Humidification for Data Centers

An indepth look at the role humidification plays in maintaining a functional and sustainable digital world.

Humidification, Dehumidification and Evaporative Cooling

Data centers are crucial for internet traffic but consume significant energy. Their construction is rapidly growing due to increasing computing demands.

Introduction

Data centers serve as the backbone of the internet, powering the majority of global internet traffic. Whether it’s streaming platforms, cryptocurrencies, social media, scientific computing, or online collaboration, data centers play a vital role in facilitating the flow of incoming and outgoing data. However, powering the world’s internet comes at a significant energy cost, with data centers collectively accounting for approximately 2% of total electricity consumption in the United States.

Given the ever-increasing demands for computing power, the construction of data centers worldwide continues to grow rapidly, and it is projected to maintain a compound annual growth rate of around 20% by 2026. As organizations embrace cloud technology and migrate their systems to cloud environments, the past decade has witnessed an exponential surge in hyperscale and colocation data centers, leading to a substantial rise in power usage. Consequently, data centers are actively seeking new technologies and strategies to enhance energy efficiency and decrease their overall energy consumption.

Data Center Metrics and Benchmarking

PUE & DCiE

Energy efficiency metrics and benchmarking are essential for monitoring data center performance and uncovering opportunities to minimize energy consumption. Several benchmarks are available, encompassing Air Flow Efficiency, Heating Ventilation and Air-Conditioning (HVAC) System Efficiency, Rack Cooling Index, and Return Temperature Index. Among these metrics, the most commonly utilized are Power Usage Effectiveness (PUE) and Data Center Infrastructure Efficiency (DCiE).

PUE is defined as the ratio of the total power required to operate the data center facility to the total power consumed by all IT equipment within it:

$$PUE = \frac{\text{Total Facility Power}}{\text{IT Equipment Power}}$$

In traditional data centers, cooling systems can consume more than half of the facility's total power consumption. This highlights the significant role of data center cooling equipment.

A PUE of 1.0 translates to 100% efficiency. The average data center has a PUE of 2.0, meaning that the total demand is double the amount of energy required to power the IT equipment. A good PUE rating is 1.4 and super-efficient data centers have been able to achieve a PUE of 1.1.

DCiE is defined as the ratio of the total power consumed by all IT Equipment to the total power to operate the data center, or inverse of the PUE:

$$DCiE = \frac{1}{PUE} = \frac{\text{IT Equipment}}{\text{Total Facility Power}}$$

So, for the average data center with a PUE of 2.0, the DCiE would be 0.5, or 50%, indicating that the IT equipment consumes 50% of the facility's power.

These two metrics are typically evaluating average annual power usage rather than instantaneous power usage which accounts for variable free-cooling energy savings that peak at different times of the year.

How Much Energy do Data Centers Use?

The power density of an average data center typically falls within the range of 46.452 W/ft² (540 W/m²) to 204.417 W/ft² (2200 W/m²). However, it is important to note that power usage is heavily influenced by the data center's design and is impacted by various factors such as equipment layout, cooling strategies, and air system design.

In traditional data centers, cooling systems can consume more than half of the facility's total power consumption. This highlights the significant role of data center cooling equipment, which accounts for approximately 40% of the energy consumed by the entire telecommunications industry. Notably, chillers and CRAC/CRAH units are the primary consumers of this energy.

Research conducted on traditional data centers has revealed an interesting trend: for every Watt utilized to power the IT equipment, an additional 0.5-1 W is consumed for cooling purposes. This emphasizes the importance of energy-efficient solutions to minimize power consumption and optimize cooling efficiency.

Humidification in data centers can minimize the risks associated with electrostatic discharge (ESD) and static electricity, protecting critical components.

Humidification helps minimize the risk of electrostatic attraction and subsequent particle contamination, which can negatively impact data center equipment.

Strategies for Energy Savings

1. Centralized Air Handling Systems

As data centers continue to grow in size to meet the escalating computing demands, they are incorporating oversized ductwork and cooling capacity to accommodate long-term expansion and flexibility. In this context, the adoption of specifically designed central air handler systems, as opposed to traditional drop-in computer room cooling units (often referred to as CRAC units), has demonstrated notable improvements in energy efficiency.

Data centers that employ centralized air handler systems, as compared to traditional CRAC units, can achieve energy savings of up to 33%.

