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IT HANDBOOK

Energy Efficient Cooling

Improving the energy efficiency of your data center can be as easy as making a few key adjustments to your cooling system.

BY JULIUS NEUDORFER

- SETTING UP A COOLING MONITORING SYSTEM
- OPTIMIZING DATA CENTER COOLING EFFICIENCY
- USING HOT-AISLE/COLD-AISLE CONTAINMENT SYSTEMS
- ECONOMIZER SELECTION AND IMPLEMENTATION

Setting Up a Cooling Monitoring System

To optimize your data center's cooling system efficiency, the first step is to measure how much energy your site consumes.

INDUSTRY RESEARCH HAS shown that after IT equipment, a data center's cooling system is the largest energy consumer. The irony of this is that many data center managers have no real visibility into their cooling system's effectiveness or efficiency. Before you can begin to improve your cooling system's efficiency, you need to measure how much energy it's using in the first place.

Installing an environmental and energy monitoring system helps you establish a baseline of data center and cooling system usage characteristics, including overall temperature and humidity levels.

If you already have a central data center management system, then you most likely can receive, accept and format third-party information via SNMP or BMS. If not, you may want to consider installing a central console monitoring and management system. Depending on your data center's size and budget, you might want to invest in a combined energy and environmental system or a simple low-cost temperature and humidity monitoring system.

A data center's temperature is the easiest metric to acquire. However, where and at how many sites you monitor temperatures is a critical issue. In most cases, your individual computer room air conditioner (CRAC*) unit will report the temperature of the return air. If you have an SNMP card (or BMS system), this information can be reported back to your central system console. Although the return air temperature is measured by most CRAC control systems, it is the least useful information for monitoring the effectiveness of your cooling sys-

**NOTE: This handbook generically refers to both computer room air conditioner (CRAC) and computer room air handler (CRAH) as CRAC. In general, a CRAH is a fan coil that relies on chilled water supplied by an external cooling plant; a CRAC contains a mechanical cooling system compressor.*

tem. However, if you also measure the CRAC output temperature (and know the CFM), thereby allowing the basis of a temperature differential (fjT) calculation of BTUs, this number provides a basic indication of the cooling that each CRAC delivers. Using this information, calculate the unit's relative thermal and electrical efficiency.

While return air temperature is how most CRACs regulate their operation and overall data center temperature and humidity, it is the most ineffective way to control the cooling system in a data center, since it is not a true indicator of the air temperature at the IT equipment. Typically most CRACs monitor and respond to the return air temperature, activating the compressor cooling cycle simply because the return temperature is at or above the set point (commonly 20 degrees Celsius or 68 degrees Fahrenheit), which can result in inefficient "overcooling."

Proper monitoring of the data center will depend on the size of the room and

The Impact of ASHRAE 9.9 Guidelines

UNDER ASHRAE 2004 guidelines, data center room temperature and humidity were measured as room ambient, with a relatively narrow range of temperature and humidity (68 degrees F to 77 degrees F). The ASHRAE 9.9 guidelines issued in 2008 broadened the acceptable temperature range to 64.4 degrees to 80.6 degrees F. However, more significantly, the point of measurement was changed to inlet air temperature of the IT equipment, which means you should measure temperature at the front of the rack, instead of the room air. Additionally, if your data center uses high-density racks, ASHRAE recommends that you monitor the temperature at various points per cabinet—face of the rack as well as lower, middle and top of the rack. The humidity range was also broadened to reduce the energy required by humidifier/reheat systems.

Broadening the temperature and humidity range is an important efficiency step; data center managers are slowly trying this as a way to conserve energy. More significantly, where to measure temperature is a radical departure from existing cooling system control points.

its heat-load density. In 2008, ASHRAE made a significant change to its recommendation regarding where and how to measure temperature. See "The Impact of ASHRAE 9.9 Guidelines" on page 3.

Having an outside temperature monitor that is tied into the central monitoring system is helpful because it tracks the external (outside air) temperature in relation to the room temperature as well as the effect of cooling energy used as the seasons change. It also helps you calculate and plot the efficiency of an economizer system.

Humidity is an important part of environmental control, but you don't have to measure it in as many places as you need to measure temperature. Because the air is constantly circulating in the room, the overall humidity is relatively the same throughout. One or two sensors are usually sufficient.

