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AWT: SALT-BASED & CHEMICAL INHIBITION

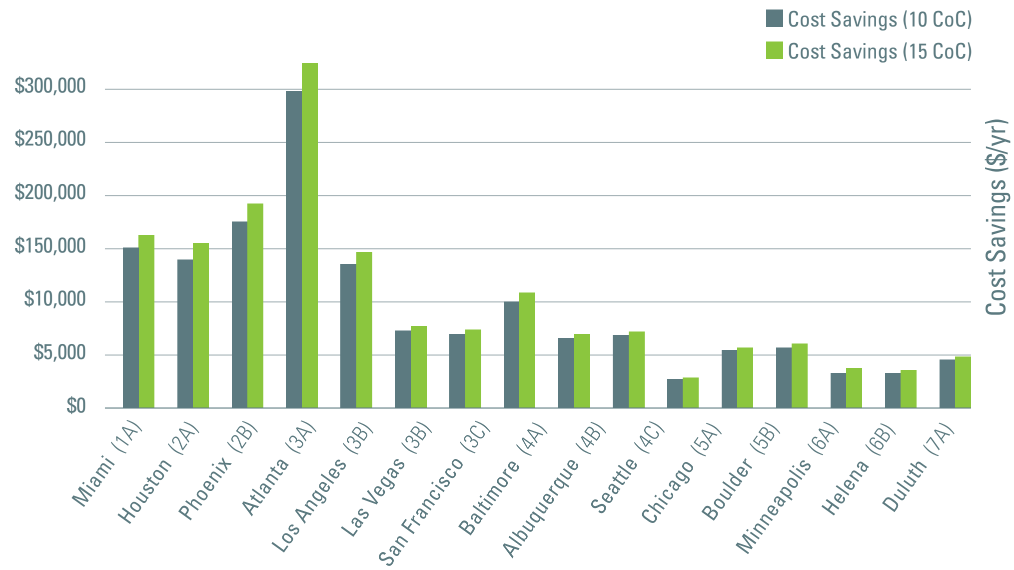
Two Off-the-Shelf AWT Technologies that Maintain Water Quality and Reduce Water Use

Typically, GSA treats the water in its chilled water plants conventionally, with chemicals. It contracts with third-party providers to deliver this specialized service for a fixed fee. Chemical treatment limits scaling and corrosion and mitigates biological growth but it also creates significant amounts of waste water and increases disposal and sewage charges. In fact, the use of conventional chemicals also requires that between a third and a half of a chiller's condenser water be drained on a regular basis (a process called "blowdown") and replaced with fresh water, aka "make-up water" to maintain adequate water quality. The application of alternative water treatments (AWT) in place of traditional chemical water treatment has the potential to reduce make-up water and sewer costs, decrease chemical use, and increase chiller efficiency. Toward this end, researchers from the National Renewable Energy Laboratory (NREL) worked with GSA's Proving Ground to assess the effectiveness of three off-the-shelf AWT technologies at the Denver Federal Center (DFC). Two of the three systems (a salt-based ion exchange system and a chemical scale-inhibition technique) maintained adequate water quality, reduced blowdown, and curtailed water use by about 25%. The third system, a hydrodynamic chemical-free process, experienced uncontrolled biological growth and was decommissioned before water use could be measured. Both the salt-based and chemical scale inhibition systems had less than a three-year payback at the GSA average water/sewage cost of $16.76/kgal. With GSA water rates having increased 41% between 2014 and 2017, alternative water treatment technologies present an attractive investment opportunity and should be considered for cooling-tower retrofits throughout GSA's portfolio.

INTRODUCTION

Modeled Cost Savings per Cycles of Concentration (CoC)

Most water savings are achieved by a CoC of 10; 84% of the savings achieved at 30 CoC were captured at 10 CoC



"Buy-in for the new systems increased significantly once our O&M teams were properly trained."

— Tyler Cooper
Supervisory Energy Project Manager
GSA Rocky Mountain Region (R-8)
Denver, Colorado

What Is This Technology?

AWT TECHNOLOGIES DIFFER IN HOW THEY TREAT WATER

Chilled water plants use cooling towers to reject heat into the atmosphere through evaporation. Because the evaporative process results in significant water loss, cooling towers require a constant supply of "make-up" water, which must be treated to limit scale, corrosion, and biological growth. Compared with traditional chemical-based solutions, which use corrosion and scale inhibitors, algaecides, and biocides, most alternative water treatment (AWT) technologies forgo chemicals for the most part, though they differ significantly in how they treat the cooling tower water. The salt-based AWT system uses a proprietary salt-based softening system that removes hardness from make-up water without having to add additional chemicals. The chemical scale-inhibition system takes a more conventional approach to water purification. This system adds chemicals to regulate water quality; however, its chemicals differ from traditional chemicals in such a way that they enable increased Cycles of Concentration (CoC), the ratio of solids in the recirculating water to solids in the make-up water. The hydrodynamic cavitation process provides chemical-free water treatment, using two side-stream water loops.

What We Did

REPLACED TRADITIONAL CHEMICAL TREATMENT IN THREE BUILDINGS AT THE DENVER FEDERAL CENTER

AWT technologies were installed in three buildings at the DFC. A salt-based system was installed in Building 25—a multi-use facility of laboratories, data centers, and office space. A chemical scale inhibition system was installed at Building 67—a 14-story high-rise. A hydrodynamic chemical-free system was installed at Building 95, which houses offices and laboratories. Traditional chemical water treatment was used in all three buildings prior to the AWT installations.

