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Optimizing your Cooling Energy Consumption in New and Existing Data Centers

Practical Methods for Reducing the Overall Energy Consumption of Cooling Systems Within a Data Center

David Joy
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Practical Methods for Reducing the Overall Energy Consumption of Cooling Systems Within a Data Center

David Joy, VP Sales and Marketing
STULZ

Data center IT equipment produces heat and requires precision cooling to protect it from operating at temperatures or humidity ranges that reduce life or lead to failure.

The problem is that data centers consume a lot of energy, between 2 and 3% of all energy usage in the U.S., and the cooling equipment represents approximately 50% of the total energy consumed.

In order to self-regulate energy consumption, ASHRAE has developed ASHRAE TC9.9 to define recommended and allowable temperature and humidity ranges, higher and broader respectively than what was the standard in the previous ASHRAE standard.

As an example, raising IT entering air temperatures from 75 to 95°F dry bulb increases CRAH sensible capacity by 66%, or provides same or better sensible capacity with 33% less fan power, and/or allows higher chilled water temperature for more efficient chiller operation.

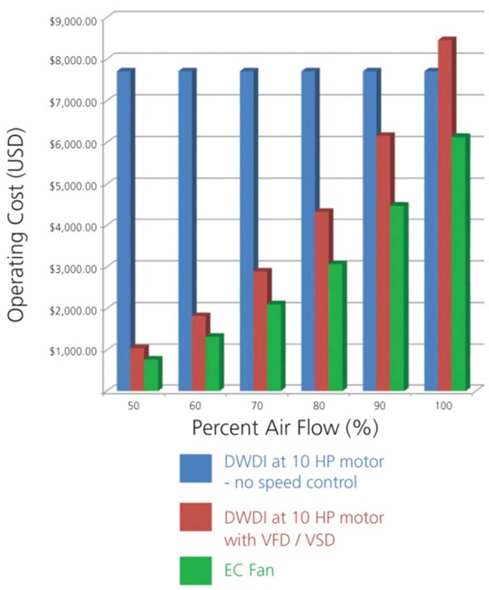
ASHRAE also developed ASHRAE 90.1 that outlines the use of air or water side economizers to provide free cooling. Water economizers must meet 100% of the expected load at the following conditions: cooling towers temperatures of 40^{0}F dry bulb / 35^{0}F wet bulb and dry coolers at temperatures of 35^{0}F dry bulb.

Changes in data center best practices for precision cooling equipment includes the use of backward curved plenum fans with electronically commutated (EC) motors (FIGURE 1), chilled water as a cooling medium for medium-large data centers, adiabatic humidification using ultrasonics, Air Handlers and perimeter cooling with DX or CW as part of an air or water side economizer solution providing free cooling.

EC fans provide over 20% energy savings running at full load, and over 60% energy savings is possible when running at partial load with the added benefit of built-in redundancy. (See TABLE 1)

FIGURE 1: EC Fan

TABLE 1: COMPARISON OF FAN TECHNOLOGY



Another best practice is to operate multiple CRAHs at a lower fan speed providing better energy savings and redundancy.

Operating 3 x CRAHs @ 75°F / 50% EAT with 45°F water operating with 1 unit on standby capacity at an airflow of 2 x 17,000 cfm = 34,000 CFM, for a fan energy consumption of 2 x 9.1 = 18.2 kW.

Operating 3 x CRAHs @ 75°F / 50% EAT with 45°F water with all three units operating at the same time at an airflow of 3 x 11,333 cfm = 34,000 cfm, for a fan energy consumption of 3 x 2.69 = 8.07 kW.

The delta of 10.13 kWh / year = $8,874 of energy savings / year (at a cost of $0.10 / kWh).

Traditional control of a CW valve and a centrifugal fan has been in series. Today it is possible to have independent control of a CW valve and an EC fan maximizing energy savings and limiting latent cooling.

Over the past several years, perimeter cooling has been used to cool IT equipment in racks oriented in a hot aisle / cold aisle configuration. The challenge has been to avoid wasting energy by mixing air from the hot aisle to the cold aisle. Return air plenums were added to direct hot air back to the perimeter cooling. The plenum draws the hot air and reduces the possibility of hot air mixing. Hot/cold aisles also help to maintain a small pressure differences between cold aisle supply air and the return air plenum. As we've seen, return air at higher temperature allows the perimeter cooling unit to operate more efficiently.

