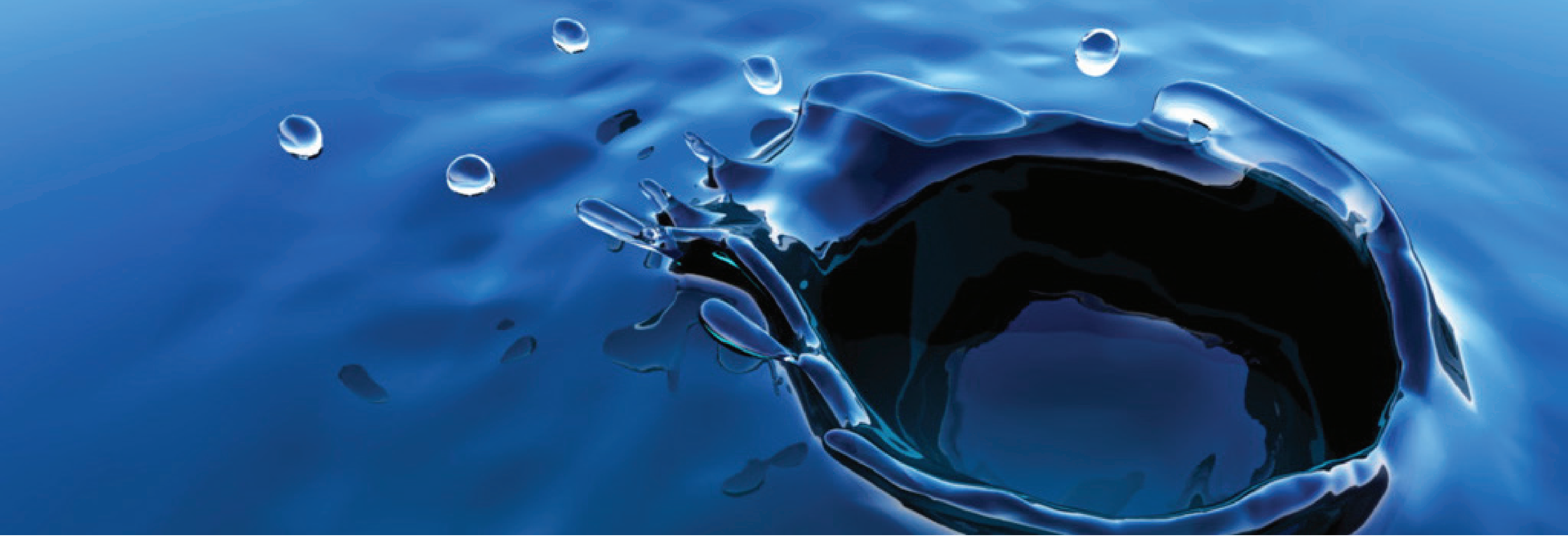

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# Data Center Water Usage for Denver, Phoenix and Los Angeles: A Look at the Big Picture

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According to the United States Drought Monitor, about 37% of the contiguous United States was in at least a moderate drought as of April 7, 2015. The extended drought in many areas of the United States has led a number of companies to examine the impact of water usage 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 data center, and understanding those components are important before making any decisions.

When evaluating air versus water cooled condensing systems in a data center we know that water is a more efficient medium than air for removing heat from cooling processes as evaporation enhances the cooling process. Using water cooled condensing systems versus air cooled condensing systems can significantly reduce your cooling energy costs; however the effectiveness of evaporative cooling is very location dependent since the dryer climate results in greater efficiency.

One question that is currently a large topic of discussion is if energy reduction comes with an increase in onsite water usage due to evaporation. Evaporation is evident during colder months when steam plumes billow from the cooling towers that sit on top of 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 of the considerations that need to be evaluated to answer these questions. Water and energy use will be evaluated for a sample data center located in Denver, Colorado; Phoenix, Arizona and Los Angeles, California.