FINDINGS

WATER SAVINGS OF 23% FOR SALT-BASED SYSTEM, 24% FOR CHEMICAL SCALE INHIBITION The salt-based system in Building 25 saw a 99% reduction in blowdown and a decrease in water use from 2.59 gal/ton-hr to 2.01 gal/ton-hr. The chemical scale inhibition system in Building 67 reduced blowdown 94% and water use from 1.76 gal/ton-hr to 1.34 gal/ton-hr. Building 95's hydrodynamic chemical-free system was not performing adequately and was decommissioned before it was evaluated. Note that there is a limit to how much water can be saved. Some evaporative water use provides cooling to the condenser loop and cannot be eliminated; the lower limit for water use is between 1.1 and 1.32 gal/ton-hr.

IMPROVED CHILLER OPERATIONS NREL's economic assessment did not take into account potential energy savings from increased chiller efficiency due to cleaner condenser tubes and increased heat exchanger effectiveness. However, both Building 25 and Building 67 saw improved chiller performance after the AWT systems were installed—building engineers reported that they were able to run the flat-plate chillers more frequently, and in Building 67 they were able to meet comfort requirements with only one of the two chillers running most of the summer.

INSTALLATION VARIED The salt-based system for Building 25's three 500-ton cooling towers required 8 ft^2 of floor space for two brine tanks. The chemical scale inhibition system for Building 67's two 600-ton cooling towers required 8 ft^2 of floor space for three 5-gallon containers and a double-walled mixing basin and sand filter. The chemical system also required additional plumbing, with dedicated supply and return lines for a side-stream filtration system.

O&M REDUCED FOR SALT-BASED SYSTEM, INCREASED FOR CHEMICAL SCALE INHIBITION SYSTEM The salt-based system in Building 25 reduced annual maintenance 47% from 152 hours to 80 hours. It also reduced ongoing material costs by $2,768 a year, by eliminating almost all chemicals and using a less expensive salt regeneration process. The chemical scale inhibition system used in Building 67 also reduced maintenance labor significantly, by 48% from 132 to 69 hours but it increased ongoing material costs by $5,100 a year from $8,400 to $13,500, due to higher quality chemicals. The side-stream filtration system used in Building 95 was plagued by algae growth that led to an increase in maintenance before the system was decommissioned.

INCREASED CYCLES OF CONCENTRATION CoC compares the concentration of solids in blowdown water to the concentration of solids in the original raw make-up water. Higher CoCs indicate greater water efficiency. Typical CoC for GSA facilities range between 3 and 6. The CoC for the salt-based system ranged between 30 and 75. The CoC for the chemical scale inhibition system ranged between 13 and 18.

WATER CHEMISTRY DEVIATED FROM GSA STANDARDS Water quality for the salt-based system fell outside GSAs designated ranges for conductivity (from 300% to 800%), pH (up to 13%) and "M" alkalinity (from 68% to 300%). Water treated by the chemical-scale inhibition system in Building 67 also fell outside the desired range for conductivity (from 5% to 290%). However, falling outside the specified ranges is not necessarily an issue of concern. These ranges were defined for traditional chemical treatment systems and might not be applicable to AWT systems.

LIFE-CYCLE COST-EFFECTIVE AT AVERAGE GSA WATER/SEWER COSTS For the salt-based system, payback was 3.2 years and the Savings-to-Investment Ratio (SIR) was 4.7 at the Denver water/sewer cost of $7.14/kgal, At the 2017 GSA average water/sewer cost of $16.76/kgal, the projected retrofit payback would be 2.2 years with an SIR of 6.7. For the chemical scale inhibition system, payback was 8.1 years, and SIR was 1.8, based on the Denver water/sewer cost. At the 2017 GSA average water/sewer cost, the retrofit payback would be 2.7 years with an SIR of 5.5.

CONSIDER AWT FOR ALL COOLING TOWERS Both salt-based and chemical-scale inhibition systems can be retrofitted to any cooling tower.

CONCLUSIONS

These Findings are based on the reports, "Alternative Water Treatment Technologies for Cooling Tower Applications" which is available from the GPG program website, www.gsa.gov/gpg

For more information, contact GSA's GPG program gpg@gsa.gov

Technology for test-bed measurement and verification provided by Water Conservation Technology International, Terlyn Industries and EcoWater Systems.

What We Concluded

TRAINING OF LOCAL O&M STAFF IS CRITICAL

With rapidly rising water rates, technologies that save water are an attractive investment opportunity. The main challenge for widespread GSA deployment of AWT systems is separating those that work from those that don't and ensuring their proper installation and operation. Cooling tower water treatment is a specialized niche in the building maintenance industry. To perform it properly, technicians must be knowledgeable about several subject areas: heating, ventilating, and air conditioning; water chemistry; and organic growth. For successful portfolio-wide implementation of AWT, local O&M teams must receive training in the new systems and contracts must contain language that incentivizes their use.

After the successful evaluation of the salt-based and chemical-scale inhibition AWT systems, Region 8 deployed five additional salt-based systems and seven additional chemical-scale inhibition systems. In 2018, regional staff learned that two of each of these systems had been removed because the O&M contractors preferred the traditional chemical systems they were more familiar with.

Best Practices

- Install only AWT systems that have been validated by GSA's Proving Ground and have adequate sales and manufacturer support.
- Design AWT systems for the specific facilities in which they will be installed.
- Integrate AWT systems with building management systems or programmable logic controllers to allow for remote monitoring and operation.
- For AWT systems that do not include side-stream filtration, install an add-on side-stream filtration system. This can be particularly important for open cooling towers, which are prone to collect dirt and debris.
- Anticipate changes needed to O&M contracts to transition from traditional chemical treatment to AWT systems.
- Train local maintenance teams on the installed AWT systems.