



Free Cooling Concepts for Data Centers



Cooling costs can account for more than half of a data center's total annualized operating cost as energy costs and IT power consumption continue to rise.

As such, data center operators are pursuing various strategies to increase their data center cooling efficiency. One of these strategies is leveraging free cooling—an approach to lowering the air temperature in a building or data center by using naturally cool air or water instead of mechanical refrigeration.

The ambient outdoor air at many latitudes and elevations can be considerably cooler during certain seasons and times of day than the air that is warmed by data center equipment. By filtering and humidifying cooler outdoor air directly into the data center, it is possible to reduce or eliminate the use of mechanical cooling for the majority of operating hours especially in dry, cooler climates. Cooling systems that use this approach are typically called fresh air or air-side economizers.

Some data centers utilize the cooling tower to cool the condenser water to a low enough temperature when outdoor air conditions permit, to pre-cool the data center loop without using the chiller. Alternatively a source of cold water from local rivers, lakes or ocean sources can be circulated into a data center and used to achieve the same result. Systems using this approach are often called water-side economizers, which can either be used to cool room air or directly liquid cool IT equipment cabinets using rear-door heat exchangers or other systems.

In both cases, mechanical cooling would only be needed when the outdoor air temperature become too high for free cooling systems like air- or water-side economizers to be effective. Consequently, the working life of installed refrigeration systems can be significantly extended.

Reductions in cooling system use also mean drastic reductions in data center power consumption and service/repairs, lowering the energy and maintenance costs for facility owners. If local climatic conditions allow continuous use of air- or water-side economizers, mechanical cooling systems may be eliminated entirely. In actual practice, free cooling is not entirely free, because pumps, fans and other energy consuming air/water-handling equipment are needed, and that equipment also requires periodic repairs and maintenance.

AT A GLANCE

- Free cooling can offer impressive energy cost savings for data centers
- New recommendations for both thermal and dew point ranges mean free cooling can be used in more climates
- Several available methods of free cooling provide data center operators with the opportunity to select the option that best meets their specific system requirements.

Types of Free Cooling within a Data Center

There are two main free cooling options for a data center or server room, with the first one being an integral free cooling or economizer coil on computer room air handlers or DX air conditioners, or a centralized cooling tower and heat exchanger that works alongside the chiller. Integral economizer coils are ideal for sites with limited space and can offer high energy efficiency levels.

The second option is an independent free cooler using direct and/or in-direct evaporative cooling that has a higher efficiency of heat exchange rate. The independent free cooler is sized to maximize efficiency, enabling higher heat rejection capacity using larger coil face areas for the transfer of thermal energy. Independent free coolers have shown energy savings of up to 70 percent versus mechanical refrigeration. The cost savings associated with this method are due to the compressor's inactivity, since the fans and pumps are still operational.



Methods of Data Center Free Cooling

Assuming the data center system can leverage free cooling, there are several ways to employ the practice. For example, a popular social media company leverages hot aisle containment with FANWALL TECHNOLOGY® from Nortek Air Solutions equipment brands in its facility in the Pacific Northwest as part of its free cooling system. The efficiency of that free cooling system contributed to energy costs 52% lower than a comparable mechanical cooling system and to LEED® Gold certification for the facility.

Other free cooling methods include:

Strainer Cycle

The cooling tower water can be directly linked into the flow through the chilled water circuit. If the cooling tower is open, then a strainer is required to eliminate any debris that could accumulate within the tower. The cost savings are associated with the limited use of the water chiller energy. There is an increased risk of corrosion using this method.

Plate & Frame Heat Exchanger

A heat exchanger will transfer heat directly from the chilled water loop to the cooling tower loop. The exchanger keeps the cooling tower water separate from the coolant flowing through the cooling coils. The chiller water is thus pre-cooled.

Energy savings result from the reduced chiller loading, and thus a reduction in energy consumption occurs as well. There is a small increase in pumping cost due to the additional pump power needed to compensate for the pressure drop of the heat exchanger.

Refrigeration Migration

A valve arrangement within the water chiller opens a direct path between the condenser and the evaporator. The relatively warm fluid in the chiller loop vaporizes the refrigerant, and the energy is carried directly to the condenser where it is cooled and condensed by the water from the cooling tower.

This method is driven by the idea that the refrigerant tends to move toward the coldest point in a refrigeration circuit. The cost savings associated with this method are due to the compressor's inactivity, since the blower, fans and pumps are all operational.

Free Cooling through the Seasons

It is possible to manage highly energy efficient and reliable data centers, not just in cool, dry climates, but in all climates provided data center operators and users operate their IT equipment at the high-end of the thermal range and within the wider allowable dew point recommended in the guidelines published by the ASHRAE Technical Committee 9.9 on Mission Critical Facilities, Data Centers, Technology Spaces and Electronic Equipment.

Even in Singapore, a hybrid cooling solution using 25°C (77°F) supply air from air handling units and cold aisle containment and 16° to 20°C (60.8° to 68°F) chilled water to liquid-cooled racks will provide adequate cooling to maintain supply air inlet temperature within the ASHRAE recommended range, while reducing chiller capacity and fan energy required for traditional direct air cooling of IT equipment cabinets.



YEAR-ROUND SAVINGS

Tips to help manage free cooling in data centers through the seasons:

High Ambient Operation

When the process return water temperature required is equal to or higher than the ambient air temperature, free cooling is not suitable. The system's controls will continue to direct the fluid flow through the chiller's compressors to be cooled to the required set point temperature.

Mid-Season Operation

For midseason operation the water is partially cooled by the compressor and partially by the ambient outdoor air. The percentage of free cooling achieved mid-season is dependent on seasonal temperatures, although partial free cooling commences when the ambient air temperature is 1°C (33.8°F) below the process return water temperature. The water is partially cooled through the free cooler, and then flows through the chiller's compressors to achieve the required set point temperature.

Winter Operation

In winter, when outdoor temperatures are low enough, the water is cooled solely by the free cooling coil. This allows the chiller compressors to stop operating, saving significant amounts of energy. The only electrical power used in winter operation is for fan and pump operation. This can be achieved once the ambient air temperature is 3° to 5°C below the process supply water.

Limitations

Freezing can be difficult to avoid once the cooling tower water temperature gets below 3.9 °C (39°F). Another limitation is the temperature difference across the heat exchanger. A heat exchanger that has a very low temperature difference can become economically unfeasible. The economics of the heat exchanger allow for a minimum free cooling water temperature of approximately 5°C (41°F).

For more information about free cooling solutions, Nortek Air Solutions or about the Data Center Products team, contact datacenterinfo@nortek.com or visit www.datacenters.nortekair.com.

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