BATTLE OF THE CRACS

The problem that occurs most often is that if all the CRACs contain humidification/reheat control systems, they will actually battle or compete with one another—one CRAC tries to add humidification, while another unit senses and tries to remove any additional humidity. This is a very common scenario and becomes a significant source of energy inefficiency in cooling systems.

Installing a centralized cooling control can mitigate or eliminate this problem. Also consider simply deactivating most of the humidification systems in the CRACs and leaving only one or two systems active with different set points.

For example, you could set the primary unit at 35% to 70% relative humidity (RH) and the secondary units at 30% to 75% as backup, in case the primary systems fail or cannot fully manage the load. Alternatively, some new installations use external independent systems to add humidity as needed.

MONITORING ENERGY USE

Measuring the power of the cooling system can be simple or complicated, depending on where your power panels are located in relation to each component. In larger data centers, being able to measure each system individually will give you a more granular look at how much cooling each unit delivers. That data allows you to fine-tune and improve the entire cooling system's effectiveness and energy efficiency.

In order to measure energy usage, the electrical distribution panels will need to have current transformers and potential (voltage) transformers installed on each output circuit leading to a cooling component. If the entire panel is dedicated to only cooling, then you only need to monitor the main feed to obtain the total cooling energy reading. This method costs less and allows you to calculate your Power Usage Effectiveness (PUE); however, it doesn't provide you with detailed information for optimizing individual areas or subsystems.

Each type of cooling system is different, but it's still important to include all components—fan decks, chillers, pumps, etc.—not just the CRACs in the room. Be sure that the system you are considering is capable of measuring true power (kilowatts, not just kilovolt amps) and can record and display energy use over time (kilowatt hour) and other useful information such as peak kilowatts per day, week, month and year. It should also be able to provide subsets of the information, such as cooling levels (CRAC and chillers), IT load and PUE.

The EPA's Energy Star for Data Centers program is scheduled to be released in June. As a result, manufacturers are producing and promoting new energy and environment monitoring and management systems. With this impending onslaught of new products, how do you know what's best for your data center?

A lot of vendors offer combinations of hardwired, network or wireless remote versions of units that measure temperature, humidity levels and power usage in the data center. System costs vary widely based on the number of points and type of measurement you'll be doing, as well as by the sophistication and features of the monitoring software package. Prices range from $5,000 to $10,000 for a basic system to $50,000 to $100,000+ for a large-scale installation.

Once you've selected a system and installed it, you can begin obtaining some baseline measurements of temperature, humidity levels and power usage. ■

Optimizing Data Center Cooling Efficiency

Raising the server inlet temperature is the next step to improving energy efficiency in your data center cooling system—but pay close attention to how this change affects equipment performance.

THE RELEASE OF ASHRAE 9.9 changed data center recommendations in two ways.

1. It raised the upper temperature limit range to 80.6 degrees Fahrenheit and expanded the humidity range.
2. It changed the point of measurement to inlet temperature of IT equipment.

You should include several temperature sensors in each aisle of your data center, installed at the front of the rack. If your data center runs high-density racks, consider using one or more sensors at the face of each rack for a better view of conditions at the rack level.

In addition to the ASHRAE recommendation, it's important to note that most major IT equipment manufacturers typically list their maximum operating temperatures as high as 95 degrees F. While I don't necessarily advocate running higher than AHSRAE 9.9's 80.6 degrees F recommendation, the proverbial 68 degrees to 72 degrees F standard is no longer an equipment-driven necessity.

HOW TO MEASURE INLET AIR TEMPERATURES

Before you begin increasing the server inlet temperature, you'll need to obtain a baseline reading of your existing IT equipment. For example, a baseline condition is a non-high-density, raised floor data center with an average baseline air temperature of 68 degrees F to 72 degrees F (with several sensors placed in a

Go ahead; pack the racks.

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Today's data centers are really heating up.
Racks are packed with more and more equipment, driving the highest-ever rack power densities. The result: unprecedented heat levels, row by row. Meanwhile, virtualization is everywhere, leading to more dynamic loads and shifting hot spots. Tackling this challenge with traditional raised floors and perimeter cooling alone poses a real struggle: How can you bring enough cooling exactly where it's required? Too often, the result is inefficiency, worsened by soaring energy costs. What's the efficient and effective solution? InRow cooling from APC by Schneider Electric.