We first examined the regional power grid and determined how much water the power companies consume to produce a kilowatt-hour (kWh) of power. Based on data from National Renewable Energy Laboratory's (NREL) technical paper TP550/33905, water consumed at Colorado area power plants is on average 1.2 gallons/kWh, in Arizona this value is 7.88 gallons/kWh and for California at 4.64 gallons/kWh. 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. Similarly, Arizona uses 7.8% renewable energy and California generates 13.5% of its energy by renewables and 9.6% by large hydroelectric facilities. (This is according to the U.S. Energy Information Administration data updated August 2014.)

For the purposes of this article, we examined the cooling for a data center, located in each city, which 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 all options were not considered in our analysis because they are similar in each case.

Refer to the following table for the full load power consumption of the air and water cooled chillers.

**Table 1. Full Load Chiller Consumption**

| Chiller Type | Denver (kW/Ton) | Phoenix (kW/Ton) | Los Angeles (kW/Ton) |
|---|---|---|---|
| Air Cooled | 1.250 | 1.340 | 1.250 |
| Water Cooled | 0.431 | 0.462 | 0.426 |

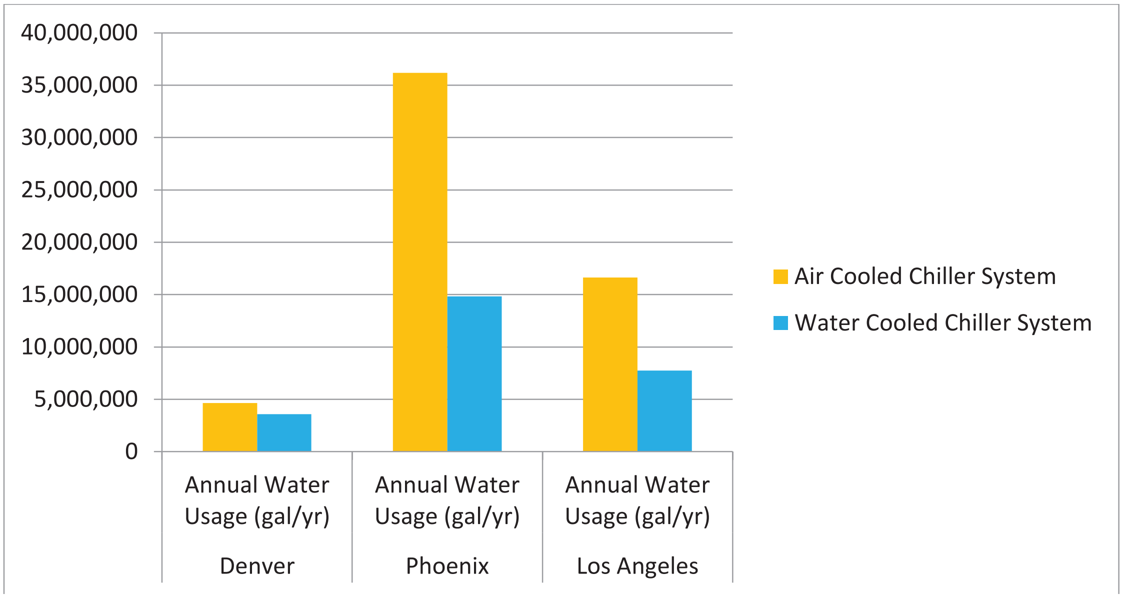
We calculated water use based on Typical Meteorological Year (TMY3) data obtained from the National Solar Radiation Data Base (NSRDB). This analysis of water use assumed full mechanical cooling through partial free cooling to full water economizer.

The findings are as follows. The water cooled chiller system consumes 1,963,773 kWh of energy annually, and the air cooled chiller system consumes 4,189,382 kWh of energy. The following table shows the energy and water usage for the mechanical chiller systems analyzed in each city. There are significant differences in water use because of the amount of water consumed at the power generation facilities is far greater than water consumed on site. Because the air cooled chiller system uses no on site evaporation and consumes more power, all of its water use is at the rate of power plant water consumption. Whereas, the water cooled chiller has lower power consumption and a combination of onsite and power plant water consumption.

