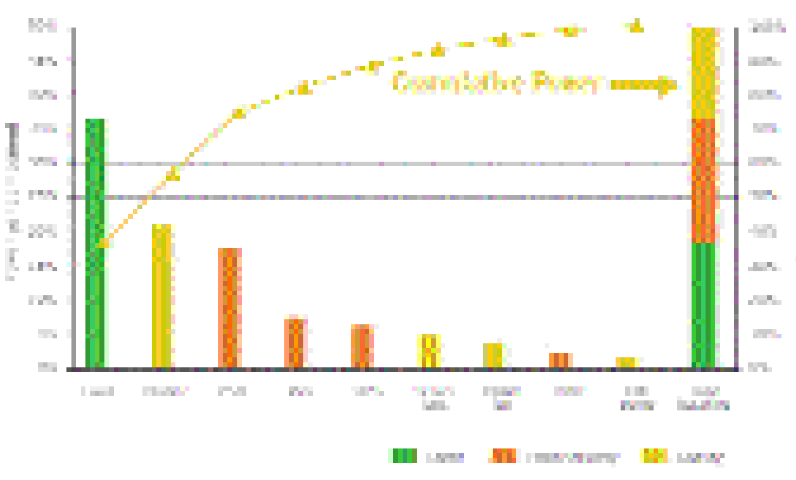
UPS EFFICIENCY DEFINED

The efficiency of a UPS, as defined by the International Electrotechnical Committee, is "the ratio of (active) output power to (active) input power under defined operating conditions," where defined operating conditions refer to a specific percent load and load type (linear/resistive versus non-linear).[1] Active power is measured in watts or kilowatts.

IMPORTANCE OF UPS EFFICIENCY

The power demands of datacenters are significant and growing. The U.S. Environmental Protection Agency (EPA) estimated datacenters consumed 61 billion kilowatt-hours (kWh) in 2006 at a total electricity cost of approximately $4.5 billion. The EPA's baseline forecast predicts a near doubling of energy consumption by 2011 to more than 100 billion kWh and $7.4 billion, assuming current growth and efficiency trends.[2] In its alternative forecast views, EPA identified adoption of higher efficiency UPS systems as a key factor in reducing datacenter power consumption.[3] A study by Intel Corp. showed typical UPS systems as contributing 6-7 percent losses to overall datacenter energy use.[4] See Figure 1.

Fig. 1) Sources of Datacenter Power Use



At the individual datacenter level, improving UPS system efficiency offers direct, 24-hour-a-day energy savings, both within the UPS itself and indirectly through lower heat loads and even reduced building transformer losses. When a full datacenter equipment load is served through a UPS system, even a small improvement in system efficiency can yield large annual cost savings. Pacific Gas & Electric (PG&E) estimates a 15,000 square foot datacenter with IT equipment operating at 50 W per square foot requires 6.9 MWh of energy annually for the IT equipment. If the UPS system supplying that power has its efficiency improved by just 5 percentage points, the annual energy bill will be reduced by 384,000 kWh, or about $38,000 at $0.10 / kWh, plus significant additional savings from the reduced cooling load.[5]

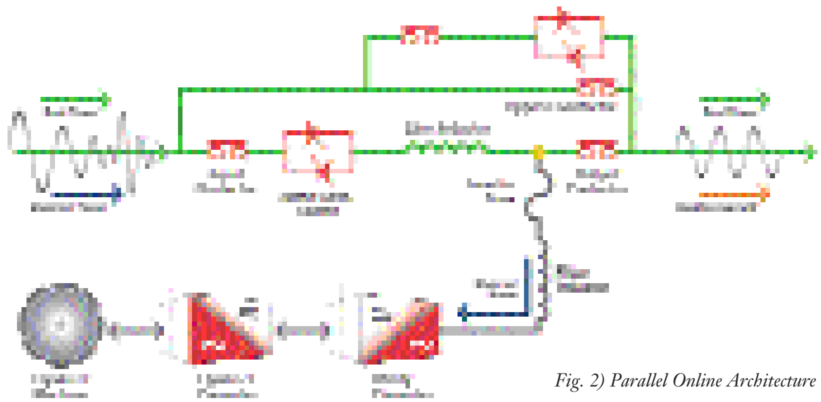


Fig. 2) Parallel Online Architecture

COOLING REQUIREMENTS AS A FUNCTION OF EFFICIENCY

When evaluating a UPS and its efficiency, it is important to keep in mind the first law of thermodynamics that "energy can neither be created nor destroyed." With respect to UPS systems, the difference in active input and output power represents heat loss as a result of the activity the UPS performs. Heat interferes with the environmental conditions in a defined space such as an electrical room and will ultimately drive the temperature up and potentially cause short- or long-term damage to equipment as it exceeds designed temperature thresholds.[6] A sound design of an electrical room includes an air-conditioning or precision cooling system to maintain a certain temperature band. The lower the efficiency of the UPS, the more heat is generated and the more cooling is required in the room, driving up capital costs and the ongoing operational expenses of the cooling system. As a general rule of thumb for an efficient centralized cooling plant, it takes 0.33 kW of power to cool 1 kW of heat. As a result, the operational cost of a low efficiency UPS is further exacerbated by the additional cooling cost.

FACTORS IMPACTING UPS EFFICIENCY

There are two key factors influencing UPS system efficiency: the topology of the UPS system itself and the design of the datacenter's power supply and distribution, which determines the load factor of the UPS.

UPS TOPOLOGY

The design of the UPS system itself has a significant impact on efficiency. Put simply, some UPS designs are inherently more efficient than others. There are two major topologies in use today in mission critical facilities – parallel online (also known as line interactive) and double conversion.

PARALLEL ONLINE

Parallel online UPS systems place the inverter and charger circuitry or transformers in parallel with the AC utility signal. This design allows a parallel online UPS to compensate for over- or under-voltages in the incoming utility power and, with the right electronics, to eliminate transients, voltage fluctuations or other disturbances. When utility power is unavailable or reaches unacceptable limits, a parallel online UPS enters stored energy mode. The UPS disconnects the load from utility power and reroutes this load with a static switch to backup power, provided by a battery or flywheel through the inverter.

DOUBLE CONVERSION

Double conversion UPS systems completely isolate IT loads from unconditioned utility power. They receive their name, predictably, because they convert unconditioned utility power two times under normal operating conditions – first from AC to DC electricity and then back again from DC electricity into a highly conditioned AC signal. Double

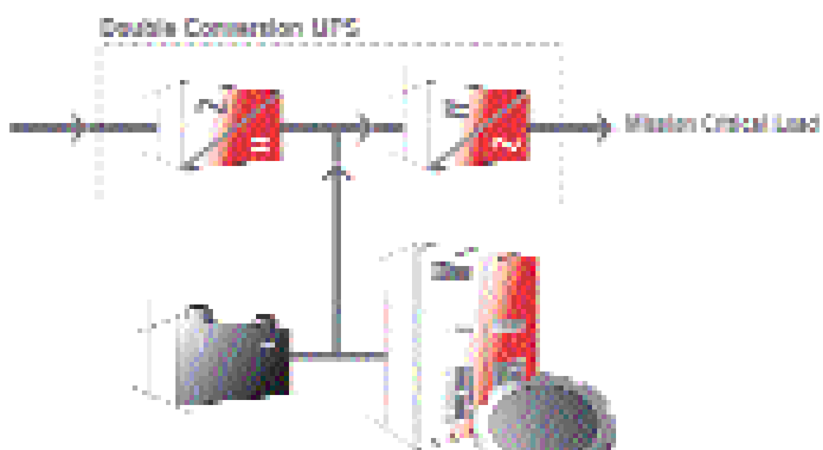


Fig. 3) Double Conversion UPS Architecture

conversion UPS systems always provide the load with a conditioned AC signal even during normal operation when utility power is available and no disturbances are present.

POWER CONDITIONING

To properly understand the differences between double conversion and parallel online topology, we first have to understand what UPS systems are protecting against.

The Institute of Electrical and Electronics Engineers (IEEE) Standard 1159-1995 defines seven categories of power quality disturbances, such as transients, sags, swells and frequency variations. Depending on the quality of the power being delivered to the facility by the utility, one or more of these disturbances may occur frequently. At a minimum, the power conditioning function of the UPS ensures output power transmitted to the IT load is well within the tolerance of the IT power supplies.[7] It does this by correcting utility power quality disturbances and delivering conditioned power to the critical load.

With a double conversion UPS, all power is rectified from AC to DC and inverted from DC to AC, ensuring a perfect sine wave and frequency protection on the output and protecting against all seven types of disturbances. This approach both exceeds the requirements of modern IT equipment power supplies – which do not always require a perfectly conditioned load – and uses a significant amount of energy.

The parallel online UPS offered by Active Power address most disturbance types in an almost identical fashion to a double conversion UPS. Active Power's CleanSource UPS uses a fast acting microprocessor and fast voltage transient discharge window which samples the incoming 16.67 msec sine wave 333 times every 50 microseconds and mitigates any transients with output filter capacitors. Reviewing the simplified one-line diagram for the parallel online flywheel UPS, it is apparent the flywheel output electrical path is almost identical to the double conversion UPS. (Compare Figures 2 and 3.)

The most common objection to the parallel online UPS design is frequency regulation because it is mains-synchronized: whatever the frequency on the input is what the frequency on the output will be. Active Power addresses this using the same microprocessor, set to allow as little as +/- 0.2 percent frequency fluctuation to pass through by using the flywheel to compensate during these events.

Ultimately, the parallel online topology is a simpler design with fewer components that is inherently more efficient while providing the same protection to the mission critical load on the output. Double conversion UPS systems condition more than required by today's IT equipment at the expense of efficiency. As shown below, flywheel based parallel online UPS systems have been proven in laboratory tests to have materially higher energy efficiencies than double conversion systems across all load factors.

In addition to the higher efficiency of the UPS topology, flywheel systems use less energy maintaining temperature and other atmospheric conditions than conventional double conversion UPS with batteries. The CleanSource UPS available from Active Power supports a wide temperature operating range (32 – 104° Fahrenheit), so it does not need to be housed in a temperature controlled battery room. And it takes up less than half the space of an equivalent rated set of batteries. Combined, this results in a significant reduction in cooling energy requirements compared to battery UPS systems.

ECO-MODE

In recent years, UPS vendors have developed an alternative operating model, known as "eco-mode" or "soft mode," for their double conversion systems as a way to improve efficiency. In eco-mode, a standard double conversion UPS keeps only the inverter module on, while the active input power is routed through its bypass circuit, not the main electrical path originally intended for full power conditioning and backup. Only in the event of an outage, momentary or extended, will the UPS switch the input power from bypass to the rectifier and inverter. Vendors promoting this mode claim their efficiency at 98 to 99 percent across a wide range of loads.

Logically, a UPS running in this "eco-mode" would reduce its losses quite significantly given it is performing less work. But it achieves high efficiency only by almost completely abandoning its power conditioning function. A UPS operating in eco-mode protects against only a full interruption of utility input. The other six IEEE defined power disturbances are not corrected because no power conditioning is taking place. Through active sensing of the bypass path, the UPS will sample the active input power, but will generally feed most of the power straight through, provided there are no interruptions. In the event of an interruption to the UPS input, it will, through fast switching, switch from the bypass path to supplying power directly from its DC energy storage (usually chemical batteries) through the inverter. But no other disturbances are addressed or remedied, so the quality of the active output power is dramatically reduced, leaving the mission critical load exposed and potentially causing long-term damage of the protected load.

An often overlooked aspect of the viability of eco-mode is its reliability in a demand situation, where demand is defined as an interruption of the incoming utility. Presumably, the UPS would switch from bypass mode to DC energy storage, providing power in a narrow band of time. However, it is commonly understood that an electrical switching device represents the single most likely cause of a failure in a UPS. Risk-assessment consulting firm MTechnology, Inc., concluded through the use of probabilistic risk assessment (PRA) that an automatic transfer switch, for instance, participates in about 95 percent of expected system failures as it represents a single point of failure.[8] That is the equivalent mean-time-between-failure (MTBF) of 100,000 hours for a complex electromechanical component. This switch within an eco-mode UPS represents an equivalent single point of

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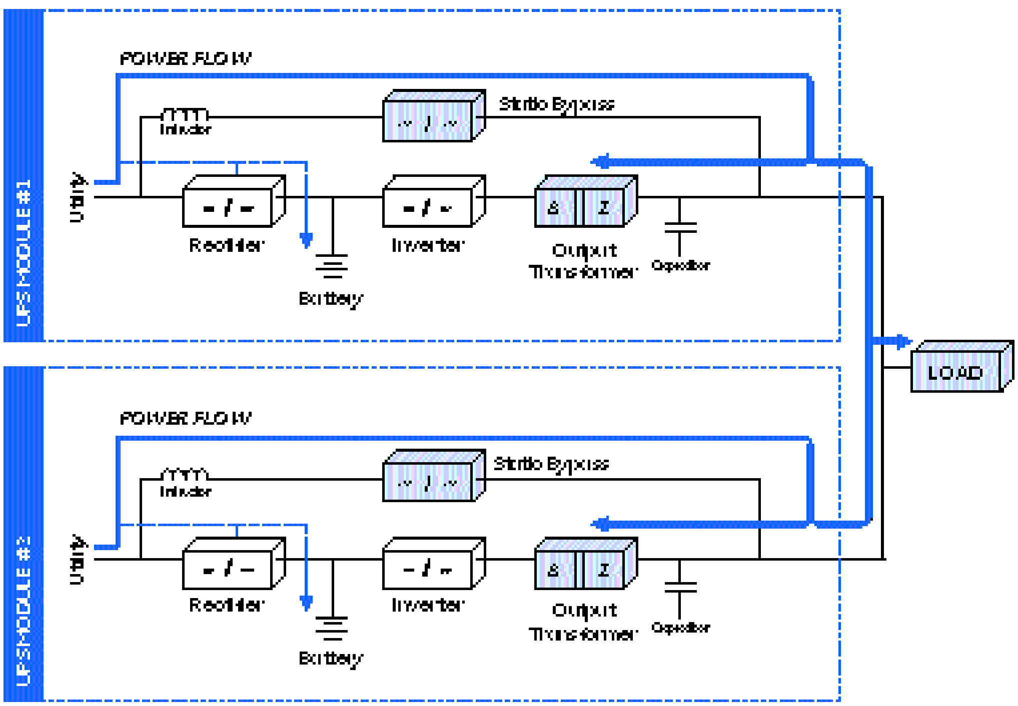

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failure; applying MTechnology's analysis raises significant reliability questions of the eco-mode UPS approach.

In sum, while a standard double conversion UPS wastes too much energy to condition power compared to parallel online systems like Active Power's, a UPS in eco-mode achieves efficiency equivalent to Active Power's only by sacrificing too much functionality. The increased probability of failure and the absence of power conditioning make a double conversion UPS working in "eco-mode" inferior to parallel online UPS topology like Active Power's CleanSource UPS.

UPS LOAD FACTOR

UPS systems in mission critical environments typically operate between 30 percent and 80 percent of rated capacity depending on the level of redundancy designed into the electrical system.

In facilities with the highest required redundancy, UPS systems are deployed in 2N configurations: the load of the facility is shared between two UPS systems so that if one fails, the other will still supply the datacenter's critical load. In this configuration, the entire mission critical load cannot be more than half of the UPS capacity installed. Under normal operating conditions, the UPS equipment never operates at more than 50 percent load. Typically, these designs end up operating at 30 percent to 40 percent of UPS capacity because common practice dictates that UPS systems should not be run at 100 percent capacity even in abnormal operating conditions and datacenters are usually designed with excess capacity to permit growth over time.

In an N+1 configuration, one or more UPS systems work as a spare, providing redundancy to support the full load should any one of the UPS systems fail. In an N+1 system having three UPS modules, the design load cannot exceed 66 percent of the installed UPS capacity and under current design standard will usually not exceed 90 percent of that level, or 60 percent of installed capacity, when the datacenter is fully populated. If the datacenter is not fully populated, loads can range from 40-60 percent.

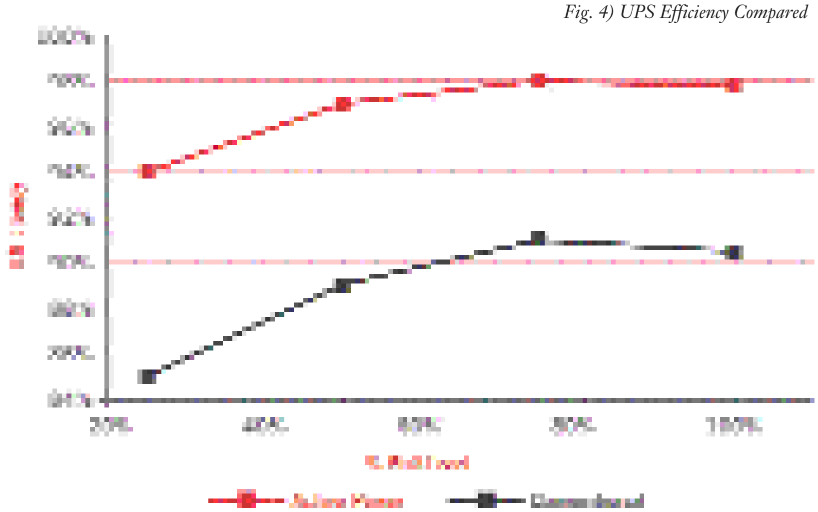
UPS efficiency varies with the amount of active power being supplied to a load and tends to decrease at partial load. The efficiency drops significantly at lower loads because the UPS generally has a base consumption or fixed "overhead" of power use, similar to a car at idle. The base consumption is driven by its control circuits, air circulation and charging currents, which remain virtually constant regardless of loading. Power used in the conditioning of active output power is almost directly proportional to the load protected, so as the load increases the base consumption has less and less of an impact on energy efficiency.

Energy efficiency at various loads for Active Power's CleanSource UPS system and a typical double conversion UPS system with batteries are summarized in Figure 4, below.

being very energy conscious in the buying process, some UPS vendors post far too optimistic efficiencies of their UPS systems to attract buyers. This is not to say the claims are untruthful, but rather they are practically impossible to replicate in a properly designed mission critical infrastructure at the end user site. There is a need to be cautious and critical of the data provided since it can change dramatically as options (such as filters and transformers in the case of double conversion UPS with batteries) are added.

Even when vendors provide efficiency ratings across a range of loads, those ratings often prove to be impossible to replicate when tested in controlled situations or measured in the field as described below. By contrast, the flywheel UPS from Active Power has proven 98 percent efficiency at 100 percent loads and 96 percent efficiency in 2N redundant / 40 percent loads, as shown below.

Fig. 4) UPS Efficiency Compared



VENDOR CLAIMS – FACT VERSUS FICTION

Many UPS vendors publish an energy efficiency percentage as part of their product documentation. Most vendors publish a single "up to" efficiency rating for their system in ideal conditions, generally 75 to 100 percent of rated active output.[9] With users and operators

EMPIRICAL RESULTS: LABORATORY TESTS

A study by Lawrence Berkeley National Laboratory (LBNL) examined the energy efficiency of the different UPS topologies across various load condition.[10]

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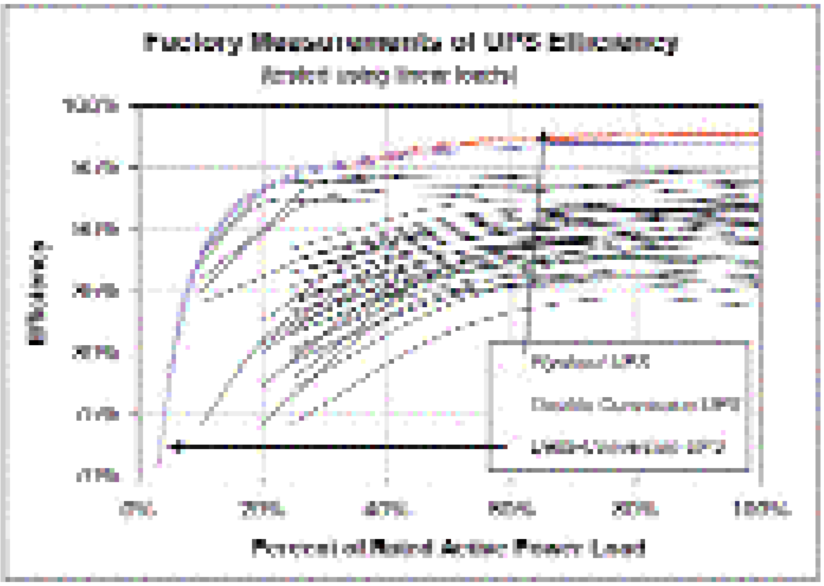

Fig. 5) Factory Measurements of UPS Efficiency *Source: LBNL*

Flywheel UPS systems like Active Power demonstrated efficiencies of 95 percent at 33 percent loads, rising to 98 percent at loads above 50 percent. By contrast, double conversion UPS systems showed a wide range of much lower efficiencies with most exhibiting 80 to 90 percent efficiency at 33 percent load and 85 to 94 percent efficiency at 50 percent load. The most efficient double conversion UPS approached 95 percent only as loads exceeded 75 percent with most still clustered at 85 to 92 percent efficiency.[11]

These results led both LBNL and PG&E to strongly endorse flywheel UPS technology to improve datacenter energy efficiency.[12]

CONCLUSION

Datacenter energy consumption is a significant and growing concern for operators, utilities and policy makers. Inefficient UPS systems can contribute to this concern with 10 percent or more of utility input going to electrical waste within the UPS itself. Flywheel-based parallel online UPS systems such as Active Power's CleanSource UPS can be part of the solution. Proven in the lab to reach at least 96 percent efficiency at loads as low as 40 percent, CleanSource UPS can reduce datacenter energy losses by multiple megawatts and hundreds of thousands of dollars annually compared to double conversion UPS systems, while meeting or exceeding the power quality and system reliability of other topologies.

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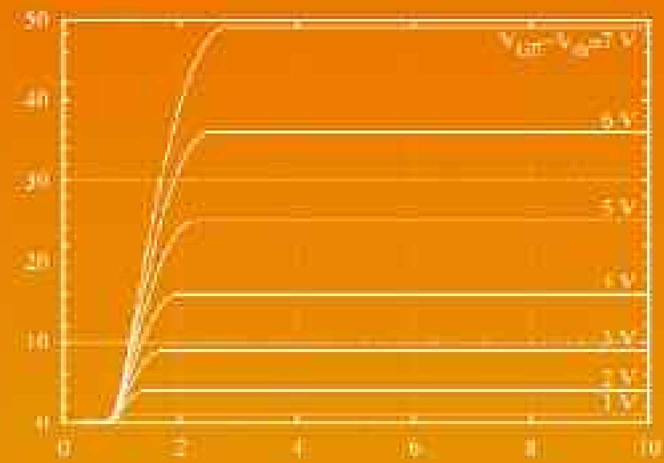

TRANSFORMERLESS
UPS SYSTEMS
AND THE 9900

by **John Steele**

INTRODUCTION

There is a growing trend in the UPS industry to create a highly efficient, more lightweight and smaller UPS system. Data Centers across the world are constantly searching for new ways to maximize reliable UPS power while minimizing the UPS and associated equipment footprint. In addition, operating costs for large data centers always will be a priority.

In applications which require a smaller capacity UPS (less than 200 kW), true on-line double conversion transformerless UPS systems have emerged as the topology of choice. In larger applications, most UPS systems consist of a UPS with a transformer, or multiple smaller UPS power modules paralleled together to achieve the required capacity. Most UPS manufacturers are finding it difficult to create a true on-line double conversion transformerless UPS system larger than 200 kW due to factors such as ground faults, high frequency noise and efficiency.

Transformerless UPS systems utilize Insulated Gate Bipolar Transistor (IGBT) for all power conversion processes (AC/DC converter, DC/DC chopper and the DC/AC inverter). IGBTs are much faster than the traditional thyristor and can be controlled by simply toggling an on/off gate signal using a digital signal processor and a field programmable gate array as opposed to waiting for a zero crossing. When the gate signal is removed, the IGBT turns off. The combination creates a series of pulses to re-shape existing voltages (conversion from AC to DC and from DC back to AC).

As with any switching power electronic, the device itself has power losses. For the IGBT, the two primary losses are the conduction losses and the switching losses. Since the IGBTs are being turned on and turned off much faster, the switching losses will increase creating a less efficient system. This is a challenge most manufacturers have been unable to overcome in larger capacity UPS systems.

For this reason, many UPS manufacturers will still use thyristors as opposed to IGBTs in the converter section of the UPS (rectifier section). Although there are many benefits in using IGBTs in the converter section, a decrease in efficiency prevents this from being a preferred option for most in larger UPS kW rated systems (above 200 kW). In the UPS inverter, the benefits of the IGBT switching speed have far outweighed the decrease in efficiency.

It is important to note that a transformer serves many purposes in the UPS system. Even if the UPS utilizes IGBTs for switching, a transformer would still have a purpose. Other technologies such as the IGBT switching controls and fault detection still need to be considered.

This paper will discuss the new technologies used in transformerless UPS systems and the advances in the Mitsubishi 9900 series UPS systems.

POWERING EFFICIENCY

Uninterruptible Power Supplies Energy Savings Opportunity

9900A UPS
(80 kVA, 100 kVA, 150 kVA, 225 kVA)

9900B UPS
(300 kVA, 500 kVA, 750 kVA)

Features

- Digital three-level IGBT Inverter and Converter
- 15 year AC and DC capacitors
- Front access only design
- Smallest footprint in the industry
- Lightweight compact design
  - Saves on installation costs
- Module used as single or parallel
- Parallel for capacity or redundancy
  - 9900A up to four modules
  - 9900B up to eight modules

Performance

- True on-line double conversion UPS
- +15 to -20% input voltage window
- Less than 3% THD at 100% load
- .99 reflected power factor to utility or generator
- 1% output voltage regulation
- Step load (100%): +/- 2%
- 9900A output power factor .90
- 9900B output power factor 1.0

Efficiency

- Highest on-line AC-AC efficiency in the industry
- Up to 97% efficiency
- Flat efficiency curve down to 20% load
- **Guaranteed efficiency**

Contact us for details on the 9900 Series UPS and our efficiency guarantee at 724.778.3176, or visit www.meppi.com.

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Uninterruptible Power Supplies

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GSA Schedule
GSA Schedule Number: GS-07F-0520G

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Figure 1: 6 pulse rectifier with optional transformer

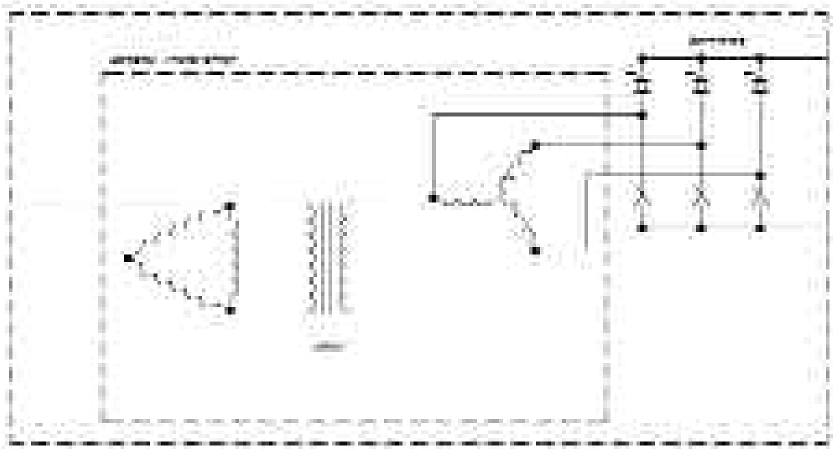


Figure 2: 12 pulse rectifier with optional transformer

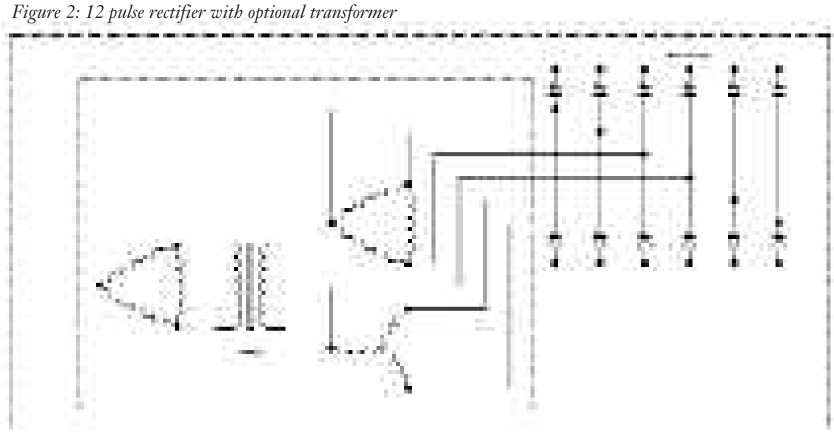
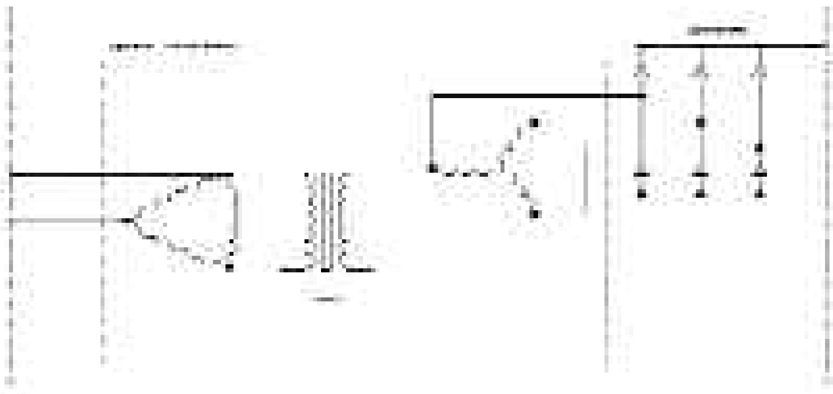


Figure 3: Diode Bridge rectifier with optional transformer



BACKGROUND

Before the advances in UPS controls and the benefits of the IGBT in the converter and inverter can start to be appreciated, the primary and secondary purposes of the transformer in traditional UPS systems must first be discussed.

CONVERTER SECTION:

The main purpose of the converter section of the UPS is to convert the AC utility power to DC power. The most popular power electronics used for this process are the Diode (6 pulse), the thyristor (SCR 6 pulse and SCR 12 pulse) and the IGBT. Until recently, the 6 pulse and the 12 pulse SCR rectifier have been the most popular.

As shown in figure 2, the 12 pulse SCR rectifier uses an isolation transformer in combination with two 6 pulse SCR rectifiers (figure 1 shows a 6 pulse SCR rectifier). The 30 Degree phase shift provided by the transformer is the main purpose of the isolation transformer. The two 6 pulse SCR rectifiers will alternate to create twice as many pulses. The 12 pulse SCR rectifier will produce fewer harmonics than the single 6 pulse SCR rectifier allowing for a smaller harmonic filter.

The Diode bridge converter (figure 3) is similar to the 6 pulse SCR rectifier, except the Diodes are natural commutation (natural on and natural off). The benefits of the Diode bridge are better efficiencies and lower harmonics compared to a traditional SCR rectifier.

Every rectifier, regardless of the technology or power electronics used, will produce harmonics. For all technologies but the IGBT (figure 4), these harmonics are greater than desired for most electrical systems, including the backup generator. Therefore, an input filter is required to reduce the harmonics to less than 10% iTHD. As shown in Figure 5, the input filter is comprised of an inductor with a parallel capacitor. The transformer, in this case, helps add inductance to the line to further reduce the harmonics. Figure 6 shows reflected harmonic distortion on input current waveforms from their respective rectifier or converter technology.

Finally, the isolation transformer used in the converter section of the UPS system will provide isolation between the UPS module and the utility. This isolation helps protect against DC ground faults caused by the batteries and will minimize damage to the upstream distribution system due to a separation in the transformer input and output windings.

Although some manufacturers have started using IGBTs in the converter section, most are still switching the IGBTs based on the traditional SCR logic. The benefit of using a slower switching speed for the IGBT converter is a higher efficiency (less switching means less switching losses). In this case, the IGBT converter will still produce larger amounts of harmonics, which will require the input harmonic filter (similar to the harmonic filter for the SCR rectifiers).

The problem with traditional harmonic filters on the UPS converter is the leading power factor at small loads. When the UPS system is operating at a reduced load, the ratio of capacitance in the input filter to the load becomes very large and will produce a leading power factor from the UPS. This leading power factor can result in generator compatibility issues. To eliminate these issues, an active input filter (switching harmonic filter capacitors in and out of the circuit depending on the load) will need to be used or the input filter would need to be disconnected both resulting in an increased harmonic content.

DIGITALLY CONTROLLED IGBT CONVERTERS:

IGBT converters offer many benefits over SCR type rectifiers if applied correctly (see figure 4 above). The IGBT converter can switch at speeds in the kilo-hertz range as opposed to the slower SCR rectifier, which fires pulses in the hundreds-hertz range.

The reason the SCR rectifiers can not be switched faster is because the thyristors are turned on by a gate signal, but turned off by natural commutation (zero crossing of the AC input sine wave) or by a snubber circuit. If used properly with a digital signal processor and a Field

Figure 4: IGBT Converter with optional transformer

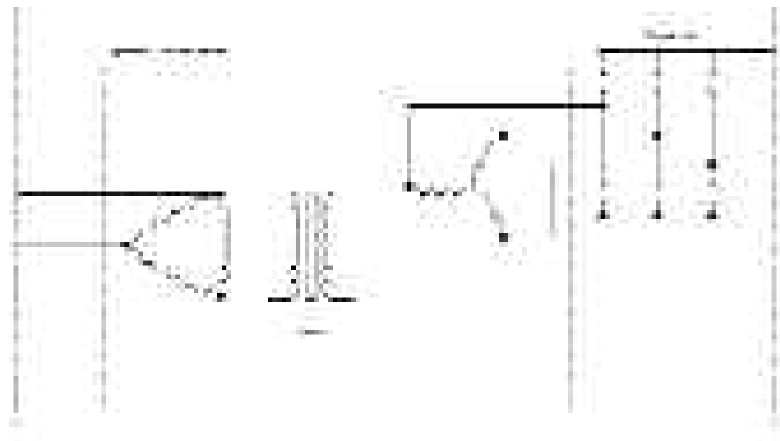
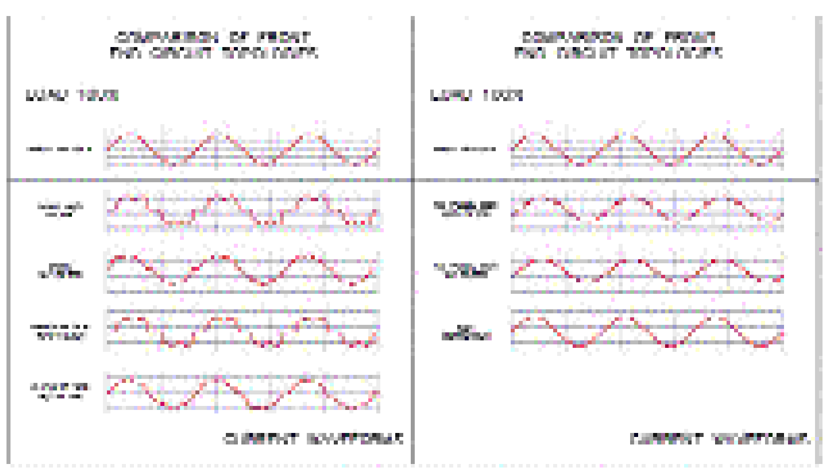


Figure 5: Filters for the rectifier section (Left) and inverter section (Right)

Figure 6: Input current harmonic comparison



Programmable Gate Array, the IGBT switching can be controlled to minimize the harmonics normally produced by a converter, thus eliminating the input harmonic filter.

As stated above, the problem exists with the UPS efficiency. If the IGBT converter is turning on and off in the kilo-hertz range, and the IGBT inverter is turning on and off in the kilo-hertz range, the switching losses will quickly add up creating a less efficient UPS.

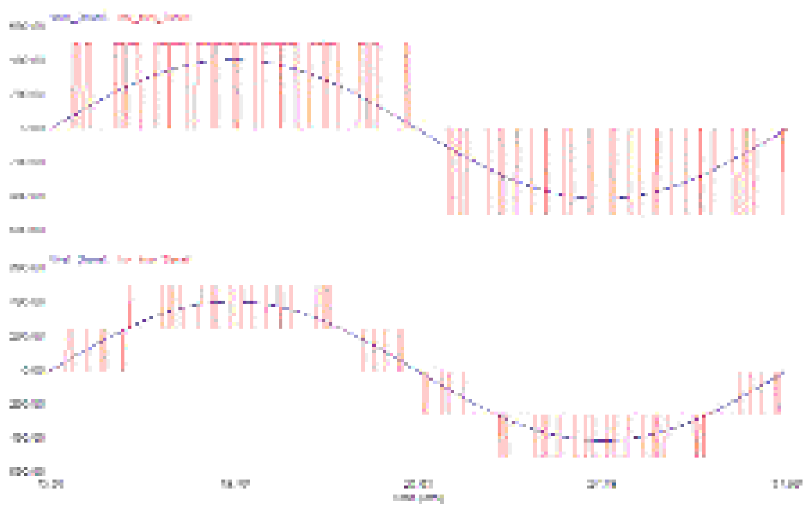
INVERTER SECTION:

Most manufacturers have recognized the importance of using IGBTs in the UPS inverter. The faster switching capabilities of the IGBT, if controlled properly, will result in a less distorted sine wave and will offer better response to various steps in the output loads and improved compatibility with downstream static transfer switches.

The IGBTs are fired in a series of pulses, which are used to invert the DC from the converter (or batteries) into a clean sine wave (refer to figure 7). Since the pulses are not continuous, high frequency noise is generated from the inverter. The high frequency noise and harmonic content on the output side of the UPS is filtered using an output filter and an output isolation transformer.

In addition, the isolation transformer on the output of the UPS provides a means to re-establish a neutral ground bond for the downstream distribution.

Figure 7: IGBT Switching 2-level (top) and 3-level (Bottom)



THE MITSUBISHI 9900 SERIES TRANSFORMERLESS UPS SYSTEMS

As mentioned earlier, there are many different factors that need to be considered when designing a transformerless UPS system. Ideally, the UPS should be designed with minimal losses throughout the conversion processes (high efficient UPS). This was one of the design goals for the 9900 series UPS. After researching the available power conversion technologies, it was concluded that the three-level topology offered the most benefits while improving the reliability of the system.

The three-level topology reduces the switching losses associated with IGBTs. The result is a more efficient True On-Line Double Conversion UPS system that maintains this higher level of efficiency at loads as low as 10% on the UPS system (reference **"The Power of Green: Mitsubishi 9900A Series High Efficiency True On-Line Double Conversion Uninterruptible Power Supply (UPS)"**).

Adding to the efficiency improvements of the 9900 series is the reduction of the filtering requirements. The input current harmonics of the 9900 is controlled to less than 3% at 100% load without the use of an input harmonic filter. Only a small EMI filter is required for the input of the UPS. By eliminating the input harmonic filter, generator compatibility issues due to harmonics and leading power factor are eliminated.

On the output, since the Three-Level Topology generates pulses that more closely resemble a sine-wave (see figure 7), the output filter is also minimized. The combination creates a highly reliable and efficient True On-Line Double Conversion UPS system. Reducing the size of the UPS filters and eliminating the transformer will also reduce the size and weight of the UPS system and increase the efficiency.

To further enhance the improvements in technology, the 9900 series UPS systems are designed with the newest, most advanced generation of Mitsubishi designed IGBTs. Most manufacturers are still using the second and third generation insulated gate bipolar transistors. Mitsubishi UPS systems are using fourth and fifth generation IGBTs which offer better efficiencies, improved reliability and a lower gate voltage.

Although these are all great benefits for the customer, the UPS control techniques and the UPS response to different types of faults that can occur must now be considered.

CONTROL SYSTEM:

Switching the IGBTs faster is of great benefit, but more important are the control techniques used for the gate signal. The Mitsubishi 9900 series UPS utilizes a high speed Digital Signal Processor (DSP), Application Specific Integrated Circuit (ASIC) and Field Programmable Gate Array (FPGA) for control.

As shown in the block diagram of the control circuit, Figure 8, the 9900 series

UPS uses a minor current control loop with a major voltage control loop to provide a precise response to various conditions imposed on the UPS.

Data from the voltage major control loop is collected and evaluated in the digital signal processor (DSP). The field programmable gate array (FPGA) is used to collect information provided by the DSP in addition to comparing the currents from the current minor control loops. Application specific programming in the FPGA processes the information and provides a switching sequence to compensate for the specific scenarios the load presents.

The multiple feedback control loop allows the UPS logic to quickly detect changes in current in addition to detecting deviations to the voltage allowing for more precise control of the IGBT switching. By using the DSP and the FPGA, which have samplings rate greater than 48 kHz (800 times per cycle), the switching sequence of the IGBTs can be manipulated to provide complete control of the power conversion processes.

In the event a fault occurs (including short circuits) which produces currents exceeding the current limits of the UPS (input or output), the control circuit will immediately stop firing the IGBTs and initiate the opening and closing of the contactors. On the converter section, the input contactor will open and the UPS will operate from the battery source. On the inverter, the UPS will initiate a transfer to bypass to allow the bypass current protection to clear the fault.

Figure 8: Block diagram of the Mitsubishi Control citcuit for a UPS

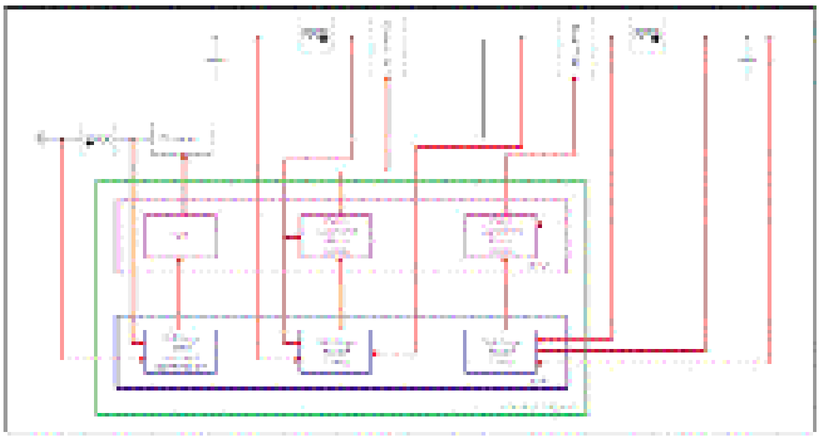
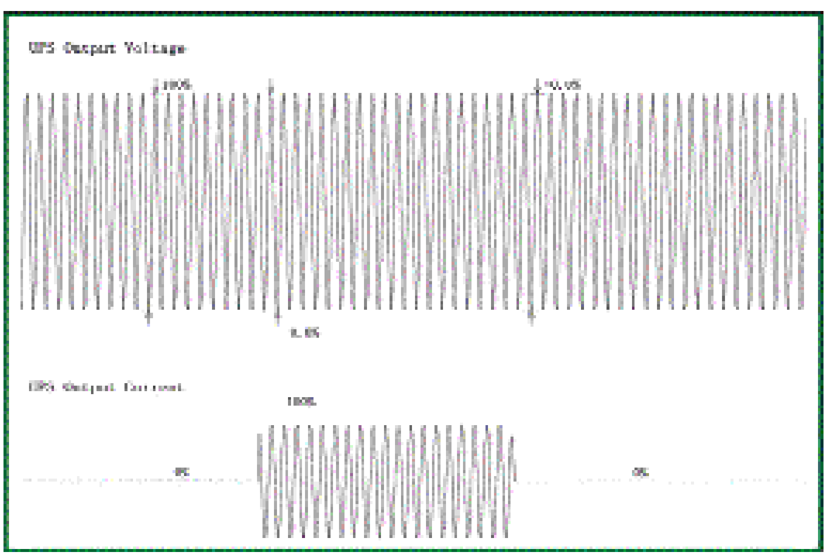


Figure 9: 100% step load on a 9900 series UPS without batteries



With minimal voltage distortion, the UPS will support any currents that do not exceed the limits of the system, including downstream inrush currents. For example, the UPS inverter can support 0% to 100% step loads on the UPS output while maintaining a voltage with less than 2% deviation (See Figure 9). Since the converter section is also controlled using the same logic, the converter can support the same step loads to the input of the inverter. Therefore, the UPS does not require power from the battery system to perform this step load.

CONTROL IN MULTI-MODULE APPLICATIONS:

The 9900 series UPS is capable of multiple module configurations (MMS), up to eight kVA matched units in parallel. For all multi-module 9900 series UPS systems, single modules are used without any changes. The same logic is used in each UPS in the multi-module configuration. For a multi-module system, redundant Cat 5e cables are used to connect the DSP and the FPGA of each UPS together. Therefore, the control logic will be looking at its own minor and major control loops, and also the information from the other UPS control loops, to match the output of each UPS on the critical bus. The result is a multi-module system which can instantaneously share load while maintaining clean, reliable, regulated and uninterrupted voltage on the critical bus (refer to figure 10). Since the 9900 series multi-module configuration is used with individual single module UPS systems, the control logic is completely redundant.

VIRTUAL NEUTRAL:

Line-to-line noise produced by the high frequency switching inside the UPS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system is easily filtered using the small input and output filter of the UPS. However, high frequency line-to-neutral components are not suppressed due to an absence of a common connection between the three phases (neutral connection).

To filter these components, the 9900 series UPS uses a virtual neutral as shown in figure 11, which is created by connecting the common point of each of the filter capacitors to a common point. By virtue of this connection, the common mode harmonics are passed through the virtual neutral of the UPS system.

In addition to the input connection, the virtual neutral is also tied to the common point of the output filter, where the common mode harmonics are cancelled by the output of the inverter, as shown in Figure 11. During battery operation, the input contactor for the UPS system (CB1) is opened and the common mode harmonics are eliminated from the equation.

The potential of the Virtual Neutral is derived from the three phases on the input. A capacitor is added between the system ground and the virtual neutral. This capacitor, under normal conditions, will have minimal potential across the terminals and minimal current, as the potential of the virtual neutral and the system ground is the same.

As shown in Figure 12 (including the following calculations), confirmation can be made that the output phase voltage referenced to ground will be the same as the output phase voltage referenced to the virtual neutral. The input common mode harmonics are introduced through the Virtual Neutral, but cancelled by the output common mode harmonics.

FAULT CONDITIONS:

The 9900 UPS system is monitoring fault conditions in multiple ways (voltage differences, current flow and current limiters) and will detect these faults depending on the installation of the system, the configuration of the distribution system and the conditions of the fault.

Figure 10: MMS system with (1) module added to the parallel bus

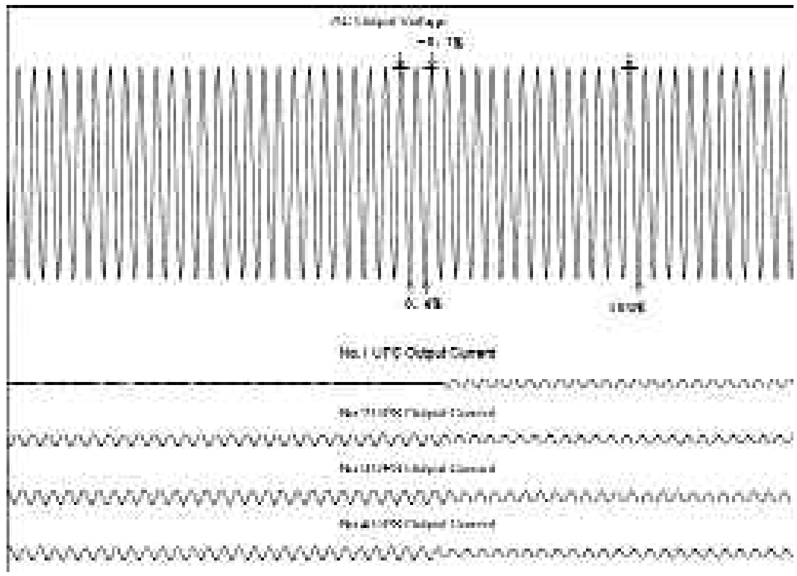
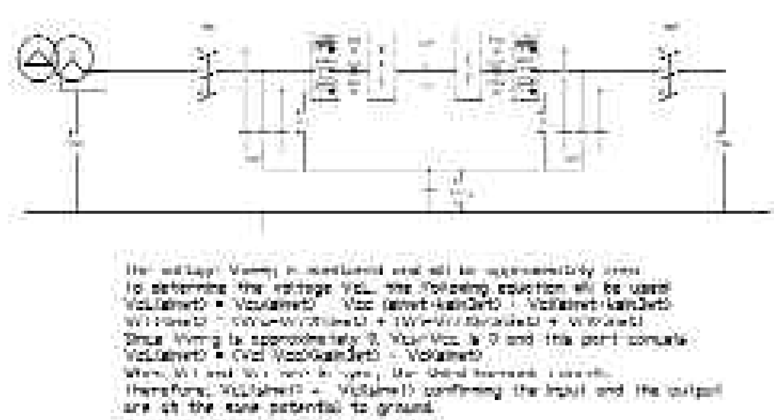


Figure 11: The 9900 series Virtual Neutral

Figure 12: Virtual Neutral with the output voltage to ground reference calculations



As mentioned above, if a fault condition occurs on the output of the UPS which produces a large amount of current, the UPS system current minor loop, current limiter and the FPGA will detect the instantaneous over-current. The PWM will then stop firing the IGBTs in the inverter and transfer the system to bypass so the bypass over-current protection can clear the fault (Figure 16). In addition, during an output short circuit, the output voltage will try to collapse. The voltage major control loop with the DSP along with the FPGA will maintain the voltage at first. If the current from the short circuit extends beyond the capabilities of the inverter logic to maintain proper voltage regulation, the DSP and the major control loop will sense a collapse in the output voltage and the system will detect an instantaneous overload.

The same would apply to a fault on the utility side of the UPS system. The converter logic will sense an immediate drop in voltage and the FPGA will stop firing the IGBTs in the UPS converter going immediately to battery operation.

DC GROUND FAULT CONDITIONS:

If a DC Ground fault occurs as in Figure 13, the potential of the system ground will be different than the potential of the Virtual Neutral. This potential difference will be detected by the UPS system and viewed as a safety hazard. The UPS will alarm on a DC Ground Fault condition. The circuit is also being monitored by the chopper circuit logic to detect improper voltages and current levels.

GROUND FAULT DETECTION:

As shown in Figure 14, if the utility source for the UPS is not grounded (no neutral-to-ground bond), the presence of a ground fault will present a potential difference between the UPS Virtual Neutral and the system ground. Therefore, the fault will be detected by the UPS.

As shown if Figure 15, if the utility source for the UPS is grounded (neutral-to-ground bond is installed), the presence of a ground fault will result in a

Figure 13: DC Ground Fault

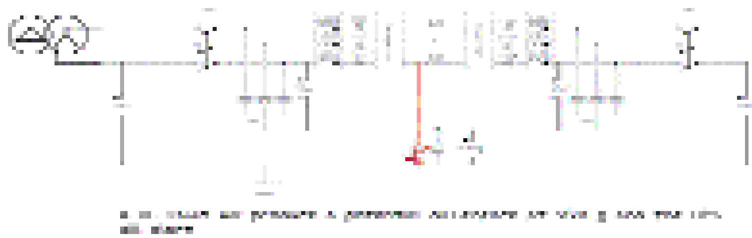


Figure 14: Ungrounded Phase-to-Ground Fault

Figure 15: Grounded Phase-to-Ground Faults

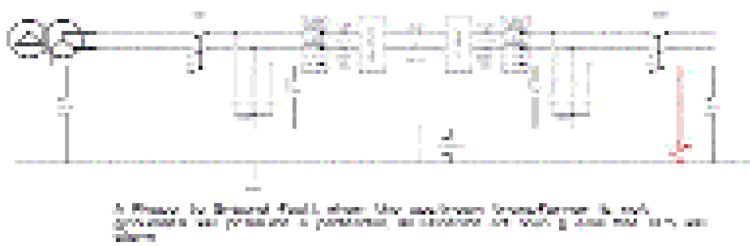
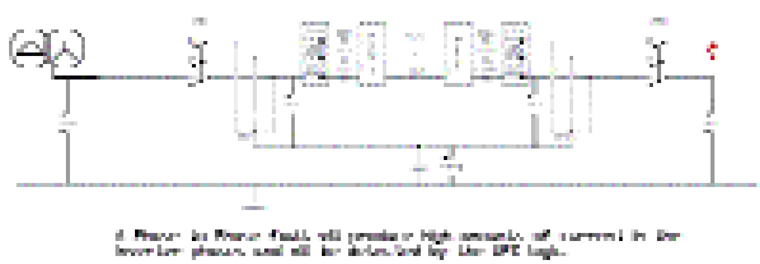


Figure 16: Phase-to-Phase Faults



second connection to ground and will produce zero sequence currents. These zero sequence currents will be detected by the UPS.

SUMMARY:

The 9900 series UPS is a high efficiency True On-Line Double Conversion transformerless UPS designed specifically for large power applications. It uses an IGBT converter section with advanced control circuitry to eliminate common mode harmonics and leading power factor issues with the upstream generators. The minor and major control loop used with the Digital Signal Processor and the Field Programmable Gate Array for the IGBT inverter results in precise control of the output voltage for maximum coordination with downstream Power Distribution Units and Static Transfer Switches. The Virtual Neutral allows the UPS logic to monitor all types of faults including system ground faults to offer maximum protection for critical loads.

The result is a UPS which can deliver reliable output power to your critical load with minimal footprint while saving the customer money through an efficiency of greater than 96% at 100% load. The 9900 is available in sizes ranging from 72 kW to 750 kW (SMS) and up to 3750 kW (MMS).

REFERENCES:

"The Power of Green: Mitsubishi 9900A Series High Efficiency True On-Line Double Conversion Uninterruptible Power Supply (UPS)" by Dean Richards and Junichiro Onishi.

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What You Should Know About PROTECTING Your Electronic Applications From DAMAGING FIRES

by **Frank Barstow**

From a smoldering circuit board to a switch gear explosion, the risk of electrical fire in data, power generation and telecommunication centers is an ever-increasing concern for the owners and operators of these facilities. Today's data center and electronics industries are looking for a fire suppression solution that is safe, effective, cost-efficient and mindful of the environment. There are a variety of fire suppression systems on the market today that are made to protect electrical and electronic applications, from water mist to gaseous to inert gas technologies, however, those systems can present design, performance and maintenance challenges. This article will review those different technologies and challenges, as well as a newer fire suppression hybrid solution that uses both water and nitrogen.

AVOIDING EXCESS WATER DAMAGE

Equipment enclosures commonly found in data center and electronic facilities, present significant fire suppression challenges and are considered "local application" hazards. Traditional, single-agent water mist systems often need to be installed directly within an enclosure to suppress a fire. This internal installation would require the equipment to be de-energized before a water mist system discharge occurs in order to prevent damage and injury.

If fire suppression is required in a larger area, where multiple enclosures or pieces of equipment may need to be protected, this would be considered a "total flooding" application. In this scenario, the water mist concentration that enters an enclosure would not be great enough to cool and suppress the fire unless the top were open.

In either scenario the equipment inside the enclosure would be subject to extreme wetting conditions along with possible damage.

MAINTAINING ROOM INTEGRITY

Alternatively, gaseous systems require hold time concentrations and some systems require the space to be modified to provide a room integrity seal so the gaseous agents remain in the hazard area during a fire event.

Where water mist systems are designed to reduce the temperature in the fire space, inert gas systems work to reduce the amount of oxygen available to sustain the fire. These particular systems

do not allow for cooling in the space, leaving open the possibility of re-ignition if room integrity is not maintained for a defined period of time.

Effective maintenance of the concentration of a suppressing agent is a value of room integrity. Proper room integrity for many inert gas systems requires significant and potentially expensive custom construction to control airflow, which can be a challenge for facility owners and contractors.

KEEP IT GREEN AND EASY TO MAINTAIN

Inert gas suppression systems, designed to reduce the amount of oxygen available to sustain a fire, also present several challenges in today's sustainability-focused marketplace. These systems utilize chemical agents and halocarbons to achieve fire suppression, raising environmental concerns. Therefore, efforts have been made to find alternative solutions that are friendly to the environment and occupants.

Beyond room integrity and environmental concerns, the full life cycle of a system must be considered, including the cost and complexity of resetting a system after a discharge. After a fire event or during regular maintenance, traditional agent storage cylinders may need to be returned to the manufacturer for refill with proprietary agents or removed from the system for weighing, costly in both lost time and money. Facility owners and operators who are focused on minimizing facility downtime are in need of more time and cost-effective solutions.

NEW SUSTAINABLE, HYBRID TECHNOLOGY

A unique solution for data centers uses hybrid technology to deliver a high velocity, low pressure blend of water and nitrogen to both cool the hazard area and remove the oxygen that sustains the fire. Electronics are kept dry and there are absolutely no toxic agents or chemicals involved. Additionally the hybrid system has been proven effective for small, smoldering enclosed fires and large, heat-releasing fires in open spaces.

By combining nitrogen and water, a homogeneous suspension of nitrogen and sub 10-micron water droplets penetrate through vented type enclosures to extinguish a fire without significant water residue. When the mixture enters the enclosure, both the nitrogen and water attack the fire simultaneously, the water cooling the space and the nitrogen reducing the oxygen content and generating steam. The result of this is complete fire suppression without significant wetting or change for re-ignition. This would not be possible with a traditional water mist system.

This innovative technology is 100 percent green, utilizing no toxic chemicals and has been identified by the Environmental Protection Agency as having Global Warming Potential of zero. Since this system discharges with high velocity under low pressure, the hybrid suspension swirls through the space, overpowering the fire plume and not requiring room integrity to remain effective, therefore additional construction or retrofit cost can be avoided.

Also, since this technology only requires the use of water and nitrogen, storage bottles can be quickly and cost-effectively refilled on site or a local gas supplier can replace cylinders. This alone minimizes system and facility downtime, increasing productivity and profit. The system is designed to receive water piped in or stored in a portable tank. De-ionized water is recommended for systems where electrical equipment is in the hazard space to minimize potential conductivity.

A PROVEN TECHNOLOGY

Many have witnessed the effectiveness of a hybrid technology, including Factory Mutual and Underwriter's Laboratories. For example, the system was tested to demonstrate the successful extinguishment of a cable bundle fire. Because this technology can be installed in a total flooding configuration, it remains completely effective at fire extinguishment inside an enclosure. With emitters installed outside the enclosure, the live circuits do not have direct exposure to the water and nitrogen suspension discharged by the system, which greatly minimizes the moisture level in the enclosure. Due to the high velocity distribution of the system, the water and nitrogen mixture travels into the enclosure through ventilation openings, ensuring that circuit boards and other electronic components are not damaged due to high levels of moisture and/or excess wetting.

CONCLUSION

Hybrid technology provides an innovative, safe and effective fire protection solution for installations that contain electronic equipment. Water mist systems that use single fluid technology cannot provide the same level of protection as a hybrid technology. Since a single fluid system will need a nozzle placed inside of the enclosure to extinguish a fire, it is certain that the powered equipment would be damaged due to extreme wetting conditions. Facility owners and operators will benefit from the hybrid technology's minimal wetting operation, simple maintenance, environmentally friendly design and rapid return to normal operations after system discharges.

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A NEW DATA CENTER THAT WILL HIT YOUR SWEET SPOT

OPTIMIZING THE PLACE WHERE FINANCE, IT AND FACILITIES CONVERGE. HERE'S HOW.

by **Mike Duffy**

EXECUTIVE SUMMARY

The decision to buy, build or lease a data center is a daunting challenge that requires a unique combination of financial, IT and real estate skills and resources. You always begin by looking hard for fatal flaws. A lack of reasonably-priced power, adequate water supply, or quality fiber provider should disqualify a potential data center or data center site from consideration.

The optimal data center offers a low total operating cost; on-site, reliable power; multiple fiber providers; scalability and flexibility; efficient, cost-saving technology; LEED Gold and/or Energy Star certification; a secure, desirable location; critical infrastructure management; one party decision-making; and flexible lease/purchase options.

Scalability and a low PUE is critical. Total cost of ownership may be fine today, but may be compromised when you need to expand. Long-term, more often than not a facility with a low PUE and more scalability is a better choice than a facility with marginally lower power cost. As the industry trends quickly toward virtualization and cloud computing, a "next generation" data center avoids the inefficiencies of partially-used servers, racks, and capacity.

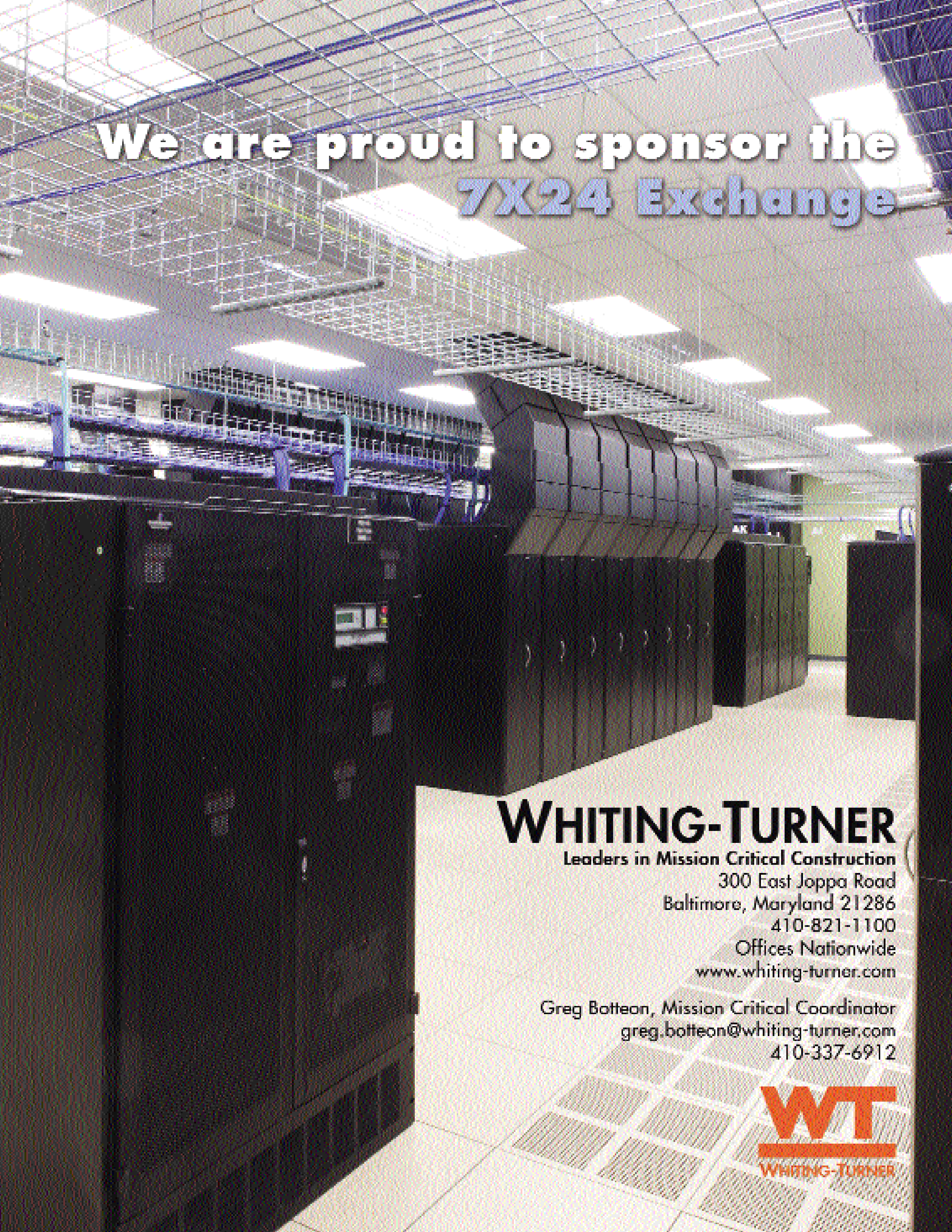
It's all about finding the "sweet spot" where all the essential factors converge.

The decision to buy, build or lease a data center is a daunting challenge. It is one of the most significant financial decisions a company is likely to make in any given year, requiring consensus among financial, IT and real estate planners, the final choice will have an enormous impact on the company's future success.

The right data center should provide reliable functionality, security, flexibility, and convenience. It should also adapt as the future unfolds. The decision demands in-depth knowledge of sophisticated technology; a detailed grasp of current and projected data center capacity requirements; financial acumen; and cooperation of senior corporate leadership.

Data centers represent a unique combination of financial, IT and real estate resources. While all three must be evaluated, the weight or prioritization of each will vary based on your specific needs. It is essential to identify the optimal blend or "sweet spot" of finance, IT and real estate. Many projects and programs have failed for not having done so.

