

# Reducing Water Costs in Building HVAC Systems

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By Dan Weimar and Allan Browning

**T**he HVAC system is the largest user of energy and water in a typical commercial building. In the past, energy costs overshadowed water costs. However, recent droughts and the need to expand municipal water supplies to support growth have led to increased water costs nationwide. Combined with the focus on water conservation in green building, the payback associated with reducing building water usage is greater than ever.

Most commercial buildings use water cooled chillers to provide air conditioning because they are much more energy efficient than air cooled chillers. However, achieving these efficiencies requires large quantities of water to operate a cooling tower. Most buildings also use re-circulating hot and chilled water loops to distribute heating and cooling throughout the building. Although not designed to routinely use water, these systems can use large amounts of water if undetected leaks occur. As the major consumer of water, the building HVAC system is an obvious target for water conservation efforts and often provides significant savings.

## Water Meters

Water meters are a valuable tool for troubleshooting operational problems in cooling towers and closed loops systems and benchmarking water efficiency improvement projects. It is recommended that water meters be installed on the makeup water and blowdown line of cooling tower systems and on the makeup water line to the closed heating and cooling loops. The LEED(r)-EB: Operations & Maintenance Rating System(tm) awards one point under Water Efficiency Credit 4.1 for continuously metering and data logging cooling tower makeup water usage.

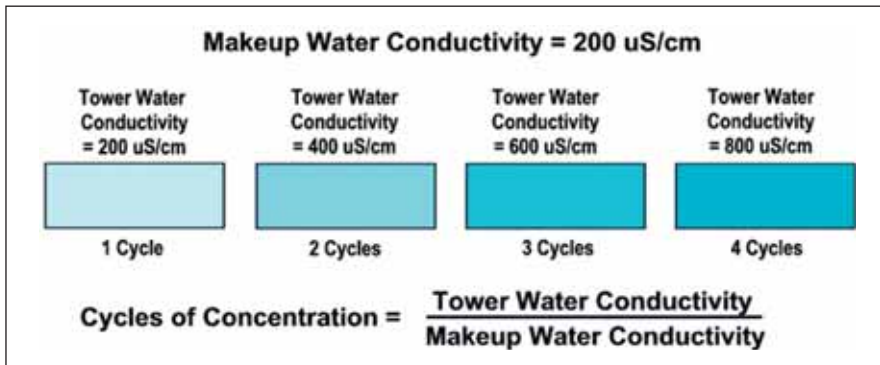
## Water Savings in Cooling Tower Systems

Cooling towers are mechanical devices that reject heat by evaporative cooling. Approximately 0.1 percent of the water circulated through a cooling tower is lost to evaporation for each degree (°F) the water is cooled. As a point of reference, a 400-ton water cooled chiller operating at a 30 percent load year-round requires almost

| WATER USE IN A TYPICAL COMMERCIAL BUILDING <sup>1</sup> |     |
|---|-----|
| Cooling & Heating                                       | 48% |
| Domestic/Restrooms                                      | 31% |
| Landscaping   | 18% |
| Other   | 3%  |



Cooling Towers on Building Roof



1.9 million gallons of makeup water just to replace evaporation losses.

Because dissolved minerals in the evaporated water are left behind to concentrate in the remaining water, a portion of the tower water must be routinely discharged as bleed. Without bleed, the dissolved mineral concentration in the tower water will eventually reach a point where deposits form on waterside surfaces, including chiller condenser tubes. A key objective of a cooling tower treatment program is preventing these deposits while minimizing bleed.

Cycles of concentration is an important concept in cooling tower treatment. Cycles of concentration reflect the degree to which dissolved impurities in the makeup water are concentrated in the re-circulating water of an evaporative cooling system and are inferred by dividing the conductivity of the tower water by the conductivity of the makeup water. The higher this ratio, the more the impurities in the makeup water are being concentrated in the system water and the lower the cooling tower bleed rate.

To minimize water use, maintaining maximum cycles of concentration is important. Optimum cycles for a particular cooling tower are largely a function of makeup water quality, operating conditions, and chemical inhibitor selection. By evaluating these factors, your water treatment consultant can recommend the cycles to maintain to prevent waterside problems and minimize water usage.