Today, racks can be organized so that cooled air from raised floor is pressurized in a cold aisle contained area. IT equipment draws in the cold air and exhausts out heated air. (FIGURE 2)

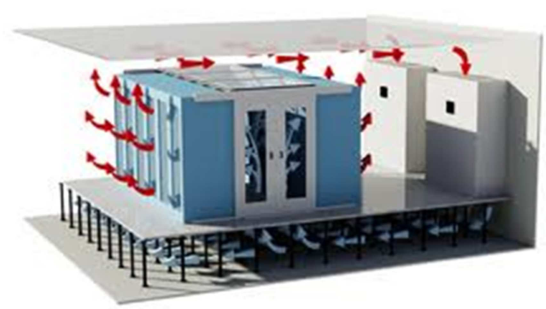


FIGURE 2: COLD AISLE CONTAINMENT ON A RAISE FLOOR

We mentioned the ASHRAE 90.1 standard which requires the use of water and air side economizers to provide free cooling. Water side economizers can save up to 60% energy by automatically switching to the best operating mode based on heat load and outside air conditions. There are several ways to accomplish this: Traditional free cooling (FIGURE 3) is comprised of a constant fan speed dry cooler, constant speed pumps, and glycol cooled free cooling CRACs with both a DX and a glycol cooling coil.

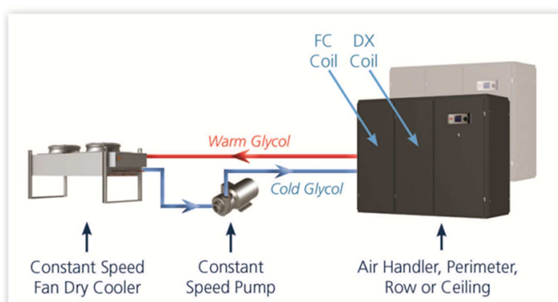


FIGURE 3: GLYCOL COOLED DX - FIXED

Dynamic free cooling (FIGURE 4) is comprised of a variable fan speed dry cooler, variable speed pumps, and glycol cooled free cooling CRACs consisting of both a DX and a glycol cooling coil.

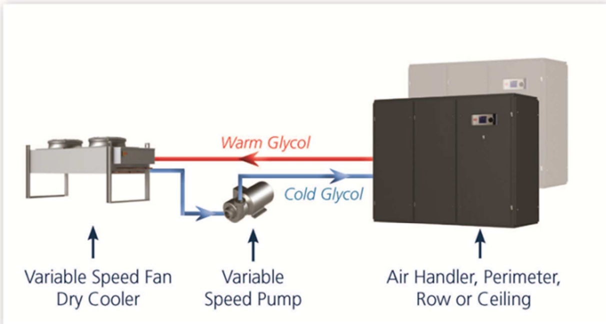


FIGURE 4: GLYCOL COOLED DX - VARIABLE

During warm weather months, the unit acts as traditional DX with a dry cooler that supplies glycol to the unit condenser.

During in-between months, a combination of a glycol free cooling coil and one DX compressor will operate.

During cold weather months, cooled glycol is transferred to a free cooling coil and the compressor is turned off. Fans on the dry coolers and pumps operate at the lowest possible speeds to supply required cooling, using the least amount of energy. As the ambient temperature increases, fans on the dry coolers and pumps increase speed to extend available free cooling.

An evaporative tower providing free cooling (FIGURE 5) is comprised of an evaporative cooling tower, constant speed pumps, and water cooled free cooling CRACs with both a DX and a water cooling coil.