What's your ideal mix? (Note: all three areas are in flux and will change based on evolving business needs and new technology.)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HOW TO HIT THE SWEET SPOT BETWEEN FINANCE, IT AND REAL ESTATE

Years of Data Center Development Experience

Having spent over a decade at Microsoft immersed in data center design and construction, I learned the importance of addressing these complex, interrelated issues to achieve a successful outcome for all stakeholders. As Senior Development Manager for Data Centers, I was in charge of creating and managing Microsoft's multi-billion dollar expansion program. Working on four of the ten largest data centers in the world, my responsibilities included financial management, site selection, negotiating tax and utility incentives, and all facets of design, procurement and construction. During my tenure Micro-soft added seven data centers totaling almost 160 Megawatts of critical capacity.

It was a great experience. I worked with really smart people and gained visibility into the emerging data center industry. We defined the best way to build data centers internally, and we studied the competition. What is Google doing? Yahoo? What are their technologies? Locations? We also explored leased facilities in the U.S., Europe and Asia; large service firms such as Digital Realty Trust and DuPont Fabros; and technology solutions with industry leaders such as Intel.

I brought all this experience in founding Duffy Development Services, a data center consulting firm in the Pacific Northwest. I'd learned the importance of a detailed vision of a 'Dream Data Center:' the most important features, options and priorities for engineering, power sourcing, advanced technology, future flexibility, location, security and financing. The goal? To align business and technical needs to the optimal data center solution.

When The Benaroya Company approached me to consult on their Seattle area South Hill Data Center project, I was a bit skeptical. At Microsoft I did a lot of site selection, including potential repurposing of existing facilities. The vast majority of properties that owners thought could be converted to data centers were completely unworkable. The opposite was true at South Hill.

Eliminating Fatal Flaws and Tallying Up The Assets

The first task in evaluating a potential data center is to look hard for negatives. Any one of three fatal flaws should immediately disqualify a site.

1. Not enough reasonably-priced power
2. Inadequate water supply (less important with air-based cooling);
3. Lack of at least one quality fiber provider (two or more are best, to provide diversity and price competition).

If a site has no fatal flaws, you begin to tally all the positive features. The more, the better. Things to look for include:

[ ] a low total operating cost – not just the base power rate

[ ] ultra-reliable power – preferably on-site and easily expandable

[ ] multiple fi ber providers

[ ] scalability and flexibility throughout

[ ] efficient, cost-saving technology

[ ] LEED Gold and/or Energy Star certification: efficient, sustainable, adaptive, secure, desirable location with critical infrastructure management

[ ] one party decision-making, with flexible lease/purchase options

THE BEST DATA CENTER I'VE SEEN IN YEARS

I've seen a lot of data centers and the one I'm most excited about is the new South Hill Data Center south of Seattle. This new data center is a reuse of a $220 million facility, originally built for chip manufacturing with a Class 1 clean room. The shell is uniquely designed to push air in a way that a typical data center can't. Intel deployed similar high density cooling principles to develop their Jones Farm facility in Oregon. The plant at South Hill was clearly an extraordinary property to reposition as a data center.

South Hill Data Center was designed with operations best practices in mind. Many facilities focus exclusively on creating capacity, to get it on the market fast. Operations then become the tenants' headache.

South Hill offers operational efficiencies such as loading dock areas for asset management, head-count areas for staffing, room for IT and facilities personnel, and storage areas so vendors won't have to work out of the backs of vans. It's a very functional, pleasant environment.

In addition, South Hill is the only data center I've seen that offers a unique combination of these three highly desirable features:

2

Evaporative cooling and air-side economizers that can cut power usage by a third or more

3

In-place scalability, which "future proofs" your investment

WHY DO USERS PLACE SUCH A PREMIUM ON THESE FEATURES?

To increase high density capabilities, you must add additional electrical capacity. In most locations this is rarely a problem. It's adding the necessary cooling capacity that often becomes a fatal flaw – because it requires financial premiums and/or significantly impacts efficiency.

South Hill is well-equipped to increase high density capabilities, quickly and economically. With evaporative cooling and air-side economizers: essentially free cooling capabilities. You don't pay for mechanical cooling; there's only the minimal cost of running the fans. For many data centers, increasing the capacity of an air-side economizer with an evaporative cooling system is challenging – sometimes impossible – because of the sheer volume required for air. South Hill can quickly increase capacity, without disruption and without premium.

South Hill's in-place scalability is unmatched in other facilities. Initially, the facility infrastructure is at 150 Watts per square foot, which can quickly scale up to 260 Watts per square foot. That's a 73% increase in power density, unheard of in data centers. South Hill can even expand further, without any impact to the server occupants.

FUTURE-PROOFING THE INVESTMENT

Scalability is a huge advantage for an operational data center. Essentially, it future-proofs your investment, because the demand for density will continue to rise. There are already a number of 80-to-100 Watt facilities that can't increase their power density, because they can't accommodate a flexible, efficient infrastructure upgrade. Basically, they are already outmoded.

Looking into the future, a true "next generation" data center must be equipped to support an industry trending toward virtualization and cloud computing.

Virtualization optimizes network and IT resources, getting away from "hands on." It's a more managed, holistic, and unified approach that avoids the inefficiencies of partially-used servers, partially-used racks, partially-used data centers. Virtualization optimizes and combines those resources, to better utilize IT assets, and to maximize their value and return.

With more virtualization, server loads will go up. And the loads will be more predictable, more sustainable, and better managed. 80 Watt per square foot data centers will quickly become antiquated. 150 Watt data centers will still have a place, but demand will grow for 200 to 250 Watt data centers.

You'll need a standard high-density pod environment, with hot-aisle/cold-aisle containment. An ideal facility is not only scalable within its own footprint, but its infrastructure and density can also scale. And with the industry trending toward additional servers housed in containers, you'll need real estate to accommodate those containers. South Hill offers more than enough space for containers and/or additional construction, including an existing cold shell building with plenty of power and fiber.

Apart from engineering, power, technological, safety and security considerations, the bottom line affecting any major financial investment is what will it cost to run? What will it take to finance? The power rate at South Hill is 5.3 cents and the PUE is 1.32. In a typical facility with a PUE of 2.0, power rates would need to be 3.5 cents to match South Hill.

And South Hill is a turnkey facility, ready for immediate occupancy. There's no risk of construction delays and cost-overruns. The easy expandability and scalability protects your investment against unforeseen financial stress.

CALCULATING TOTAL COST OF OWNERSHIP

Too often, Return On Investment (ROI) is categorized as Capital Cost per Megawatt on a balance sheet. However, companies must also run on a P&L model, with expenses in mind. You may have built the cheapest facility in the world, based on Least Cost Per Megawatt. But if the facility and infrastructure aren't efficient, operating costs will be high. If you built too much capacity – or the wrong density – expenses will be high because utilization will be low. And if critical infrastructure – especially the mechanical system – is not efficient, power use will be too high.

ROI should be calculated by Total Cost of Ownership rather than just capital cost, or cost per megawatt. It's about optimizing processing power and rack space. How many KW do you actually use relative to what you pay for? If you're using just 50% of your resources, even efficiently, you're not optimized around the Total Cost of Ownership.

That is why scalability and a low PUE is absolutely critical. When calculating Total

Cost of Ownership, you need to look long-term. Total Cost of Ownership may be fine today, but when you need to expand or scale, it may be compromised.

Looking at the total picture, you'll likely determine that it's better to go with a facility that has a lower PUE and more scalability, rather than simply a marginally lower power cost. It's all about finding that "sweet spot" where all the factors converge. If you overdo any of the critical factors to compensate for potential future demands – taking too much space, building too high a density or too much space, or settling for a poor PUE – you're stuck. South Hill has an enviably low PUE and low power costs. It fulfills all the variables for an optimized Total Cost of Ownership, both short-term and long-term.

One more thing to consider on the financial side – who holds the purse strings? In my experience, The Benaroya Company is a unique owner. They self-finance, so they don't need to get a bank, a lender, a partners' or investors' input or approval. The Company is exceptionally pro-active, willing to take calculated financial risk. They know how to move quickly, and can help you do the same.

BACK TO THE SWEET SPOT

I hope I've given you some useful guidelines for defining – and ultimately finding – your own data center sweet spot, optimized for a company's current and future financial, IT and real estate needs.

South Hill Data Center aligns well with today's medium to high density requirements. For details, please visit www.southhilldatacenter.com, or contact Dave Vranizan at 425-440-6711.

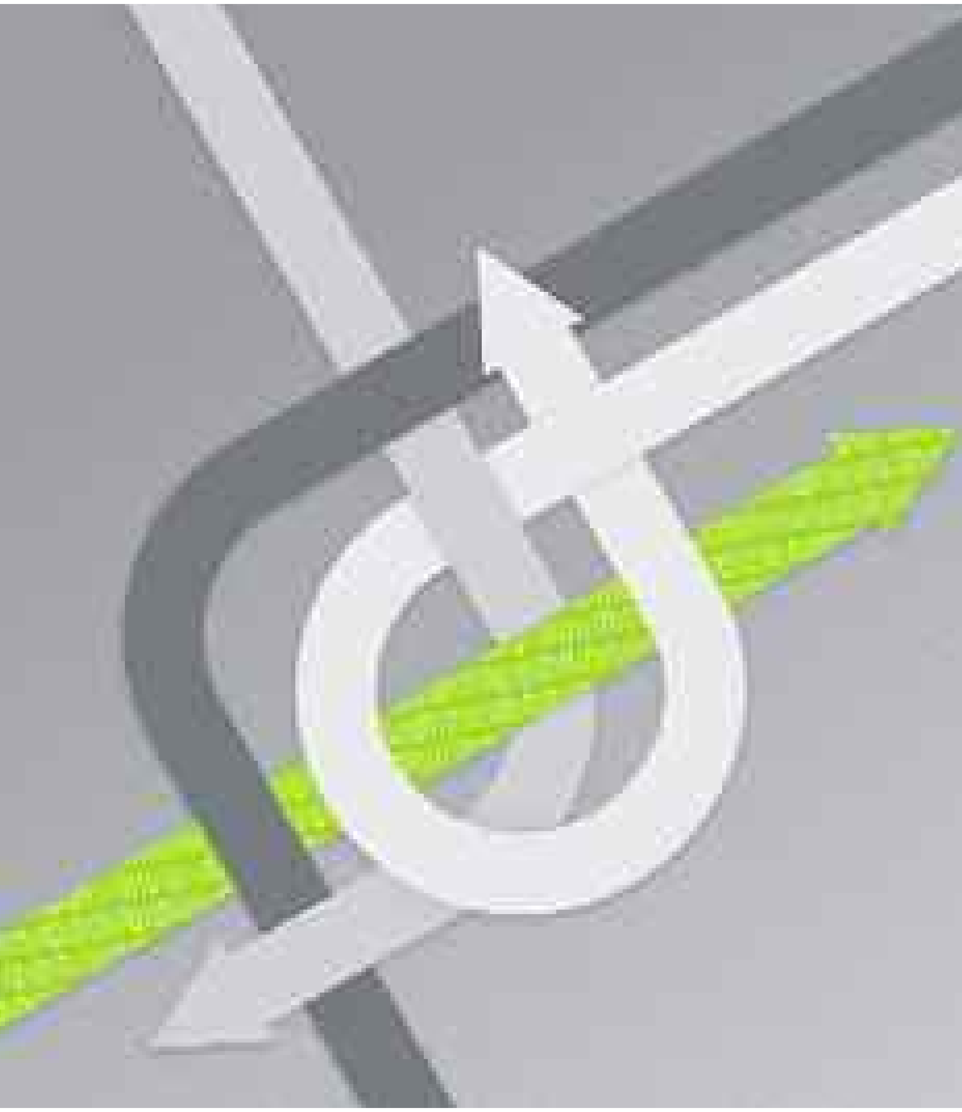
A CLOSER LOOK

South Hill Data Center gets the green light for anyone seeking an extremely reliable, secure, highly efficient, immediately available, state-of-the-art facility.

Minutes from Sea-Tac International airport, it's built on solid bedrock, high on a hill, well above the 500 year flood plain. It's constructed as a building within a building to withstand seismic activity. The site also has a huge water capacity AND multiple fiber providers for redundancy.

Today, South Hill controls 42.5 Megawatts of sub-station capacity – the largest unused block of power in the Northwest and is expandable to 67.5 megawatts. Because the on-site sub-station is dual fed by Alderton and White River, the entire region would have to lose power for the sub-station to go down. The world-class grid quality and Bonneville power backbone mean that any short outage — even a millisecond disruption — would be picked up by UPS. The backup generators will likely never be needed.

Mike Duffy is the Principal at Duffy Development Services. He can be reached at mduffy@duffydev.com



THE GREEN REVOLUTION: KEEPING YOUR DATA CENTERS AT MAXIMUM EFFICIENCY

by **Jim Embley**

In a recent report titled "The Digital Universe", industry analyst firm IDC discusses the explosion of digital information and how it is causing companies to rethink how they design, construct and manage data centers. As we live in an electronic world, data captured in the form of e-mails, documents, pictures, videos and social media all contribute to this information explosion. IDC estimates that, in 2009, this "Digital Universe" came in at a whopping 0.8 zetabytes and that number is expected to hit 35 zetabytes by 2020. That is enough data to fill a stack of DVDs reaching halfway to Mars.

But what does this have to do with going green and energy efficiency? As more information requires more IT systems, this means more hardware; and more hardware means more energy, which is a killer for green initiatives. Industry analyst firm Pike Research estimates the IT industry is responsible for approximately 2 percent of the world's carbon emissions – with increasingly complex data centers at the core of this growth. Additionally, a recent report by the EPA, "Report to Congress on Server and Data Energy Efficiency," estimates that energy consumption by servers and data centers doubled in the past five years and is expected to do so again over the next five – to more than 100 billion kWh, at a cost of $7.4 billion annually.

With more stringent government regulations, the need for data center companies to reduce energy costs and carbon emissions is essential. Pike Research also estimates that investments in greener data centers will explode over the next five years – reaching $41.4 billion by 2015. With a majority of data center servers operating at only 4% average utilization (according to the GGT Green Exchange), there is a huge opportunity for companies to power forward with energy reduction through better design and operation, such as IT virtualization and the installation of energy efficient electrical/mechanical systems.

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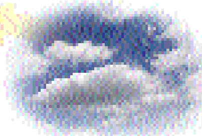

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Best Practices: Implementing an Energy Management Solution

So, how do we get there? It's clear that companies need to explore implementing comprehensive energy management strategies and solutions to exploit these opportunities. These solutions are designed to help save energy and reduce costs across all phases of the critical facility lifecycle. This service needs to go beyond standard energy efficiency audits to integrate a myriad of environmental, technical, legal and administrative energy considerations into a comprehensive energy strategy.

To implement successfully, companies need to employ both a holistic and flexible approach – one that addresses the entire facility portfolio while accommodating regional differences and regulatory change. Effective energy management initiatives that address your various facility portfolios have proven to reduce Op-ex and Cap-ex expenditures, improve efficiencies and generate income. To this end, key facets to ANY mission critical energy management strategy should include:

- **Energy Rebates and Incentives:** There are literally $100,000,000's of incentives that exist for critical facilities. Companies can obtain funding via rebates and cost-share programs from both utility and government agencies. In addition, data centers should exploit these opportunities, as well as evaluate "double-dip" incentive opportunities across multiple funding organizations.
- **Demand Response (DR):** In committing to remove load from grid power to onsite generation, most mission critical companies can realize $100,000's in annual reoccurring revenue whether or not a DR event is even called. Because most service level agreements require critical facility providers to possess and maintain onsite generation, datacenters are perfect candidates to participate in DR programs. However, like most opportunities, the devil is in the details and DR is no different. Therefore, companies must possess or retain the expertise of a partner that: understands regional generator permitting requirements; works with facility operations to ensure power distribution systems can effectively support load transfer; and has a working knowledge of DR providers to streamline implementation and maximize revenue.
- **Demand Side Management & Sustainability Initiatives:** Mission critical companies must first establish a baseline by conducting effective energy audits and efficiency assessments that quantify and suggest strategies to reduce energy spend, which is one of the largest budget line items. This baseline will then help guide a data center to effectively manage equipment specifications and installations as well as create payback, total cost of ownership, and power usage effectiveness (PUE) calculations that gauge its progress.
- **Reporting & Ongoing Management:** Strategy is pointless unless success can be quantified and measured. Therefore, energy management programs need dedicated resources to monitor, manage and regularly update the various initiatives across a facility portfolio. This is key to not only achieving established goals but also proving to senior management the effectiveness of a company's energy management plan.

With the digital universe exploding, comprehensive energy management strategies must be implemented to stay competitive. The world is changing and you need to change with it. Significant efficiency and revenue opportunities are there for the companies that drive energy management initiatives. Start with a plan, retain the expertise to implement the plan, and stick with it because the results will give your organization a competitive advantage as well as cash to the bottom line.

Jim Embley is CEO at Rubicon Professional Services. He can be reached at jembley@rubiconps.com

Energy Incentives at Your Fingertips

There are $100,000,000's of energy incentives throughout the US for mission critical data centers, including:

- NYSERDA – New York State Energy and Research Development Authority
- Con Ed (NYC Utility)
- NJCEP – New Jersey's Clean Energy Program
- NStar (Boston Utility)
- Com Ed (Chicago Utility)
- Oncor (Dallas Utility)
- Centerpoint (Houston Utility)
- Seattle City Light (Seattle Utility)
- Southern California Edison (Utility)

Additionally, a data center administrator can find many incentive programs through the Database of State Incentives for Renewable & Efficiency (DSIRE) http://dsireusa.org/. Established in 1995, the Database of State Incentives for Renewable & Efficiency (DSIRE) is an ongoing project of the North Carolina Solar Center and the Interstate Renewable Energy Council (IREC). It is funded by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE), primarily through the Office of Planning, Budget and Analysis (PBA). The site is administered by the National Renewable Energy Laboratory (NREL), which is operated for DOE by the Alliance for Sustainable Energy, LLC.

Identifying the programs is easy. The real question is how to effectively obtain cash funding from these organizations in a timely manner while meeting both the goals of the applicant and the agency administering the program.

Recommended Best Practices:

- The incentive agencies must achieve kW reduction goals and issue amounts of funding that are proportionate to obtaining such goals. To this end, many incentive agencies undergo annual audits by the state's attorney general's office or public utility commission/service.
- Although similar in objective, each incentive body throughout the county has different initiatives, processes, timelines, and amounts of funding. For example, there are incentives for energy site assessments, energy efficient equipment installs, and demand response equipment installs. All require varying degrees of effort and documentation on behalf of the applicant and have varying funding levels/caps.

• Applicants must be mindful that funding levels for each agency change from year-to-year. Rubicon informs clients of funding levels prior to investing time in creating and submitting applications.

• To obtain funding, organizations must do more than simply fill out a form. Partner with a vendor that can advise on timelines, stages, gates, and measurements/verifications required to obtain funding and incorporate these in the overall facility infrastructure plan. For example, most agencies will disqualify funding if energy efficient equipment has been ordered prior to submitting the incentive application!! To prevent disqualifications, only a dedicated resource with knowledge and experience can manage multiple incentive agencies and the various funding initiatives.

• In addition, agencies subcontract the administration of most incentive programs to third parties because they typically do not have the in-house personnel to manage these initiatives 100%.

Therefore data centers need to retain resources (either through in-house talent or outside partners) with expertise and experience in dealing not only with the incentive agencies, but also their subcontractors, and have an understanding of the criteria and amounts of funding for the various initiatives that each incentive agency offers. To acquire this level of expertise – especially for mission critical companies with a national footprint across various incentive bodies – data centers need a resource dedicated to identifying incentive opportunities, knowing what initiatives bring in the maximum amount of funding, and shepherding the process from creating the application to cashing the check.

Differentiating legitimate programs from a potential scam

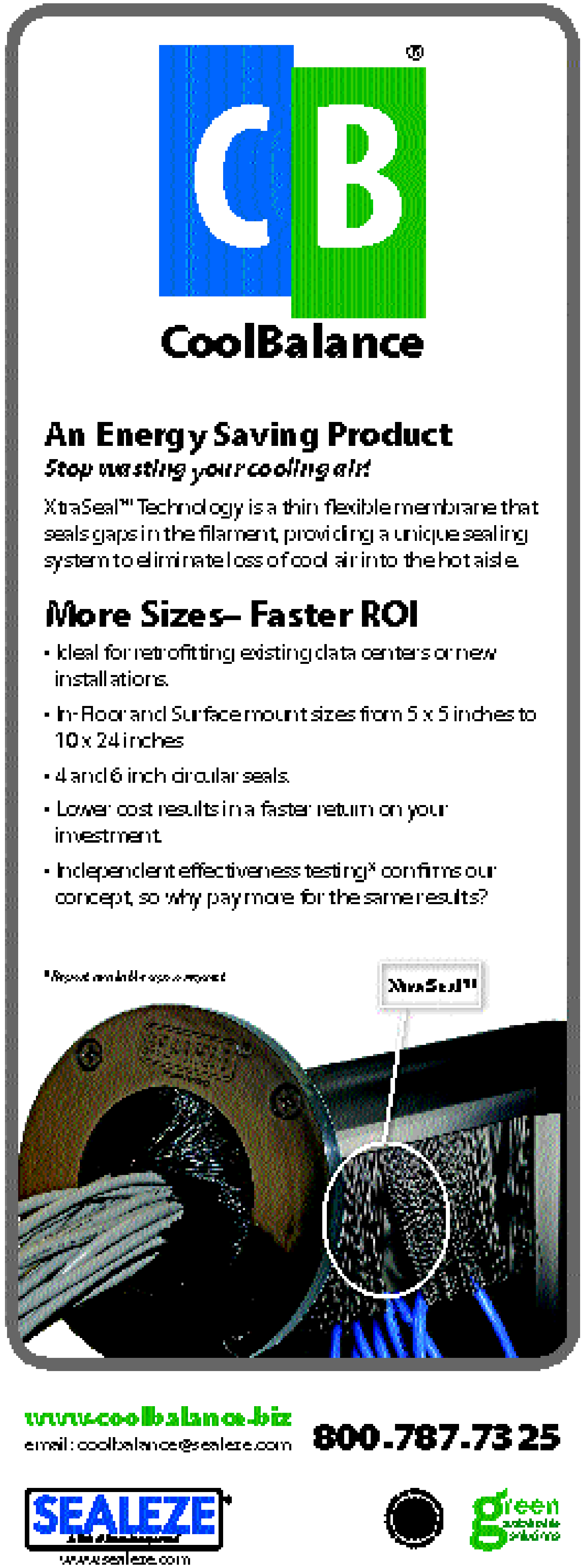
• As a rule of thumb, all energy incentive programs are either administered by a local utility (e.g., Con Ed) or a state agency (e.g., NYSERDA).

• To validate the incentive program, one should at least contact the applicable state's Public Service Commission/Service or the applicable state's Attorney General's Office, as well as reference http://dsireusa.org/.

Examples of "double-dip" incentive opportunities

• In New York, a data center can receive capital funding for demand response equipment installs from NYSERDA, while receiving demand response quarterly payments from NYISO.

• In several states, a data center could receive funding from two different agencies for the same site. For example, can include a new construction incentive from the local utility concerning the build out of a suite, and an energy efficiency incentive from a state agency for upgrading equipment in another part of their site.



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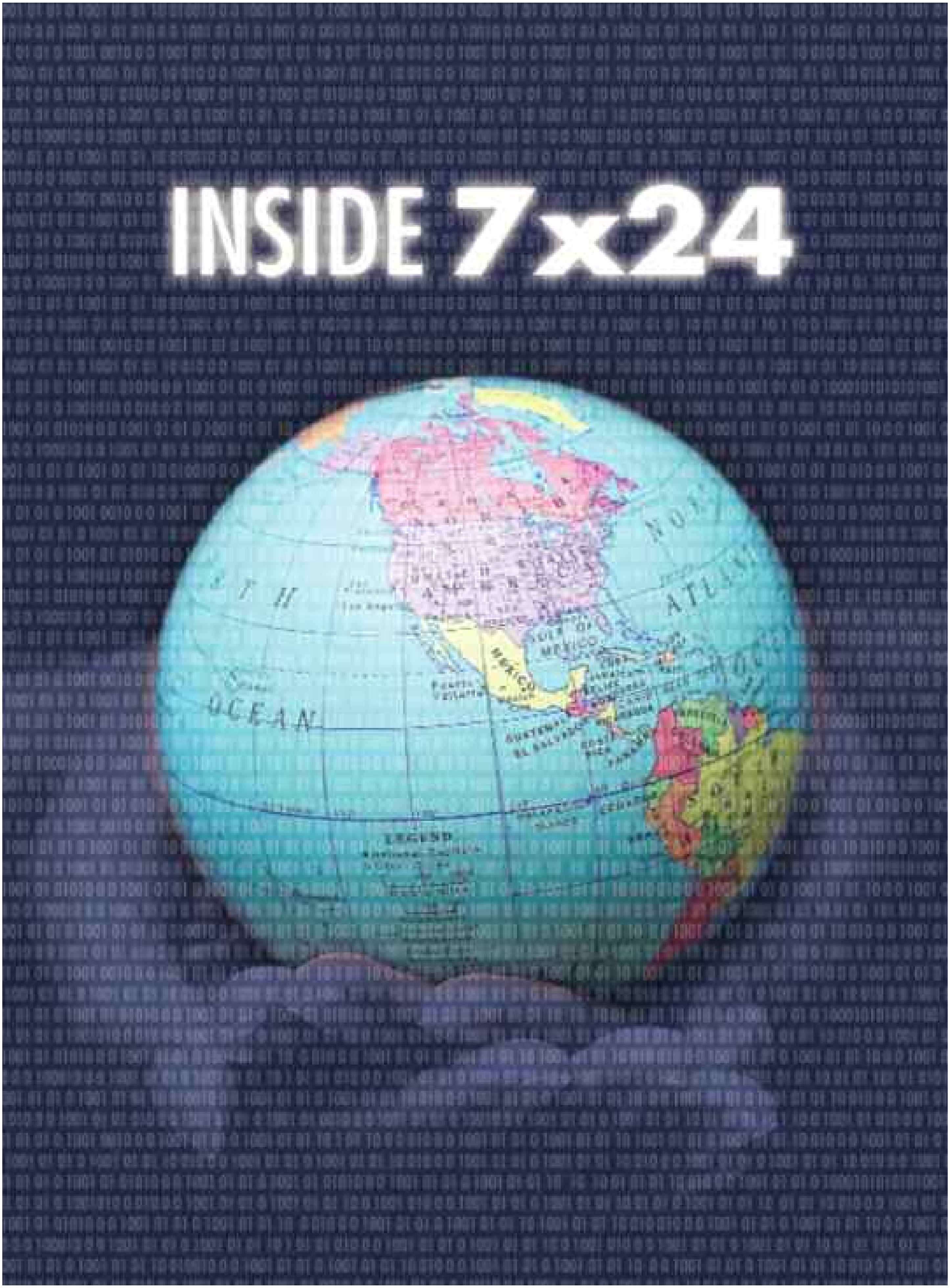
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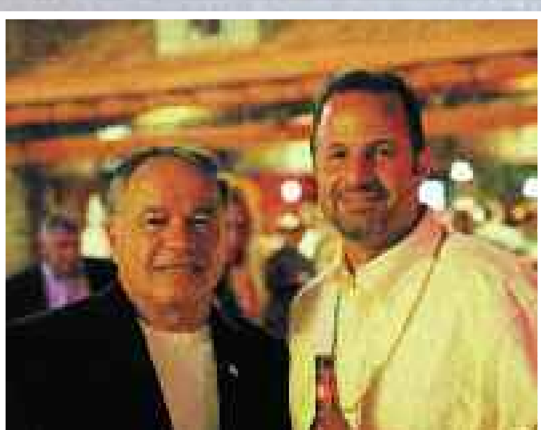
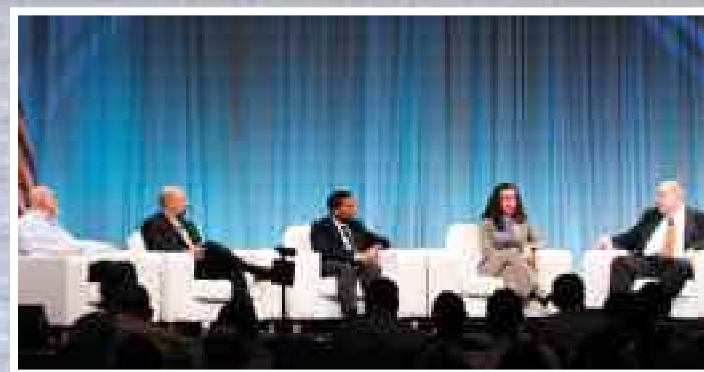



The end-to-end



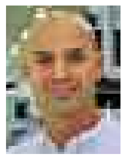


2011 SPRING CONFERENCE HIGHLIGHTS

For the complete Spring Conference program and registration information please visit 7x24exchange.org or call (646) 486-3818.

The Spring Conference themed "End-to-End Reliability: Emerging Trends" will be held June 12-15 at the Hilton Bonnet Creek in Orlando, FL. The Spring Conference will feature a Data Center Energy Practitioner workshop and exam, compelling keynotes, concurrent sessions, sessions on solar flares, modular data centers, emerging trends, a spectacular vendor event, and more...

Robert F. Kennedy, Jr., Visionary, Environmental Business Leader & Advocate, will kick off the conference with a session entitled "Green Gold Rush: A Vision for Energy Independence, Jobs and National Wealth".



Yahoo's Vice President of Operations, Scott Noteboom, will open the second day with a keynote presentation entitled "Right Place. Right Way. Right Cost: Evolving Efficiency in Data Factory Design and Operations".

Bob Cashner, SVP of Corporate Properties Group for Wells Fargo will provide the closing keynote "End User's Perspective on Successfully Navigating Data Center Emerging Trends".

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

- eBay – Data Center Goes Gold
- NASA – The Influence of Solar Flares and Solar Storms: Why We Should Care About Space Weather
- Green Grid – Economic and Environmental Value in Business Computing
- Uptime – Data Center Issues: Past, Present & Phuture
- United Parcel Service – Open Heart Surgery on the World's First Tier IV Data Center
- University of Chicago – What's Old is New Again: Integrating a High Density Data Center into a Historic Building

In addition to enhanced programming 7x24 Exchange International presents "An Evening At Sea World". Join us on as we venture off property to Sea World where attendees will be treated to cocktails, dinner, musical entertainment and a special visit from live animals followed by the opportunity to enjoy the attractions at Sea World.

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CHAPTER NEWS

Delaware Valley Chapter

The 7x24 Exchange Delaware Valley Chapter celebrated its 50th Chapter meeting at the historic Union League of Philadelphia. The event featured two presentations by John Diamond of DAS Associates, and a former Board Member of the Delaware Valley Chapter, "7x24 Exchange Delaware Valley Chapter at 50: A Look Back, A Look Ahead," and "Data Centers 2011: State-Of-The-Art, From Micro To Mega." 130 people attended the black tie optional event, which featured a jazz quartet from University of the Arts in Philadelphia. Frank Reidy was honored for his service as Past President of The Board of Directors.

1st Row: (L to R) Gary Aron, Donna Manley, Frank Reidy, Phil Michel
2nd Row: (L to R) Tom Reusche, Rich Werner
3rd Row: (L to R) Mike Rinaldi, Gary Hill, Bill Leedecke

1st Row: (L to R) Gary Aron, Donna Aron, Tom Reusche, Erin Reusche, Donna Manley, Mark Jacobs
2nd Row: (L to R) Robin Rinaldi, Diane Werner, Louise Marvel, Ruth Michel, Phil Michel
3rd Row: (L to R) Mike Rinaldi, Gary Hill, Rich Werner, Bill Leedecke, Frank Reidy, Doris Leedecke

CHAPTER NEWS

Washington DC Chapter

Celebrated its one year anniversary with over 100 members and guests at our 1st Annual Membership Drive and Vendor Night on March 21st. Thanks to our vendor table sponsors who made this a huge success: Active Power, B'Tech, ComRent, Digital Realty Trust, HorizonLine Technologies, Power Protection Unlimited, RTKL, Server Technology, T5, UGL Services and Whiting-Turner.

Membership Drive: Jonathan Litvany – Digital Realty Trust and Chuck Meyer – TM Technology Partners

From March 21st Membership Drive: Steve Mantua & Chris Maruca both with CTS Services, John Fritz of HITT Contracting, Melanie Naugle EDG2, Ben O'Conner CTS Services and Tommy Inscoe with Power Solutions.

On April 8th, seventy-five of our chapter members and guests were given a tour of Fannie Mae's Tier 4, LEED Certified Data Center from the professionals that designed, built and are currently maintaining it. An open panel discussion was held at the tour conclusion allowing members to hear the current and future sate of data center design. Due to the huge success of this event, we'll be touring Dupont Fabros' facility in Ashburn for our June event. (info available at www.7x24dc.org)

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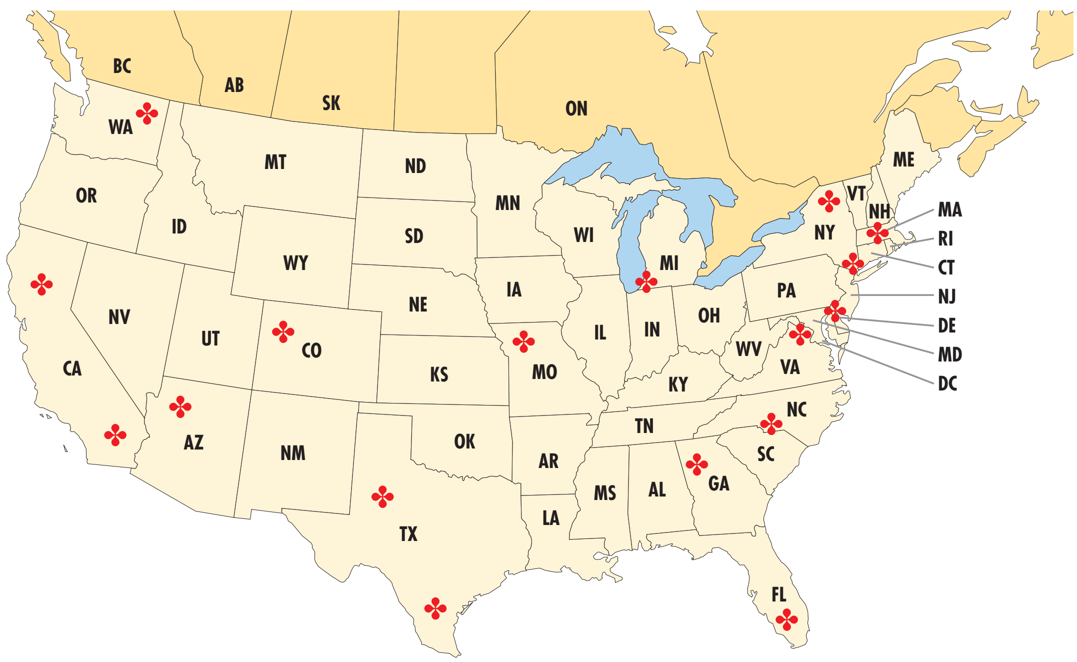


✤ = 7x24 CHAPTER

- Arizona
- Atlanta
- The Carolinas
- Delaware Valley
- Florida
- Greater Washington DC Area
- Lake Michigan Region
- Lone Star (Dallas)
- Metro New York
- Midwest (Kansas City, MO)
- New England Area
- Northern California
- Northwest (Seattle, WA)
- Rocky Mountain
- Southeast Michigan
- Southern California
- Texas South

Attention end users and vendors...

VISIT WWW.7x24EXCHANGE.ORG TODAY TO PARTICIPATE IN YOUR LOCAL CHAPTER

7x24MAGAZINE OPPORTUNITIES

Following are the Editorial Guidelines together with the Member Advertising Rate Card. Advertisers interested in placing an ad may fax the insertion order to 7x24 Exchange at 212.645.1147 or email to jeremy@7x24exchange.org. Questions? Please call Jeremy O'Rourke at 646.486.3818x109.

MEMBER ADVERTISING RATE CARD

BLACK AND WHITE RATES

Size	1X	2X	3X
Full Page	$1,500	$1,300	$1,100
2/3 Page	1,100	1,000	900
1/2 Page Island	900	800	700
1/2 Page	700	600	550
1/3 Page	600	550	500
1/4 Page	500	450	400

COVERS & PREMIUM POSITIONS – INCLUDES 4 COLOR

Size	1X	2X	3X
DPS	$5,000	$4,500	$4,000
2nd / 3rd Cover	2,500	2,200	2,000
4th Cover	3,500	2,750	2,500

COLOR RATES

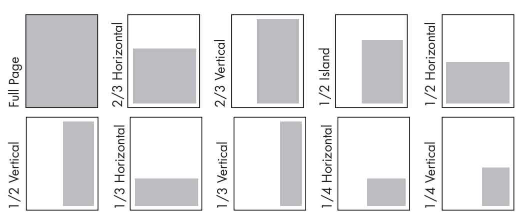
Process Color (4/c):	$900
Revisions and Proofs:	$50
Position Guarantee:	15% premium

*Non-Members add 40% to all rates

NON-BLEED AD DIMENSIONS

Size	Width	Length
Full Page	7.5″	10″
2/3 Horizontal	7.5″	6.5″
2/3 Vertical	5″	10″
1/2 Island	4.875″	7.5″
1/2 Horizontal	7.5″	4.875″
1/2 Vertical	3.625″	10″
1/3 Horizontal	7.5″	3.25″
1/3 Vertical	2.5″	10″
1/4 Horizontal	4.5″	3.25″
1/4 Vertical	3.25″	4.5″

8 1/2″ x 11″ MECHANICAL REQUIREMENTS



Live Area: 7.5″ x 10″
Trim Size: 8.5″ x 11″
Bleed Size: 8.75″ x 11.25″
Halftone Screen: 133 lines up to 150 lines

DPS Mechanical Requirements:
Live Area: 16″ x 10″
Trim Size: 17″ x 11″
Bleed Size: 17.25″ x 11.25″
Halftone Screen: 133 lines up to 150 lines

Press optimized PDF or EPS accepted. No JPEG or TIFF accepted.

Convert all spot colors to CMYK.

Do not use 4 color black. All 4 color black will be replaced with 100% black at the advertiser's expense.

Fonts must be embedded or outlined.

Maximum ink density 280%

Advertiser indemnifies 7x24 Exchange against losses or liabilities arising from this advertising. 7x24 Exchange assumes no liability whatsoever, except to the extent of a one time paid advertisement of the same specification, in the next or similar publication, if any proven or admitted errors or omissions have occurred. Payment is due upon receipt of the invoice. Interest shall be charged at 2% per month compounded to yield 26.82% per year on overdue accounts. Revisions to previously submitted ad copy are subject to additional charges. A charge of $30.00 will be levied for returned checks. In the event of a contract cancellation, the advertiser or agency agrees to repay 7x24 Exchange any discounts granted for multiple insertions less any discount applicable for the number of insertions completed in the contract. All cancellations must be received in writing prior to the advertising sales deadline. All premium positions are non-cancelable. Prices are net of agency commission.

EDITORIAL GUIDELINES

Manuscript specifications: Feature articles vary in length from 500 to 2,000 words. While we accept articles in a variety of formats, it prefers to receive materials on CD. All articles must be received by the deadline to be considered for a specific issue. Material submitted after the deadline will be considered for the following issue.

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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