### Evaporation Credits

For facilities connected to a sanitary sewer, water cost is divided into two parts:

water purchase and sewage surcharge. Most municipalities assume all water entering a facility leaves through the sanitary sewer and therefore apply the water purchase and sewage surcharge costs to the entire water bill. However, in facilities with cooling towers, a large portion of incoming water leaves by evaporation, not the sanitary sewer.

Often, the local water authority provides facilities with cooling towers a credit (called an evaporation credit or sewage surcharge rebate) on the evaporated water. Requirements vary for documenting the amount of evaporation, but typically the facility is required to install an approved water meter on cooling tower makeup and bleed water lines. Assuming there are no leaks in the system, the difference between the makeup water meter and bleed water meter readings is the amount of water evaporated from the cooling tower in a given time period. Savings associated with obtaining an evaporation credit depends on the average cooling load and sewage surcharge and can be considerable.

### Eliminate Leaking Makeup and Bleed Valves

Not all chiller systems run 24 hours/day, seven days/week. If a cooling system shuts down during the night or weekend, the tower overflow line should be observed for signs of overflow. Float valves are notorious for leaking when the cooling tower is shut down. Since these valves throttle the water flow based on demand, the seats are easily cut, leaks occur, and the valve will not properly shut off. The float or control valve could also be out of adjustment allowing water to overflow through the drain. Water meter readings will help detect this problem. Bleed valves can also not seat properly and allow tower bleed excessively to the drain. This wastes water, but can also throw the chemistry out of balance and lead to deposits and poor microbiological control. Water meter readings will help detect this type problem.

### Use a Blend of Soft Water for Cooling Tower Makeup

In some areas, high hardness level in the water necessitates a high cooling tower bleed rate to prevent scale deposits. In these areas building water usage may be reduced by blending soft water with untreated water for the cooling tower makeup water. In certain situations, softening the makeup water can allow the cooling tower to be operated at a greatly reduced bleed rate. However, this is not viable or economical in all areas. Blending soft water in the tower makeup usually requires new softeners and routine salt purchases. Also, some municipalities are limiting salt discharge to the sanitary sewer to lower salt content of wastewater treatment plants. Your water treatment consultant can help evaluate payback on water and chemical savings.

| <b>COOLING TOWER EVAPORATION CREDIT*</b> |                        |                                     |
|--|------------------------|-------------------------------------|
| Cooling Load (Tons)                      | Evaporation Rate (GPD) | Annual Evaporation Credit (\$/Year) |
| 50                                       | 2,160                  | \$1,971                             |
| 500                                      | 21,600                 | \$19,710                            |
| 1,000                                    | 43,200                 | \$39,420                            |
| 2,500                                    | 108,000                | \$98,550                            |

\*Based on sewage surcharge of \$2.50/1,000 gallons water

| Cycle of Concentration | <b>ANNUAL WATER SAVINGS BY REDUCING COOLING TOWER BLEED</b> |                   |                      |                          |                         |
|------------------------|---|-------------------|----------------------|--------------------------|-------------------------|
|                        | Annual Water Usage & Cost                                   |                   |                      | Savings Versus 3 Cycles  |                         |
|                        | Bleed (Gal/Year)  | Makeup (Gal/Year) | Water Cost (\$/Year) | Water Savings (Gal/Year) | Water Savings (\$/Year) |
| 3                      | 2,365,200   | 7,095,600         | \$23,652             | 0                        | \$0                     |
| 4                      | 1,576,800   | 6,307,200         | \$7,884              | 788,400                  | \$15,768                |
| 5                      | 1,182,600   | 5,913,000         | \$5,913              | 1,182,600                | \$17,739                |
| 6                      | 946,080   | 5,676,480         | \$4,730              | 1,419,120                | \$18,922                |
| 8                      | 675,771   | 5,406,171         | \$3,379              | 1,689,429                | \$20,273                |
| 10                     | 525,600   | 5,256,000         | \$2,628              | 1,839,600                | \$21,024                |

Based on 300-ton cooling load, 24 hr/day, 365 days/year, water purchase price of \$2.50/1,000 gallons, and sewage surcharge of \$2.50/1,000 gallons.

