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Data center water use in Colorado

According to the U.S. Drought Monitor, about 37 percent of the contiguous United States was in at least a moderate drought as of April 7. The extended drought in many areas has led companies to examine the impact of water use in their data center cooling strategies. As cooling strategies are evaluated, it is important to remember that a reduction in water use at an individual facility does not always result in an aggregate reduction in water use for the regional water supply system. There are many factors that impact the actual water usage consumed by the facility, and understanding those components is important before making any decisions.

One of the many perks of Colorado is its dry climate, which reaps the benefits of evaporative cooling and condensing that reduces the energy use of mechanical cooling systems. In Colorado, using water-cooled condensing systems versus air-cooled condensing systems can reduce cooling energy costs by 40 to 50 percent. However, this energy reduction comes with an increase in on-site water use from evaporation. During the winter months, this evaporation can be seen as steam plumes billowing from the cooling towers that sit atop many buildings. So is this evaporation a waste of water? Instead of using water-cooled equipment, should you consider air-cooled equipment? This article will address some considerations that need to be evaluated to answer these questions by examining the water and energy use of an example data center.

The first consideration is to look at the regional power grid and determine how much water the power companies use to produce a kilowatt-hour of power. Water consumed at Colorado area power plants is on average 1.2 gallons per kWh, based on data from National Renewable Energy Laboratory's technical paper TP550/33905. For this analysis, we have taken into account that Colorado's regional power supply consists of 17 percent renewable energy that does not use evaporative water in the process of producing power. (This is according to the Colorado power generation use from renewable energy from the U.S. Energy Information Administration data updated August 2014.)

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For the purposes of this article, we will examine the cooling for a data center located in the Denver area that has a steady 1,500 kW cooling load. A comparison is made between a standard efficiency water-cooled chiller system and a standard efficiency air-cooled chiller system, as well as an evaporative system with no mechanical cooling. The water-cooled plant includes a chiller system, pumps, cooling tower and plate/frame heat exchanger in series with the chiller. The air-cooled chiller includes the chiller system and pumps. The air delivery systems for options were not considered in our analysis because they are similar in both cases.

The water-cooled chiller has an average annual energy consumption of 0.525 kW per ton, and similarly the air-cooled chiller annual energy consumption is 1.12 kW per ton. The calculated average value for on-site water consumption by the water-cooled chiller is 0.63 gallons per kWh. This is a weighted average from full mechanical cooling through partial-free cooling to full water economizer.

In comparison, the water-cooled chiller system consumes 1.96 million kWh of energy annually, and the air-cooled chiller system consumes 4.19 million kWh of energy. The water-cooled chiller consumes 3.19 million gallons of water annually, which is a combination of on-site water use and usage by the regional power grid to produce the power. The air-cooled chiller system consumes 4.17 million gallons of water annually, which is all used by the regional power grid. In this example, on-site evaporative cooling results in nearly 1 million gallons less water being consumed from the regional water supply system or a 31 percent reduction over an air-cooled solution.

Now that we have looked at data centers with partial mechanical cooling, let's address some of the data centers that are cooled only by evaporative cooling. These energy-efficient facilities only use 472,202 gallons of water per year. Similar to the two chiller options, the air delivery system's energy was not included in our analysis, only the spray pump and evaporative cooling portion of the fan energy was considered; however, there are other operational considerations that users should be aware of before using full evaporative cooling.

How are data centers able to operate using no mechanical cooling? The new server equipment technologies allow substantially higher inlet temperatures. Server equipment inlet temperatures were allowed to rise from 55 degrees to the mid- to upper-70 degrees. This temperature rise allowed data centers to start using free cooling strategies that include direct and indirect evaporative cooling. Lowering energy costs has been one driver for data centers to move in this direction. This analysis shows that substantial water savings will be another driver to change the operating conditions within the server room environment.

There are many combinations of evaporative and mechanical cooling solutions that can be evaluated to meet your specific goals. As the discussion of water is added to the list of design considerations, it is important to look at the ecosystem of power and water and how they are linked to ensure you are making the best decisions for meeting your energy and water conservation goals.