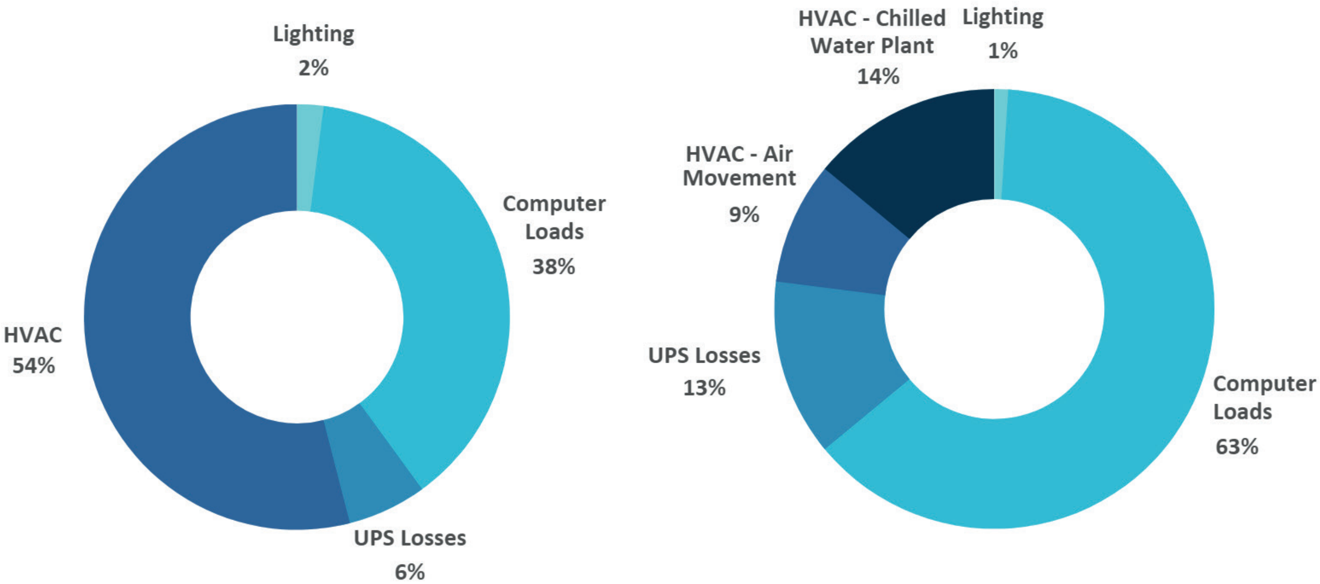
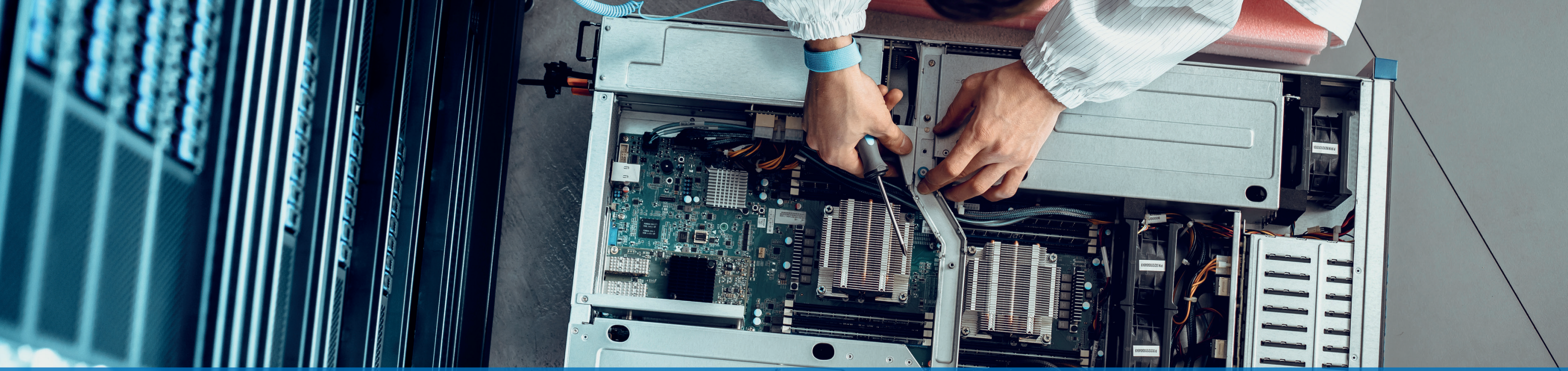


Figure 1: Illustrates the differences in energy-efficiency of Multiple Distributed CRAC Units, compared to Central Air Handler Systems.



Humidity management is essential for ensuring the stability and integrity of data storage media, such as magnetic tapes and hard disk drives.

This increased efficiency can be attributed to the utilization of larger fans and motors in air handler systems, which inherently offer greater energy efficiency. Additionally, air handlers can easily integrate variable frequency drives, allowing them to optimize efficiency during partial loads.

By implementing these advanced air handler systems, data centers can effectively enhance their energy efficiency, reduce operational costs, and contribute to a more sustainable approach to cooling infrastructure.

2. Hot and Cold Air Aisles

Data centers can reduce operating costs and heat related process failures by using hot/cold

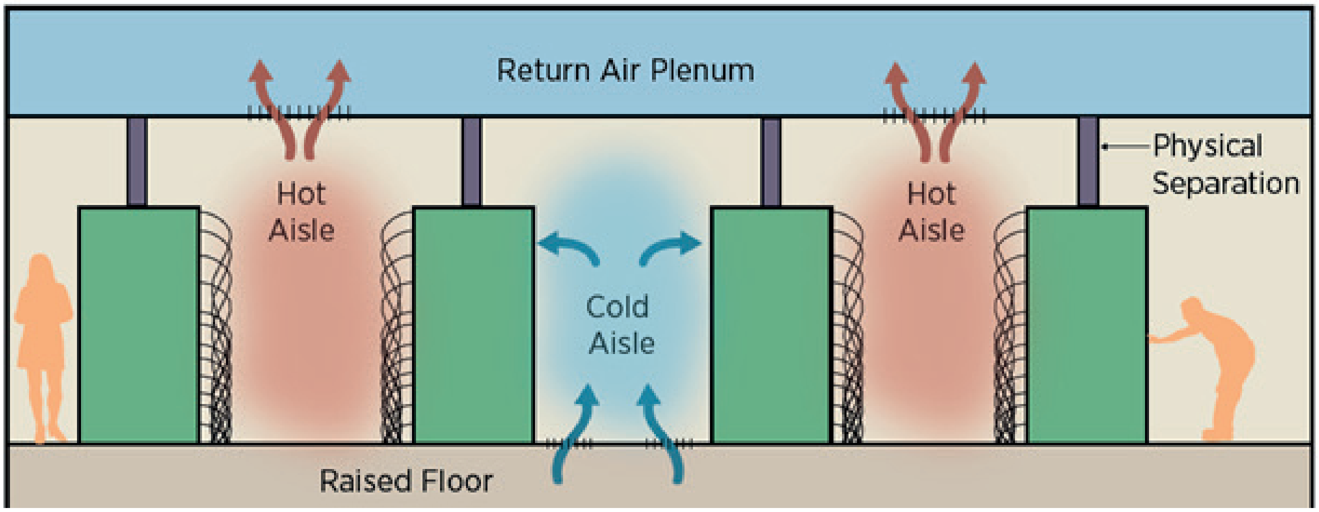


Figure 2: Hot/cold aisle configurations within data centers.

Condair's humidification systems for data centers offer scalability and flexibility, allowing for easy integration into existing infrastructure and accommodating future expansion needs.

Maintaining optimal humidity levels in data centers can improve the reliability and performance of servers and other IT equipment.

aisle separation and containment. Hot/cold aisle configurations increase the efficiency of air-cooling systems by minimizing or eliminating mixing between the cold supplied air to the equipment and the hot exhaust air from the equipment. This type of configuration can significantly increase cooling capacity within the data centers cooling system and save up to 23% cooling energy, which can result in up to 10% reduction in PUE.

Hot/cold aisle configurations are laid out in rows of server racks with alternating cold and hot aisles between them. Because the hot air is not mixed with the cool supply air, return air temperatures can range from 85°F (29.4°C) to 100°F (37.8°C). Higher return temperatures will increase the mixed supply air temperature, which can extend air economizers hours or be used for exhaust evaporative cooling.

3. Air-Side Economizer

Air-side economizers can be a simple yet effective way for data centers to reduce their energy usage. Rather than cooling the hot air coming off the servers, an air-side economizer will exhaust this hot return air and replace it with fresh, cool outside air, removing or reducing the need for mechanical cooling. Though most effective in colder climates, economizers still provide useful hours at nighttime or during the winter months in warmer climates. Air-side economizers can provide incredible energy savings especially when used in conjunction with evaporative cooling systems.

Air-Side Economizer Savings

According to a study by Intel IT, a 500kW data center facility can save up to $144,000 annually and a 10MW facility can save up to $2.87 million annually by using an air-side economizer with 100% outside air at temperatures of up to 90°F (32.2°C) to cool servers.

Humidification contributes to a comfortable and healthy working environment for data center personnel, ensuring their well-being and productivity.