## WATER COST SAVING OPPORTUNITIES IN BUILDING HVAC SYSTEMS

- Meter cooling tower and closed system water usage
- Reduce cooling tower bleed rate
- Obtain credit on cooling tower evaporation
- Eliminate leaking makeup and bleed valves
- Use a blend of soft water for cooling tower makeup
- Use air handler condensate for cooling tower makeup
- Use reclaim or gray water for tower makeup
- Use rain water for tower makeup
- Identify and correct closed system leaks

1. Check all circulating pumps for leaks around the seals or packing. Replace and/or tighten if necessary.
2. Check the expansion tank to ensure it is not full of water. If the expansion tank does not have sufficient air space for expansion when the system water heats up, the relief valve will lift to relieve the excess pressure. If the tank is full of water, manually drain so it is only about 1/3 full when the system is cold.
3. Check all pressure relief valves. Closed systems can intermittently relieve excess system pressure due to temperature changes and an improperly functioning pressure regulator (located on makeup line). If the regulator fails, the system pressure can slowly increase to the point where the pressure relief valve momentarily opens. Water will then be expelled until the pressure returns to normal.
4. Check all automatic air vents to see if they are leaking water. Pay particular attention to vents that are piped directly into a drain. Replace all air vents that are leaking water.
5. Check the back flow preventer. Be sure the makeup line has a properly installed and functioning back flow preventer. This is especially true if the system pressure is greater than the makeup water line pressure. Without proper back flow preventers, system water can be lost into the makeup water line. Swing type check valves are unacceptable since they will not function properly under a vacuum - as water rushes from the closed system (higher pressure) to the makeup line (lower pressure), a vacuum can occur.
6. A common cause of system pressure being greater than makeup line pressure is when someone shuts off the main water supply. All new buildings have back flow preventers on the main potable water supply line. Each closed system should have its own back flow preventers.
7. Where fan coil units are used with a chilled water system, check the water chemistry or color of the condensate (if a colored inhibitor is used). If a fan coil unit is leaking, you will detect the presence of treatment chemicals and/or hardness in the drain pan water. Otherwise, the drain pan water should be more or less distilled water (less than 25 uS/cm conductivity).  
A building HVAC system can be a major consumer of water. But with the right planning, facilities professional can ensure greater water conservation and reduced water costs. **FEJ**

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### References:

- 1) California Urban Water Conservation Council (2001), BMP 9 Handbook: A guide to implementing commercial, industrial, institutional conservation programs, June 2001.

### Use Air Handler Condensate as Tower Makeup

In hot and humid areas, large quantities of condensate are produced from air handlers or fan coil units that can be used as cooling tower makeup water. Using air handler condensate this way offers several advantages: it is cool (50o F), very pure, and would normally go to the drain. Adding this nearly pure water to the cooling tower reduces the amount of city water required for makeup and reduces the amount of bleed water. For example, a 164,000 square foot office building in Texas was able to use air handler condensate for 17 percent of their cooling tower makeup requirements.

### Use Reclaim or Gray Water for Tower Makeup

Many municipalities and industrial plants are providing reclaim or reuse water for non-potable uses, like makeup water to cooling tower systems and landscape irrigation. This is treated water that comes from a waste treatment plant. All piping associated with reclaim or reuse water is designated by a purple or lavender color. This water is an excellent source of non-potable water and significantly reduces demand for fresh water. Cycles of concentration may have to be reduced in cooling tower systems to accommodate higher solids and contaminant levels found in this water. Additional biocides may also be required to properly treat systems using this type water.

Side stream filtration on cooling towers, especially when using reclaim water,

can improve overall performance of the water treatment program. There can also be a reduction of inhibitors, biocides, and frequency of tower washouts reducing preventative maintenance costs.

### Use Rain Water for Tower Makeup

Rain water collection is an alternative source of water for cooling towers. Collection systems can be simple above or underground tanks. A 30 foot by 30 foot roof area can collect 558 gallons of water for every one inch of rain. A facility can collect thousands of gallons of water annually at an economical cost compared to purchasing city water. As with reclaim water, additional biocides may be required.

### Water Savings in Closed Systems

Closed heating and cooling water systems typically require little makeup water following initial system charge. However, when leaks occur, it can be costly and difficult to maintain treatment levels necessary for good corrosion and deposit control. The source(s) of significant water losses should be identified and eliminated.

In a treated closed system, routine testing of water chemistry can be used to determine if there has been significant water loss. If the treatment parameters decrease simultaneously, water has been lost. If water loss is significant, a 3/4" water meter installed on the makeup water line can help quantify the rate of water loss. However, leaks less than one gpm may not register on the water meter.

The following checklist may help identify why a closed system is losing water: