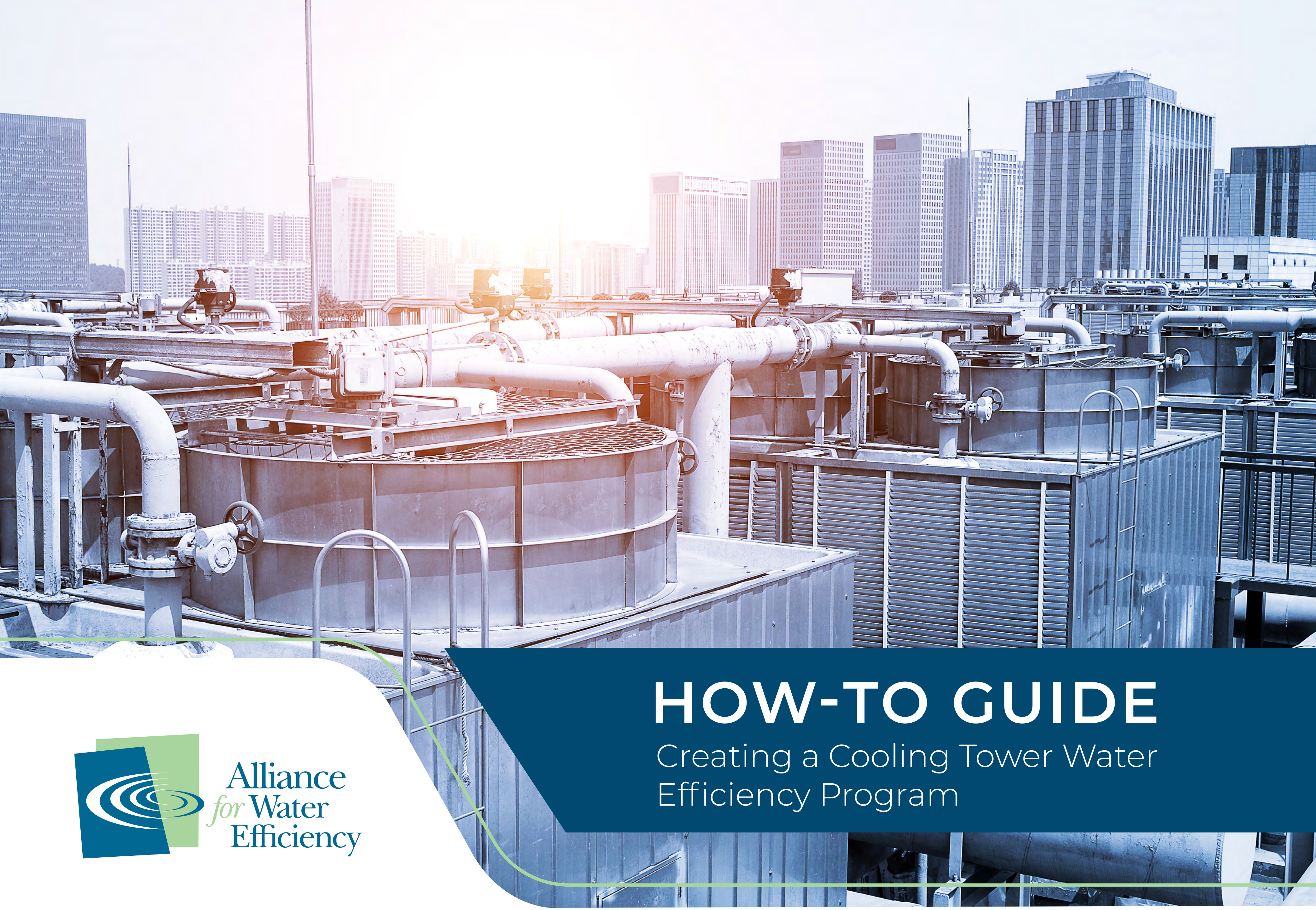

HOW-TO GUIDE

Creating a Cooling Tower Water Efficiency Program

Alliance for Water Efficiency

2022 September

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HOW TO USE THIS GUIDE

The How-to Guide for Creating a Cooling Tower Water Efficiency Program **was created by the Alliance for Water Efficiency (AWE) to provide an educational and practical resource for water supplier professionals exploring a water efficiency program focused on cooling towers.**

The guide is intended to provide useful recommendations and considerations for program design, operations, and marketing. Included in guide are strategies to find properties with cooling towers and their respective decision makers, recommended outreach and sales processes, sample email templates and case studies, options for incentive structures and more. Also included in the guide are examples of existing water supplier programs.