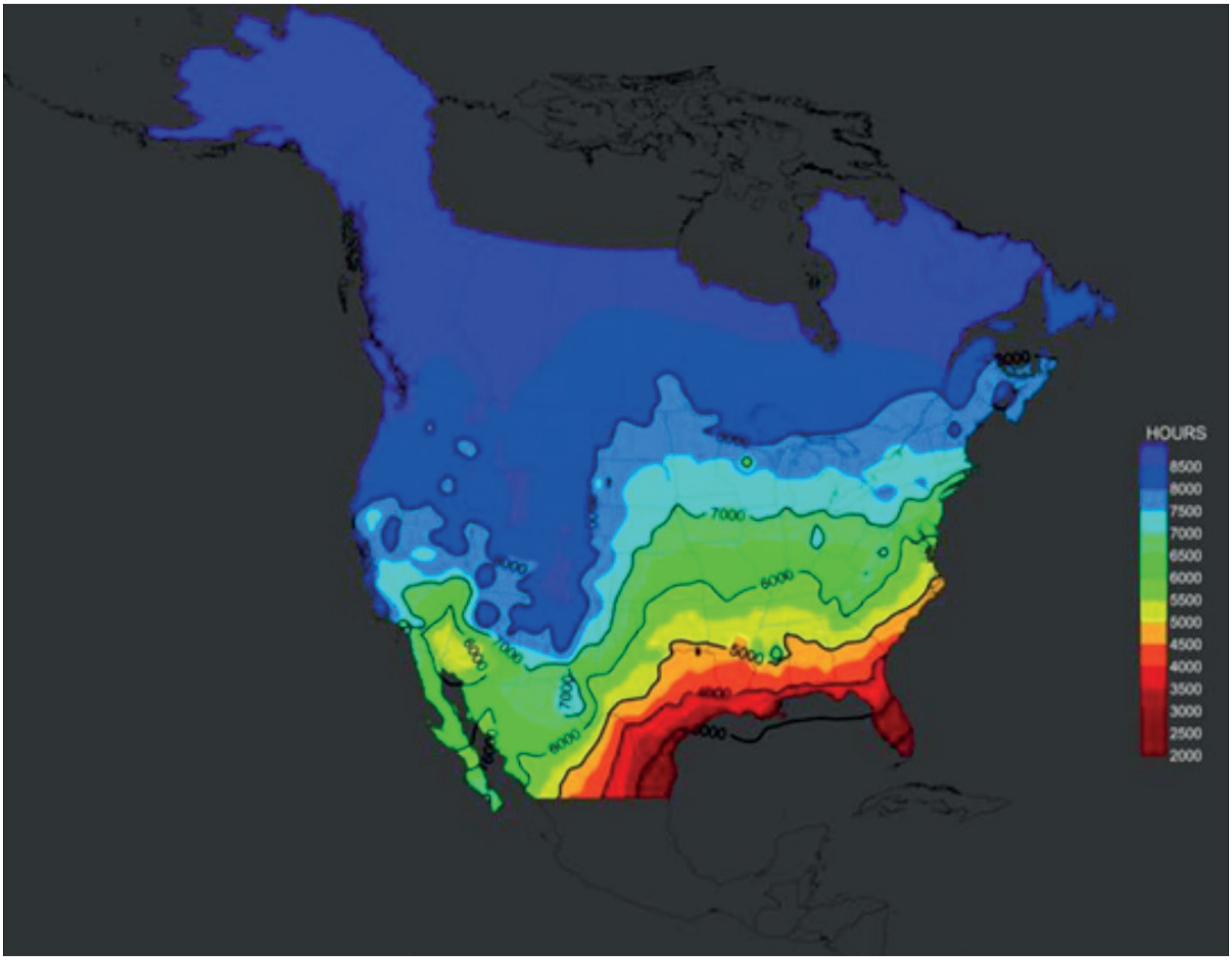


Figure 3: Estimate of air-side economizer hours for data centers.

Condair humidification systems for data centers are designed for energy efficiency, contributing to cost savings and sustainable operations.

To reduce power consumption, data centers seek energy-efficient solutions amidst the adoption of cloud technology.

4. Evaporative Cooling

Evaporative cooling is the best choice for improving the energy efficiency of data centers. Evaporative media humidifiers work by passing water directly over media that is placed in the airstream.

Passing airflow causes the water to evaporate, which generates cooling through a phenomenon known as adiabatic cooling. The net result is perceivably cooler air temperatures and an increase in humidity levels.

Taking advantage of the adiabatic cooling effect is the key to saving energy with evaporative media humidifiers. The cooling effect can maximize the useful hours of air side economizers and further reduce or eliminate the need for mechanical cooling.

The temperature drop of an evaporative humidifier can be estimated if the humidification load and the airflow rate are known, as shown:

$$\Delta T = \frac{load \times 1000\ BTU/lb}{CFM \times 1.10}$$

In the above formula, the load is multiplied by the energy required to evaporate a pound of water. This result is then divided by the product of the airflow rate and a constant of 1.10. It is common to see temperature drops of more than 10°F (-12.2°C) for evaporative media humidifiers.

The cooling rate, in BTU/hr, for an evaporative media humidifier can also be estimated if the humidification load is known, as shown below:

$$Cooling = load \times 1000\ BTU/lb$$

The constant 1000 BTU/lb required for the phase change is known as the standard heat of vaporization.