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So go ahead: Pack the racks without fear of hot spots or inefficiency. Intelligent, efficient InRow cooling handles high-density heat at the source.

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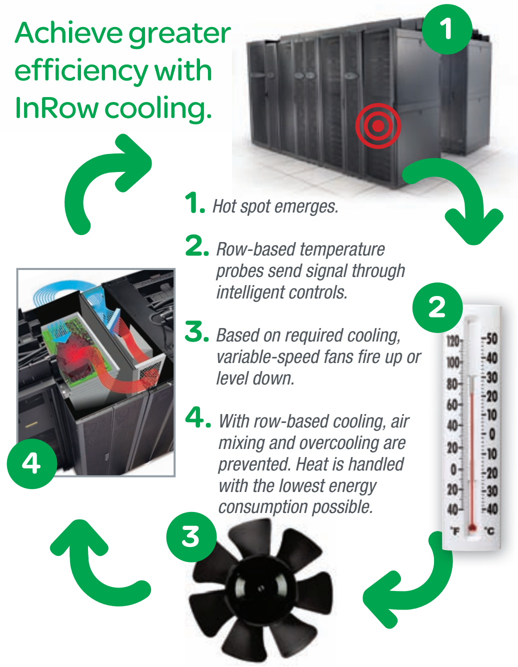

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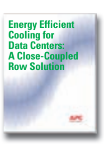

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passage way, not in a hot or cold aisle). This is best done during a stable warm season, before the economizers come into play, to see a more accurate reflection of any related energy savings.

Once you have this, follow these steps:

1. Record the average CRAC return intake temperature and the output underfloor air temperature from the CRAC. Since most CRACs regulate the cooling function based on sensing the return air, note the set points of your CRACs.
2. Measure cold-aisle temperatures at the front of several racks and at the bottom, middle and top of the rack's face.

You can use these measurements later to fine-tune your cooling system effectiveness. Take temps manually using a handheld non-contact type of infrared thermometer, a traditional contact/airflow thermometer or both. If you're using a combination of thermometers and the panel reading of the CRACs, be sure they all match before you begin measuring.

You may have noticed variations in different areas of the cold aisles as well as different temperatures at the bottom, middle and top face of the rack. It would be useful to have a detailed layout of your data center so you can mark the warmest and coolest cold aisles and racks. You should watch the hot spots closely as the temperatures are raised.

Your energy monitoring system should provide instantaneous and collective readings based on at least a 24-hour average or average readings taken over several days to a week, month or year for the data to be meaningful. With this information, along with your IT load, you can establish your data center's baseline PUE. I don't recommend using a "snapshot" approach to PUE, as it is misleading.

Once you have established your baselines, now plan to raise your room temperatures and temperatures at the face of racks. Assuming that your hottest racks are several degrees below the ASHRAE 9.9 recommendations, it should be safe to proceed. However, if the front of the hottest racks are at or near the 80 degree F mark, it's best to first address that.

TEMPERATURE AND HUMIDITY CONCERNS FOR DATA CENTER EQUIPMENT

Despite ASHRAE's expanded thermal envelope, data center managers should evaluate how any temperature adjustments will affect other equipment in the data center. One underlying issue is that the rate of temperature change can impact the failure rate of IT equipment.

The other issue is that some types of IT equipment are more susceptible to temperature and humidity than others. Tape drive equipment and tape media are more vulnerable to extremes and rapid changes, especially regarding humidity. In a large site, consider isolating tape systems in a separate space within the data center envelope or relocate them to an adjacent area with a different environmental system or subsystem.

Hot spots are common problems; raising inlet air temperatures can exacerbate the issue.

Having your uninterruptible power supply (UPS), in particular its batteries, in the same data center space as your IT equipment will negatively affect battery life when temperatures reach higher than 77 degrees Fahrenheit. I recommend contacting the battery manufacturer for information on limits and consider moving the batteries, if possible. Or, provide separate or additional cooling for that area, especially if you are aiming to keep your data center ambient temperature averages at 80 degrees F or higher.

OPTIMIZE AIRFLOW AND ELIMINATE HOT SPOTS

One of the most common problems that data centers face are hot spots; raising inlet air temperatures can exacerbate these problems. Hot spots can occur for many reasons, most often because of uneven or insufficient distribution of cool air or by mixing hot aisle air back into the cold aisle. They can also occur when hot air is recycled within the cabinet.

A variety of methods and devices can mitigate hot spots. Try to redistribute the perforated floor tiles or grates so that more cool air is available in the warmest aisles. But be careful that you don't inadvertently create new hot spots. If you add too many more perforated tiles or grates, the overall under-floor static will drop and reduce the cooling in other areas. You can do this as a trial-and-error process or by using computational fluid dynamics (CFD) modeling. However, CFD results will be meaningless unless you have an accurate model with all under-floor cables and obstructions properly mapped.

If you aren't using blanking plates in your cabinets to prevent cold-air bypass and recirculation, you should consider doing so. They are a low-cost investment that will pay off immediately and will be critical if you use containment systems. In addition, under-floor airflow into cabinets from cable openings should be mitigated using air-containment devices like brush collars.

TAKING INCREMENTAL TEMPERATURE STEPS

Once you've balanced and corrected the airflow, eliminated any hot spots and maintained a stable baseline temperature of 64.4 degrees to 80.6 degrees F for a day or more, you can begin to slowly and methodically increase the temperature.

Begin by raising the temperature one or two degrees Fahrenheit. Then wait 24 hours, ideally taking measurements at the same time of day or averaged over a 24-hour period, and compare your temperature and energy readings. You should see some improvements in energy use. Remember: You're only looking for 1% to 3% savings of cooling energy per degree Fahrenheit.

Once you get to a room temperature of 75 degrees F and higher, raise the temperature in one-degree increments and keep a close watch on the air-inlet temps in the front of the hottest racks. Watch IT systems that begin to report any internal temperature problems.

SETTING UP A COOLING MONITORING SYSTEM

OPTIMIZING DATA CENTER COOLING EFFICIENCY

USING HOT-AISLE/ COLD-AISLE CONTAINMENT SYSTEMS

ECONOMIZER SELECTION AND IMPLEMENTATION

DRAWBACKS OF RAISING THE TEMPERATURE

One of the inherent problems with pushing the temperature envelope is that your thermal reserve time will be reduced or nonexistent if you experience a loss of cooling system capacity. Consider that carefully before increasing temperatures in your data center.

The issue of time-to-recover from a cooling system failure versus thermal rise time is a complex one. Before you increase your data center's temperature, examine the redundancy and recovery time of your cooling systems. In the end, if you don't start with a good system or recovery plan in place, it will be a much more significant issue at hotter intake temperatures since you may have less time before your IT equipment needs to be shut down (or automatically shuts down from internal thermal overheating).

This can be a serious factor during a simple utility power outage—even without a cooling system failure. In most cases, the backup generator will start and begin to stabilize the system, and then the automatic transfer switch (ATS) will bring the power back online within 30 to 60 seconds.

However, the compressors—in the CRACs or in the chiller plant—will have a restart timer delay of three to five minutes. This can cause a problem unless you have some form of stored cooling reserve, especially if you plan to use a containment system to combat high-density heat loads. In a chilled water system, the pumps must continue to run or restart immediately.

Remember, each data center and cooling system is different. Your overall goal is to improve your data center's energy efficiency while still ensuring that the IT equipment remains in its environmentally safe operating envelope.

HIGHER AIR TEMPS CAN IMPROVE HEAT TRANSFER

Higher air temperatures allow CRACs to run more efficiently because a higher temperature differential (fjT) between the higher return air and the cooling coils improves heat transfer. In addition, less compressor energy is needed to maintain the higher CRAC output temperature—especially for chilled water systems where you may also be able to raise the water temperature. However, because air-inlet temperatures can run at 80 degrees F, IT equipment exhaust temps can exceed 100 degrees F. This can negatively affect some direct-expansion (DX) types of CRACs if they are used in a containment system.

If your system has or can use an economizer, higher air-inlet temperatures mean that the savings can be even greater, since the starting point for economizer operation to occur is now at a higher outside ambient temperature than before.