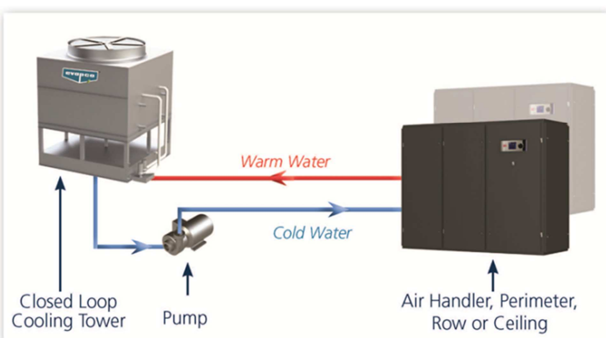


FIGURE 5: WATER COOLED DX

Finally, Free Cooling with Chilled Water (FIGURE 6) is comprised of an evaporative cooling tower, cooling tower pumps, water cooled chiller, chiller pumps, control valves, and chilled water cooled CRAHs.

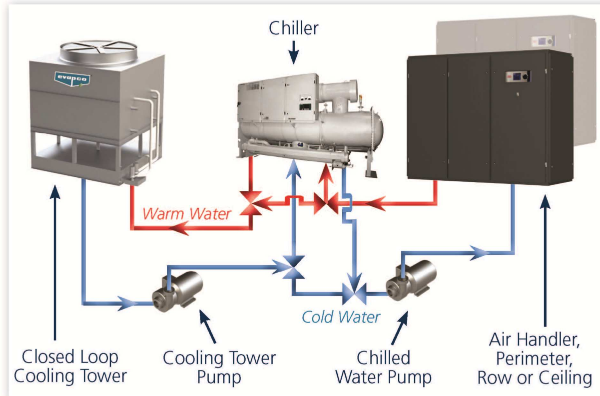


FIGURE 6: CHILLED WATER UNITS

During warm weather months, cooling tower supplies a chiller and the chiller supplies the CRAH.

During cold weather months, the cooling from the tower directly supplies the CRAH and the chiller compressor is turned off.

When it comes to air side economizers, there are also several options. Air side economizers can save up to 80% energy by automatically switching to the best operating mode based on heat load and outside air conditions.

CRACs or CRAHs can be supplied with an integrated mixing box and damper controls provide free cooling. Units can be attached to the top of a CRAC or CRAH in a vertical or horizontal position. (FIGURE 7)

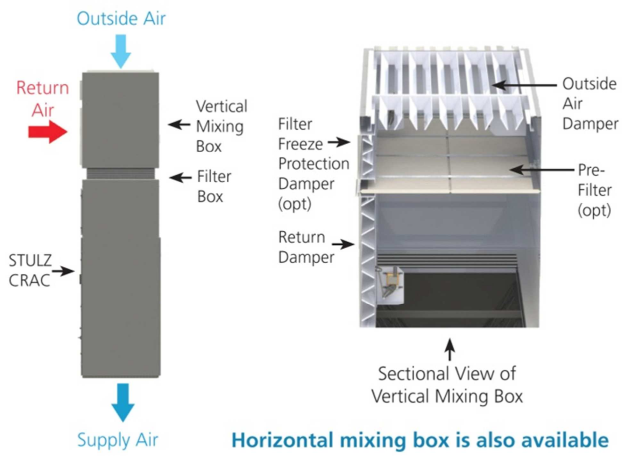


FIGURE 7: AIR SIDE ECONOMIZER WITH A VERTICAL MIXING BOX

During warmer temperatures or higher or lower humidity conditions, dampers close & the CRAC/CRAH reverts to traditional operation.

When temperatures are within a proper range, outside air is directly introduced through the dampers in the mixing box.

When temperatures are colder than desired, dampers mix outside air & return air to achieve the desired temperature.

When temperatures are below freezing, warm return air mixes with outside air before the filter to prevent freezing.

In conclusion, ASHRAE standards and best practices are driving improvements in data center energy efficiency. Improvements in data center cooling is available for precision cooling equipment and controls. Free cooling with water and air side economizers is available to provide maximum energy efficiency.

Presenter bio

David Joy has over 20 years' experience in supporting data center infrastructure. David currently works as VP of Sales and Marketing for STULZ, a manufacturer of precision cooling solutions for data centers. David previously held sales and marketing positions at McQuay, Emerson Network Power, and Rittal. David currently resides in Frederick, Maryland. He can be reached by email at djoy@stulz-ats.com or by phone at 240-529-1334.