For water, this value varies between 970 BTU/lb at the boiling point and 1075 BTU/lb at the freezing point. For estimation purposes it is common to use 1000 BTU/lb, which tends to produce slightly conservative values for cooling capacity.

Image: A double height ME Series humidification system cools a data center in Sweden.

Example: Data Center in Sweden

Northern Sweden - cold winter climate
290,00ft² (26,942.96 m²) facility
PUE 1.15
52 double height ME systems (2 story design) – each delivers 490 lb/hr of humidification
515,000 BTUs of free cooling per system
Potable water supply
Powered by hydro electricity

The upper level serves as a huge cooling system, with fresh air entering the building through louvers and then passing through the ME Series to humidify and cool the air, which then enters the server area on the lower floor. The fan wall helps maintain pressure to guide the air through the humidifiers.

Best Strategies for Evaporative Cooling

Direct vs. Indirect Evaporative Cooling

When adding an evaporating cooling system to your data center, one of the first aspects to consider is whether the direct or indirect method is best suited to the facility.

Direct Evaporative Cooling

The humidifier provides moisture to the incoming air, increasing its humidity while decreasing its temperature. The dry bulb temperature is reduced and the wet bulb temperature stays the same.

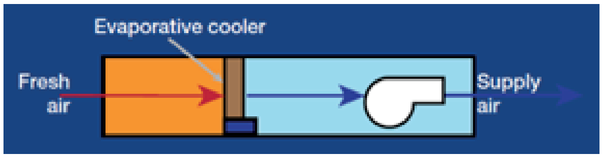


Figure 4: Demonstrates the flow of fresh air and supply air within a direct evaporative cooling system.

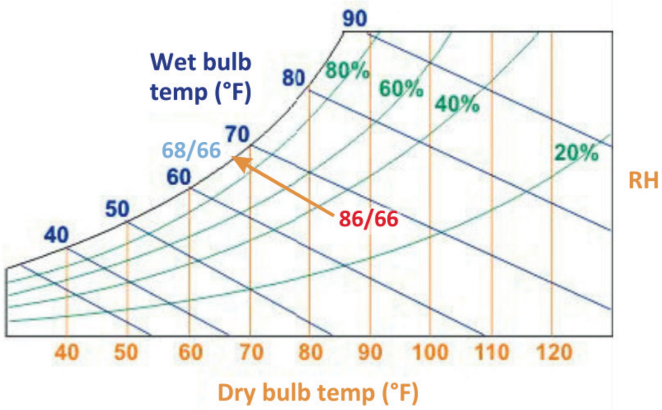


Figure 5: Because cooling is achieved by adding moisture to the supply air stream, the new dry bulb/wet bulb

Condair provides comprehensive support and maintenance services for their humidification systems, ensuring optimal performance and minimizing downtime in data center operations.

Maintaining consistent humidity levels within recommended ranges can contribute to energy efficiency by reducing the occurrence of equipment failures and the need for repairs.

The preceding example explains temperature reduction achievable using direct evaporative cooling based on a starting dry bulb temperature of 86°F (30°C) and a wet bulb temperature of 66°F (19°C).

Temperature drop achievable =
(dry bulb – wet bulb) x (efficiency of the media)*
*Assume efficiency of 90%

86°F (30°C) - 66°F (19°C) x 0.9 = 18°F (-7.8°C)

Achievable temperature = dry bulb – temperature drop achievable

86°F (30°C) - 18°F (-7.8°C) = 68°F (20°C) dry bulb/66°F (19°C) wet bulb

Indirect Evaporative Cooling

The humidifier operates on the exhaust air. Before being expelled, the air is humidified and cooled, then passed through a heat recovery unit to transfer the cool thermal energy to the incoming air. This cools the incoming air without adding any additional moisture.

Both the dry bulb and wet bulb temperatures are reduced. Indirect cooling solutions can be used when it is not desirable to add humidification to the air, or when outdoor air conditions are not favorable for direct evaporative cooling, eliminating the risk of pollutants.

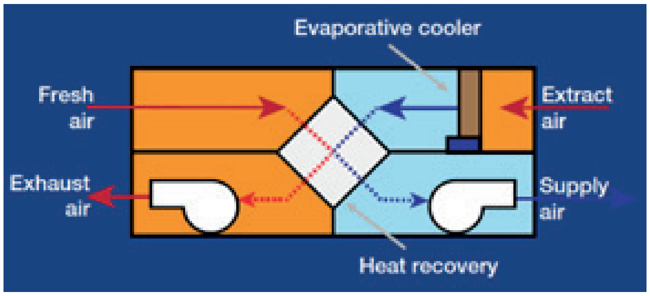


Figure 6: Demonstrates the flow of fresh air, extracted air, exhaust air and supply air thorugh an indirect evaporative cooling system.

The following example explains temperature reduction achievable using indirect evaporative cooling based on a starting dry bulb temperature of 86°F (30°C) and a wet bulb temperature of 66°F (19°C):

Humidification systems help mitigate the potential negative effects of low humidity, such as static electricity buildup and equipment malfunction.

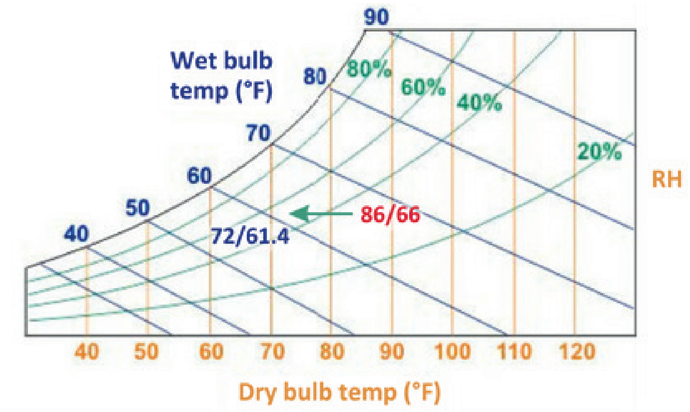


Figure 7: Because moisture is not added to the supply air stream, the new dry bulb/wet bulb temperatures are found on the dry bulb gradient.

Temperature drop achievable =
(dry bulb – wet bulb) x (efficiency of indirect module)*
*Assume efficiency of 70%

86°F (30°C) - 66°F (19°C) x 0.7 = 14°F (-0°C)

Achievable temperature = dry bulb – temperature drop achievable

86°F (30°C) - 14°F (-10°C) = 72°F (22.2°C) dry bulb/61.4°F (16.3°C) wet bulb

Cycles of Concentration

Why do we need Cycles of Concentration?

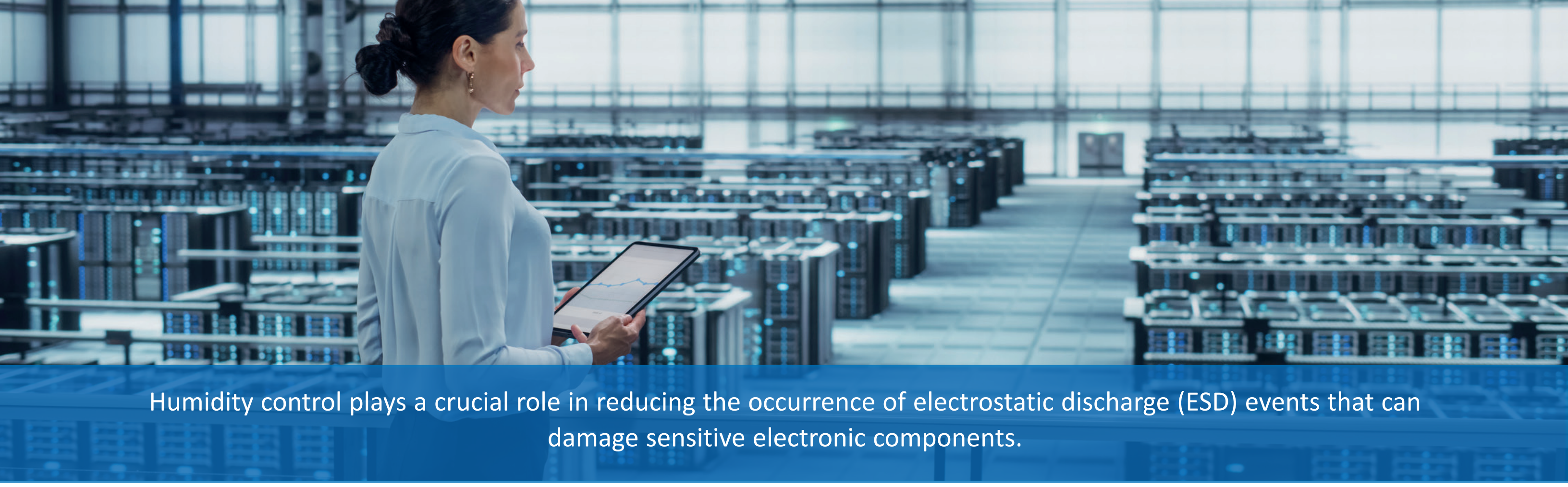
Data centers have increasingly stringent mandates on water management. As beneficial as the adiabatic cooling effect can be for a large-scale facility, water consumption is still a concern. Optimizing cycles of concentration for the evaporative media system can reduce and optimize water waste.

What is a Cycle of Concentration?

As water circulates through the ME humidifier, water evaporates from the media leaving the media pad in contact with the dry oncoming air passing through it. During the evaporation process, only the water molecules evaporate into the oncoming airstream. The supply water contents, such as Magnesium and Calcium, remain on the evaporative media pads.

As the excess water circulating through the ME system passes through the media pads,

Condair's advanced technology and precise control capabilities enable accurate humidity regulation, creating a stable and controlled environment within data centers.



Humidity control plays a crucial role in reducing the occurrence of electrostatic discharge (ESD) events that can damage sensitive electronic components.

Calcium and Magnesium contents increase in the recirculated water. Once the water is oversaturated with the minerals it will begin to precipitate onto the media. The precipitate is widely known in the industry as "scale build-up". This build-up results in a drop of adiabatic cooling efficiency and an increased pressure drop across the media.

Water-waste vs. System Performance

Evidently, we want to keep Calcium and Magnesium levels in the water to a level low enough to not compromise system efficiency. To do so, a conductivity sensor detects the content of Calcium and Magnesium in the tank, drains the recirculated water and brings in fresh water, Ultimately bringing the mineral levels down.

Clearly, there is a trade-off with system efficiency in the form of elevated water consumption. Keeping water consumption to lower levels can compromise system efficiency. With any trade-off situation, there exists an optimized solution that can meet both parameters.

Condair has the internal ability to analyze a comprehensive water quality test and optimize the ME cycle of concentration. This test measures parameters such as pH levels, temperature, hardness which allows Condair to estimate the rate of precipitation of scale build-up on the evaporative media pads.

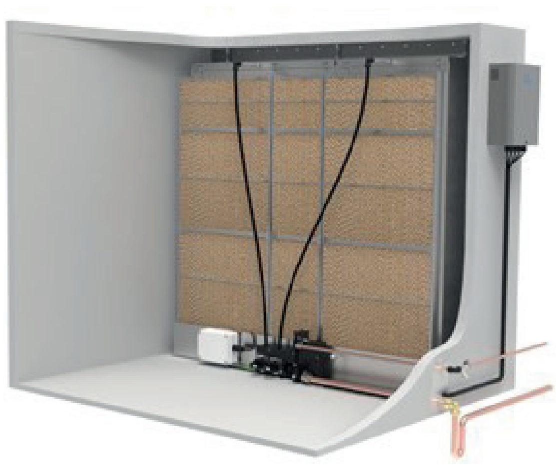


Figure 8: The Condair MC Series consists of an evaporative module and hydraulic unit, which sits inside the AHU, and a control panel located outside.

Precisely controlling humidity levels in data centers aids in preventing issues such as corrosion and oxidation of sensitive equipment.

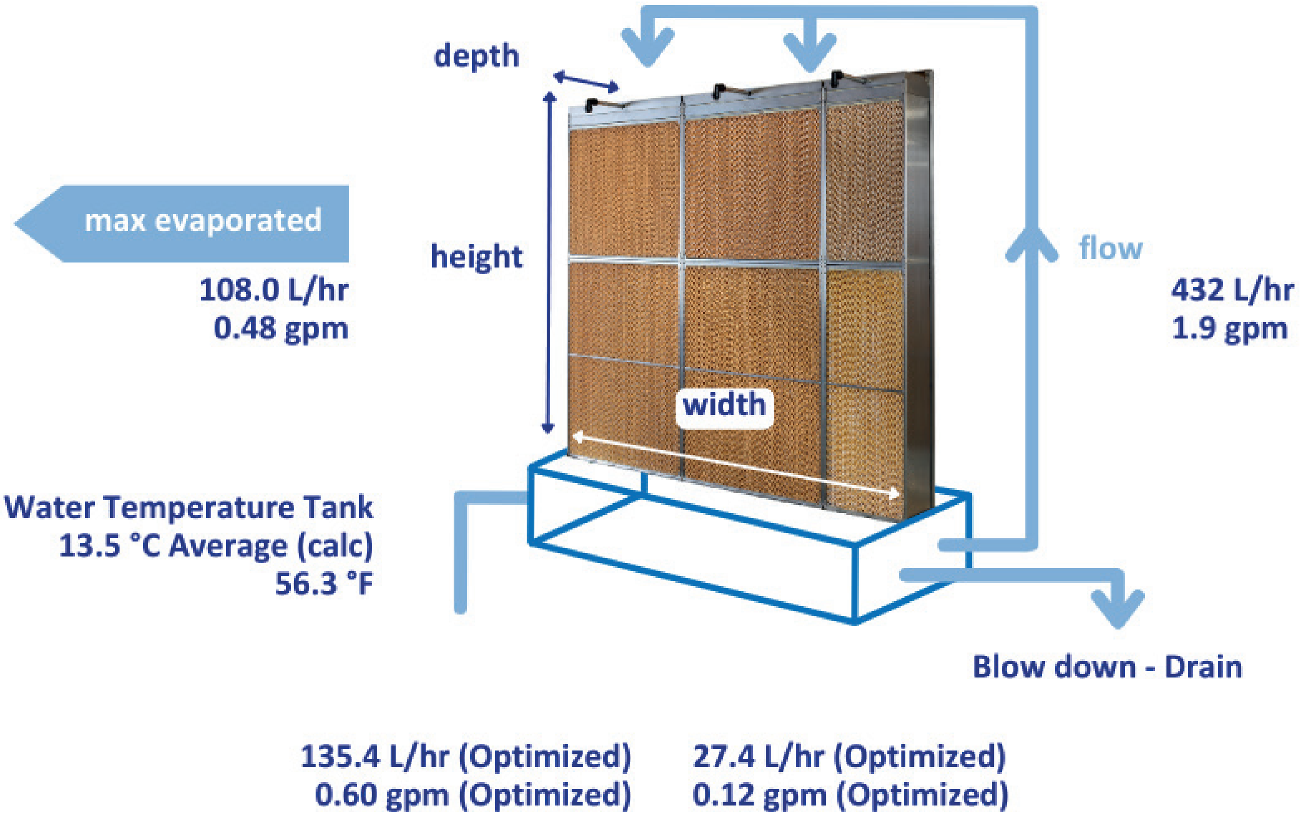


Figure 9: Demonstrates the movement of water through the MC Series humidification system.

Condair humidifiers for data centers help maintain optimal humidity levels, ensuring the reliable operation and performance of sensitive equipment.

Proper humidification can help extend the lifespan of electronic devices by reducing the effects of static electricity on their components.

Conclusion

Efficient cooling strategies are imperative in the data center industry to minimize energy consumption, enhance efficiency, and optimize cost savings. Among these strategies, evaporative cooling stands out as a highly effective solution. By harnessing the power of evaporation, data centers can achieve effective cooling while simultaneously reducing energy usage and associated expenses.

When considering the implementation of cooling strategies, it is crucial to assess the unique requirements and geographical considerations of each data center. This evaluation will enable the identification of the most suitable approach to achieve optimal results. At Condair, we provide flexible solutions tailored to meet your specific needs. Our offerings are designed to reduce your data center's Power Usage Effectiveness (PUE) and offer rapid scalability, all while maintaining a low total cost of ownership (TCO).

Benefits of working with Condair on your Data Center Project

- Extensive expertise around the world with many data center operators
- Vast product variety to provide the perfect solution for individual requirements.
- Low-energy, high-volume humidification to control both costs and air quality.
- Customer service excellence: expert advice, design, supply, installation, commissioning, maintenance, and spares supply from a single supplier.
- Ability to provide innovative proven solutions
- Maintain ASHRAE recommended conditions, combat ESD, provide low cost cooling and humidity control

Solutions for Data Centers

Condair has a comprehensive range of humidification and evaporative cooling products to suit any data center's environmental control system.

Condair offers specialized humidification systems designed specifically for data centers, addressing the unique humidity requirements of these facilities.

From an individual in-room steam humidifier to large in-duct evaporative systems, refurbishments of air handling units to newly constructed buildings or modular data centers, Condair has the technology and expertise to provide the ideal solution.

As the leading manufacturer of commercial/industrial humidification systems for more than 70 years, Condair has the technology and application expertise to meet the needs of any application.

Contact us today to ensure you have the best humidification and cooling solutions for your data center.

Trusted Technology

Condair humidifiers and evaporative coolers are used in Data Centers around the world to provide humidity control, prevent electrostatic discharge nad offer high capacity, low-cost evaporative cooling. Some of the world's largest brands put their trust in Condair humidification systems to help them fulfill their data centers' environmental control strategies.

Our Data Center Clients:

- Amazon
- Bell Canada
- Digital Realty
- eBay
- Facebook
- Goldman Sachs
- Microsoft
- Ministry of Defence

For existing data centers, ASHRAE recommends a humidity level of 41.9°F (5.5°C), dew point to 60% RH and an allowable range of 20-80% RH.

About Condair

Condair Group, founded in 1948 and based in Switzerland, is the global leader in humidification, dehumidification and evaporative cooling. Supported by science, we engineer individual, holistic solutions that customers can trust through the entire lifecycle. With optimal humidity, we increase productivity and create healthier built environments.

Condair Group has production sites in Europe, North America and China, its own sales and service organizations in 22 countries, and representatives in 50 locations worldwide. You can rely on our comprehensive portfolio of innovative technologies for air humidification, dehumidification and evaporative cooling for the entire lifecycle of each product.

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