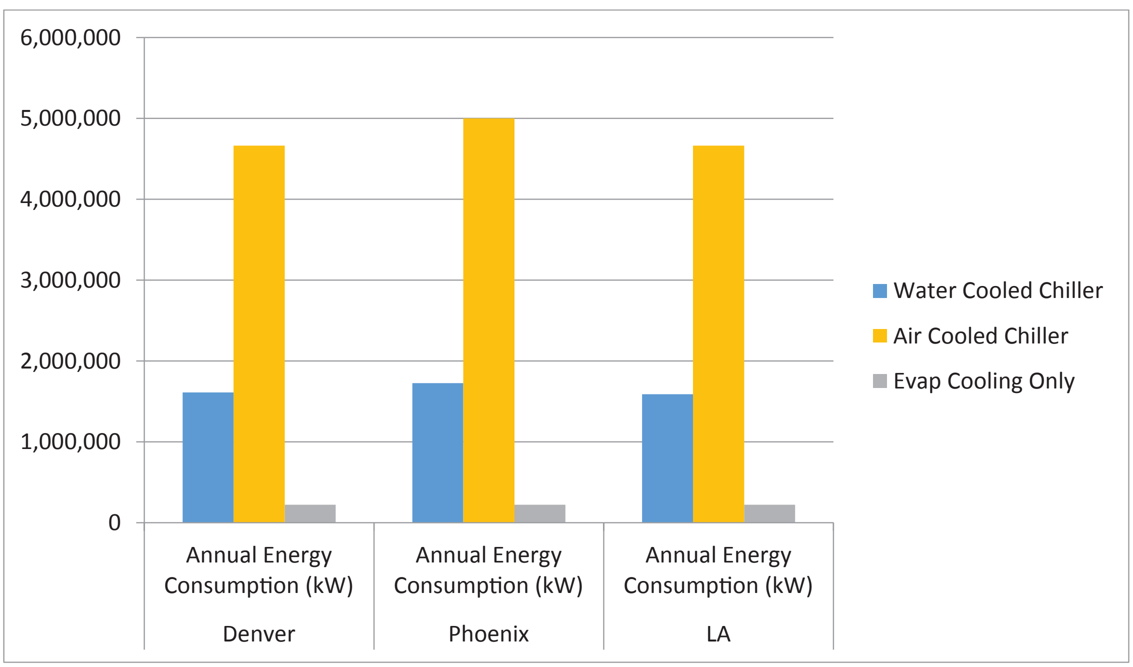
We also considered data centers that are cooled only by evaporative cooling. These energy efficient facilities use a fraction of water per year compared to refrigeration based (mechanical) cooling systems like those described above. Similar to the two chiller options, the air delivery systems energy 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.

The following charts show the comparisons both water usage and energy consumption.

### Table 2. Mechanical Cooling Water Usage




### Table 3. Annual Energy Consumption




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 have been allowed to rise from 55 degrees to the mid to upper 70s and beyond. This temperature rise has allowed data centers to start using free cooling strategies that include direct and indirect evaporative cooling and no longer have a requirement for any mechanical 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 understand and evaluate the relationship between utility power and water consumption to ensure you are making the best decisions for meeting your energy and water conservation goals.

## Additional Data

The following chart shows the actual numbers portrayed in Tables 2 and 3.

| Sample 1,500 kW Data Center | | | |
|---|---|---|---|
| | Denver | Phoenix | LA |
| | Annual Energy Consumption (kW) | Annual Energy Consumption (kW) | Annual Energy Consumption (kW) |
| Water Cooled Chiller | 1,610,748 | 1,726,603 | 1,592,062 |
| Air Cooled Chiller | 4,663,470 | 4,999,089 | 4,663,470 |
| Evap Cooling Only | 224,431 | 224,234 | 224,234 |
| | | | |
| | | | |
| | | | |
| System | Denver | Phoenix | Los Angeles |
| | Annual Water Usage (gal/yr) | Annual Water Usage (gal/yr) | Annual Water Usage (gal/yr) |
| Water Cooled Chiller System | 3,593,000 | 14,844,000 | 7,732,000 |
| Air Cooled Chiller System | 4,645,000 | 36,182,000 | 16,640,000 |
| | | | |
| Difference | 1,052,000 | 21,338,000 | 8,908,000 |
| % Water Use Reduction | 22.60% | 59.00% | 53.50% |