IMPROVED PUE: A FALSE SENSE OF EFFICIENCY

Raising inlet-air temperatures beyond a certain point can negatively affect overall data center energy efficiency. Most modern IT equipment uses temperature-controlled variable-speed fans.

As the inlet-air temperature rises, variable-speed fans begin to speed up to try to maintain internal and CPU temperatures. And that increases the energy use of IT equipment. It also improves a site's PUE twofold, since the increased fan power—not real computing load—will raise the IT load while cooling system power drops. This may look very promising to those who look only at PUE, but it can lead to a false sense of real efficiency.

A better method is to find the energy-efficiency crossover/optimization point—where raising the temperature further will increase the IT load more than the decrease in cooling system power. It requires some experimentation and tweaking since these should be incremental changes.

Once you determine the optimum operating temperature of your data center cooling system, savings will continue every day. Each kilowatt saved equals 8,760 kWh per year. In a data center with a 1 mW IT load and a PUE of 2.0, a 10% overall energy savings will equal 200 kW. This adds up to an annual savings of 1,752 MWh per year. At 11.5 cents per kWh, it represents a projected annual savings of about $200,000. ■

Using Hot-Aisle/Cold-Aisle Containment Systems

Adding a containment system in your data center will improve airflow to IT equipment. Which type to choose depends on a variety of factors.

EVERY DATA CENTER is different. Nonetheless, many use a raised floor with a hot-aisle/cold-aisle layout. Based on airflow requirements for most higher-density IT equipment such as blade servers, it becomes apparent that at about 5 kW per rack, it's more difficult to provide sufficient amounts of cool air to the front of the rack—based on the typical two-tile cold aisle.

In some cases, by increasing the tile airflow using higher flow-rate tiles (or floor grates), the under-floor static pressure for the room drops and the rest of the data center becomes starved for airflow. Alternately, by adding more CRACs to the room, it not only adds more total cooling capacity (or overcapacity), but also increases airflow and under-floor static pressure. This is not very energy efficient and, in many cases, it is completely ineffective as well.

Adding a containment system will improve the airflow to equipment. There are three types of containment systems to look at: active aisle-based, passive aisle-based and rack-based.

➜ **Passive Containment.** In the passive aisle-based system, you can contain the hot aisle, the cold aisle or both. In most typical raised floor installations, it's easier to add cold-aisle containment since you only need to enclose the cold aisle. This option is easier to install than ducted returns for a hot-aisle system. But if you have a ceiling-based warm-air return plenum, you could consider running a hot-aisle containment system instead of or in conjunction with a cold-aisle system.

You may want to create a test environment either by reserving a group of racks filled with spare or out-of-production servers, if any are available, or by renting rack-mounted load banks to simulate the heat load.

The best containment system can be built using add-on components that match the existing cabinets so that all of the pieces fit. If your existing cabinet manufacturer does not offer a containment system, use a custom-made solution or purchase a complete system of new cabinets with a containment system.

Alternately, there are several ways to build your own containment system or adapt components from pre-manufactured systems. Regardless of which

Rack-Level Containment: Rack-level containment systems require a dedicated cooling unit that can be directly attached to a rack, and they are usually provided as a complete system from the manufacturer. Therefore, the unit is a fully self-contained (front and back) enclosed cooling system.

Contained cooling units usually require a source of chilled water. They are best for projects that are expected to run at 20 kW or higher such as running three or four blade servers in one cabinet. Additionally, in the event of a loss of chilled water or cooling unit failure, there is an extremely short (usually one to two minutes) time to thermal overload. Partial rack containment systems (either front or back contained) are also available for projects requiring lower power densities.

Several vendors also offer rear-door hot-air extractors that have extraction fans that duct into a ceiling return plenum to prevent hot air from mixing with the cold aisle. Overall, this method can improve heat extraction from IT equipment. Some cabinet manufacturers offer specialized cabinets with top-mounted ducted chimneys that help contain and extract hot air. Contained hot air must be tied directly to a ducted return or ceiling plenum return system that's ducted directly back to the computer room air conditioner. ■

system you use, it's imperative that you use blanking panels to fill every open rack space. Otherwise, the system's effectiveness will be compromised.

You also have to deal with fire codes. An aisle-based containment system will prevent overhead wet (or pre-action dry pipe) systems from getting water into the contained area, which means you may need to extend the piping through the overhead containment system—an expensive and intrusive process. If you have a gas discharge-based fire-suppression system, you may be able to avoid this requirement. Consult with your system vendor before making a final determination.

There are several ways to build your own containment system or adapt components from pre-manufactured systems.

➔ **End-of-Aisle Containment.** In addition to the top portion of aisle-containment components, the ends of the aisle (either hot or cold) also need to contain airflow. If you purchase a retrofitting kit from your cabinet vendor, you should also receive a door (either slide or hinged) and a frame kit, which provide the best airflow sealing.

However, some aftermarket vendors offer soft-style air barriers that consist of clear vinyl strips that hang from a bar at the end of the aisle. The strips don't have a perfect airtight seal, but they are an easy way to retrofit non-matching cabinets and will contain the majority of airflow. Some units have melt-away links on the clips that hold the vinyl strips, so check that the system also meets all fire codes.

➔ **Active Containment.** Containment systems can be implemented passively—using existing raised floor airflow—or by incorporating active cooling systems. In many cases, especially those with densities above 15 kW per cabinet, you must add multiple close-coupled or in-row cooling units.

Manufacturers offer these systems configured with inline cooling units—in either a hot-aisle or cold-aisle design. From an overall room airflow perspective, hot- or cold-aisle active systems are virtually neutral since none of them depend on the airflow provided by the raised floor. This isolated close coupling to the IT equipment makes them very effective and energy efficient.

Some systems need to connect directly to a chilled water loop, while others connect to their own heat exchanger and coolant distribution subsystem. The advantage of active systems is that they do not affect the raised floor airflow or the heat load on an existing room CRAC. However, they will add to the heat load on the chilled water system.

Each containment system has advantages and drawbacks, especially when you need to retrofit your existing data center.

Active systems can support cooling levels of 15 kW to 20 kW per rack or more by simply changing the ratio of active cooling units to the number of IT cabinets in the system. However, there has to be a sufficient source of chilled water to support the heat load of the existing room and the contained area.

Ultimately, each system has advantages and drawbacks, especially if you need to retrofit your existing data center to accommodate a new containment system. The physical layout, the total projected heat load and the total number of high-density racks (and heat load per rack) will narrow your choices so that you can choose what's most practical for your data center site. ■

Economizer Selection and Implementation

Once you've optimized the airflow inside your data center, adding an economizer to your cooling system can help you take advantage of free cooling.

ECONOMIZERS ALLOW YOU to fully utilize available free cooling in your data center. Free cooling refers to days or hours when the outside temperature allows you to reduce or eliminate the use of compressors, resulting in significant annual energy savings. The Green Grid, a global consortium of IT companies and professionals seeking to improve energy efficiency in data centers, has online tools to help you calculate if your site has enough free cooling days or total annual hours to justify spending valuable time and money on an economizer.

You can choose from two common types of economizers: air and water. When making your selection, there are two things to remember. Generally, the effective operational temperature range for air systems is broader than for water-based economizers. And the type of economizer you implement depends on the type of cooling system you have.

→ **Air-Side Economizers.** The underlying concept of air economizers is relatively simple—open the "window" when temperatures are cooler outside than inside. However, implementing this concept in the data center is not quite as easy. You first need to control the temperature and humidity, while avoiding any sudden changes in both.

Air-side economizers bring cooler outside air into the site and exhaust warm air to reduce mechanical cooling requirements. They also filter the outside air and provide humidity control—without expending excessive additional compressor energy for dehumidification.

Most data centers are not 100% air tight, leaving them susceptible to external biological or chemical attacks or hazards such as smoke or airborne particulates.

Therefore, some operators and clients don't want any systems that allow in significant amounts of external air. Some options exist to ease these fears—indirect air-based economization systems such as the heat wheel or a Kyoto Wheel and similar air-to-air heat exchanger-based indirect systems. But these types of economizers require a significant amount of space and need to be housed in a specially designed building. They are not very prevalent in the U.S., but some data centers in Europe are exploring this option.

➜ **Water-Side Economizers.** Water-side economizers, which are more widely used, can be inserted (with control valves) into the warmed return side of the chilled water loop and then rerouted to a water-to-air heat exchanger before re-entering the chiller plant. This provides partial or total free cooling by either reducing or totally eliminating the need to run chiller compressors.

The key to maximizing the effectiveness of this type of system is to use the warmest possible chilled water temperature that still allows you to maintain the desired air temperature at the computer room air handlers.

When you implement a water-side economizer, you don't need to make any changes to the computer room air handler units in the data center.

OUTSIDE THE DATA CENTER > WET, DRY, HYBRID AND AIR-BASED COOLING

Types of available chiller plant technologies greatly. Among the options are leading-edge technologies such as heat-absorption chillers coupled to gas-turbine cogeneration systems. There are also the more common methods in which the heat output from a chiller's compressor section transfers heat to the atmosphere. Some available types of cooling systems include wet, dry, hybrid and air-cooled:

➜ **Wet.** This is an open-loop evaporative system in which heated water passes through a cooling tower and releases heat through a combination of contact with the atmosphere and through evaporation. It is most common in large commercial buildings and data centers. It requires a continuous source of water, also called makeup water, to be added to offset the amount that evaporates. While it's the most energy efficient, it uses a significant amount of water.

➜ **Dry.** This closed loop or fluid-cooled method is a sealed system that operates much like a car radiator. Warmed fluid (a glycol/water mixture) passes through a coil while a fan blows air though the coil to transfer heat to the atmosphere. In colder ambient temperatures, or low heat loads, the fans may stop or run at a lower speed to save energy. You can also add it as an economizer to an air-cooled system.

➜ **Hybrid.** The closed loop with evaporation method is similar to the dry closed-loop system but varies in that water is also sprayed on the coils to improve cooling capacity and efficiency.

➜ **Air.** This closed-loop system usually incorporates a packaged chiller system that uses the direct expansion (DX) process and contains a condenser coil with refrigerant, not water, as well as fans. The unit provides chilled water to the CRAHs, but transfers the heat directly to the air.

Air-cooled systems don't use any water and tend to be less energy efficient than water-cooled chiller systems. They are generally used in small to midsized sites and are ideal candidates for the use of economizers.

INSIDE THE DATA CENTER > CRACS VS. CRAHS

Two types of computer room cooling systems are available: CRACs and CRAHs. And CRACs come in two varieties: direct expansion and glycol loop.

➜ **Direct Expansion** CRACs have a compressor contained within the unit; refrigerant is piped directly to a condenser coil and a fan that's located outside the building. Two drawbacks of this type of system are that there is a limit to the distance that the refrigerant can be piped—typically 200 to 250 feet—and there is no native way to include an economizer, since the compressor must always run to transfer heat to the outside condenser coil. DX units are mostly used in smaller sites.

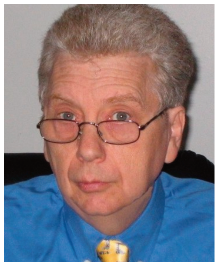
➜ **Glycol Loop**, or condenser water CRAC units, contain an internal condenser unit that's connected to a fluid-based heat exchanger. The so-called condenser loop (or glycol loop) is then piped to the outside system—either to a dedicated dry cooler or a building's cooling tower. This type of CRAC is fairly common in data centers located in office parks.

THE BOTTOM LINE

In a data center, it is not possible to simply shut down the cooling systems to do an entire "forklift" upgrade. You must add economizers or replace CRACs in controlled stages to ensure that there is always enough cooling capacity available.

There are many ways to improve the effectiveness and energy efficiency of data center cooling systems. Some methods, such as the use of blanking panels and air containment, are low-cost solutions. Other more advanced recommendations include installing economizer systems or containment systems with active cooling units and may require assistance from a mechanical engineering firm and mechanical contractors.

Improving the overall efficiency of a data center should be an ongoing goal. While the primary goal in the mission-critical application world is to make sure that all computing resources are available all the time, data center managers can't continue to provide computing resources if the data center itself runs out of energy or energy capacity. Every kilowatt that's saved in the supporting power and cooling infrastructure will trickle down—resulting in lower operating costs, more available net power for IT equipment or both. ■



ABOUT THE AUTHOR:

Julius Neudorfer has been the CTO and founding principal of NAAT since its inception in 1987. He has designed and managed communications and data center projects for both commercial clients and government customers.

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