The guide also highlights the tools and resources available through AWE. These tools are designed to help water suppliers evaluate the potential of cooling tower water efficiency upgrades in their service area and to assist with implementation of cooling tower programs. These tools include:

- Cooling Tower Estimating Model
- Water Quality Helper
- Comparing Alternatives Tool
- Sample Audit and Return on Investment Calculator

In order to understand how to optimize cooling tower water efficiency, you must first understand the basics of cooling tower operations and the importance of source water quality and its effect on water use. This information is required in order to design and operate an effective program and provide sound recommendations to customers. The guide starts with information about:

- How a cooling tower works
- The ways in which water quality impacts cooling tower operations and water use
- Standard practices for water treatment
- Types of cooling tower water efficiency upgrades

It should be noted that the guide represents recommended best practices. It is not expected that water suppliers will utilize every program component. For example, smaller suppliers may not offer rebates, but can use the guide to assess a cooling tower program's potential for water savings in their service area and to create a customer education program. Larger suppliers with established incentive programs might use the guide to start a cooling tower inventory and improve customer targeting and outreach tactics.

Why Target Cooling Towers for Water Efficiency Upgrades?

Cooling towers use water to remove heat through evaporation and are primarily used for heating, ventilation, air conditioning (HVAC), refrigeration, and industrial cooling purposes. The most common application for cooling towers is in buildings with a high cooling load such as data centers and hospitals.

According to industry experts, cooling towers, on average, account for 40% of a building's water demand, and in some buildings, they may account for far more.[1] Increasing efficiency in cooling towers provides a prime opportunity for water savings in the commercial, institutional, and industrial (CII) markets.

Programs that target cooling tower efficiency have the potential for yielding high water savings because:

1. **Cooling towers have been an under-addressed market,** and there has been minimal participation in water supplier programs.

2. **Cooling towers use a significant amount of water.** Customers that participate and improve system efficiency will see considerable water savings. An average cooling tower upgrade can save more than 300 toilet retrofits.

Despite the benefits of cooling tower efficiency upgrades, most programs struggle with low customer participation. Some known obstacles include:

- Customers' lack of knowledge about cooling tower operations and upgrade opportunities can make them hesitant to make changes.
- Customers may not track actual water usage in the cooling towers and do not understand the value of making upgrades.
- Customers often use water treatment vendors for standard maintenance and monitoring. Historically, the vendors have no incentive to manage water use.
- Customers may perceive there is a risk of adverse impacts to cooling equipment and system performance and/or reliability.

1 Better Building Challenge Los Angeles. Upgrade Cooling Tower Equipment and Operation Factsheet. 2016. https://betterbuildingssolutioncenter.energy.gov/sites/default/files/tools/2016%20Cooling%20Tower%20Onesheet_6-9-2016.pdf

Effective water efficiency programs that incorporate customer education, outreach, and incentives are needed to address these challenges. The guide will walk the reader through the following:

Topics Covered

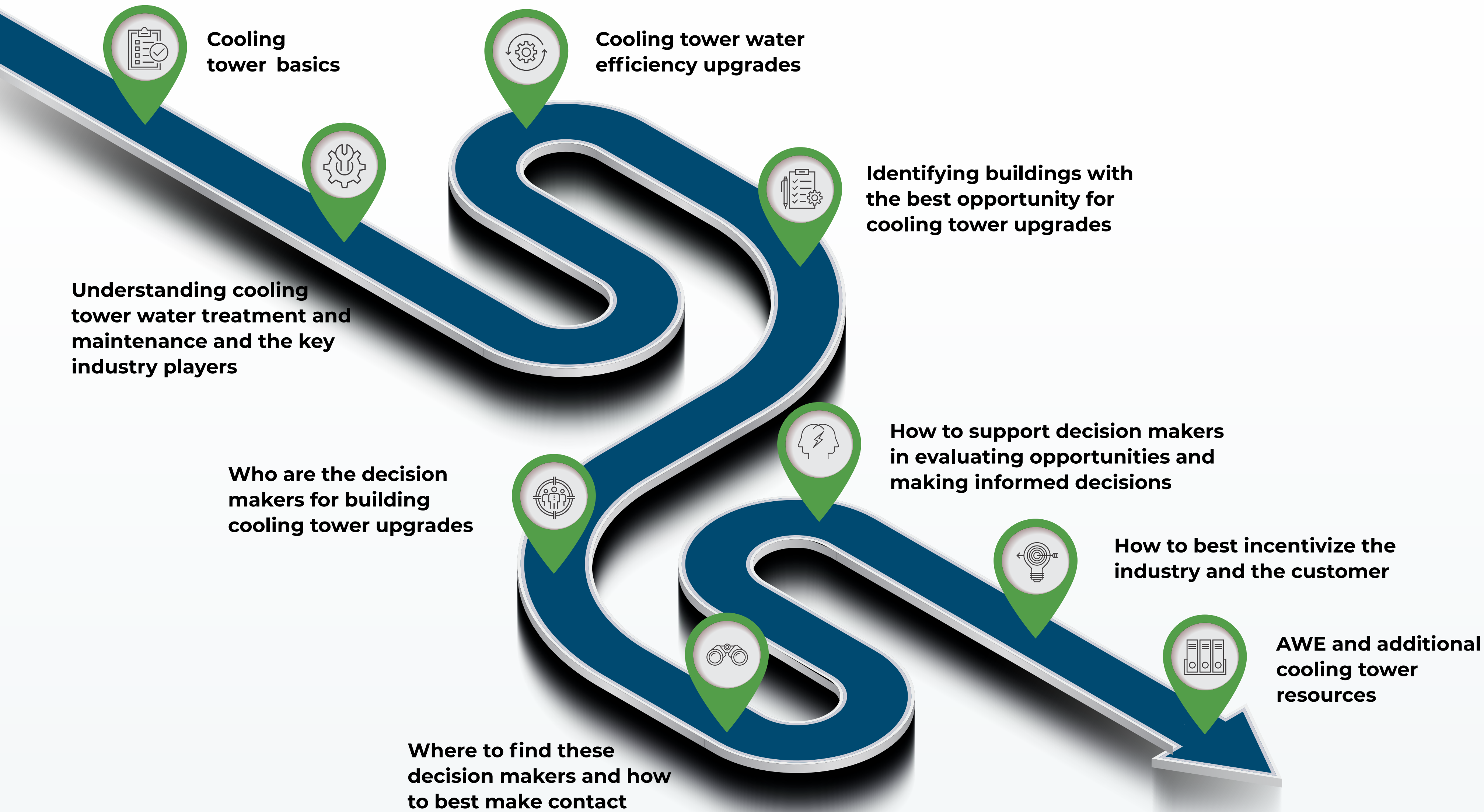


Figure 1: How-to Guide Components

SECTION 2

COOLING TOWER BASICS

Cooling towers are used to remove heat from a building or industrial process through evaporation. They work by lowering the temperature of a water stream through direct air-to-water contact. This causes a portion of the water to evaporate, lowering the temperature of the water that's circulating through the tower and thereby cooling the building or process.

Large cooling towers are used in industries like power plants, petroleum refineries and various manufacturing facilities.

However, the most common application of a cooling tower is inside an HVAC (heating, ventilating, and air conditioning) system for cooling buildings. An HVAC cooling tower is used to dispose unwanted heat from a water-cooled chiller or water-cooled condenser.

Cooling towers vary in size and design based on the cooling load of a building. The cooling load is determined by the size of a building from which heat needs to be extracted.

The most common application for cooling towers is for buildings with a high cooling load, including:

- Multi-story office buildings
- Hospitals
- Data centers
- Schools and campuses
- Large hotels and multi-family properties
- Industrial sites

The evaporative cooling process is essentially the same cooling effect that happens when getting out of a pool on a windy day. The instant sensation of getting colder is due to water evaporating off your skin when the air blows across the water droplets, lowering the water's temperature.

Cooling towers vary in size from large hyperboloid structures at power plants to smaller ones on the rooftops of office buildings. Examples of cooling towers are pictured to the right.

As the primary component used to transfer heat, cooling towers are designed to expose the cooling water to the ambient air. This process maximizes heat transfer through the evaporation (loss) of water. Cooling tower systems are very effective at evaporative heat transfer but use significant amounts of water in the process. In fact, cooling towers may account for up to 40% of a commercial building's total water use. Cooling towers use even more water in industrial applications such as power generation. In those cases, cooling towers can use up to 75% of a facility's total water demand.

There are many existing and emerging water efficiency technologies that can significantly reduce water use in cooling towers. In fact, a simple upgrade at a 100,000-square-foot office building in a mild climate can save over 1.5 million gallons per year.

As water suppliers develop and implement programs to incentivize cooling tower water efficiency upgrades, it's necessary to understand how cooling towers work, how they are operated and maintained, who is involved in operating and maintaining them, and what are the pros and cons of potential upgrades. This knowledge will help water suppliers design effective programs, outreach strategies and incentive structures that result in high customer response and long-term water savings.

How Does a Cooling Tower Work?

A cooling tower takes the heat rejected from an air conditioning compressor/chiller or an industrial process and dissipates that heat by evaporating water in the cooling tower. The cooling tower takes warm water, heated by waste heat from buildings or industrial processes, and evaporates that water using pumps, fans, and special media designed to expose the warm water to cool air. It then collects the cool water condensate and returns it to the heat source for another round of cooling (Figure 2).

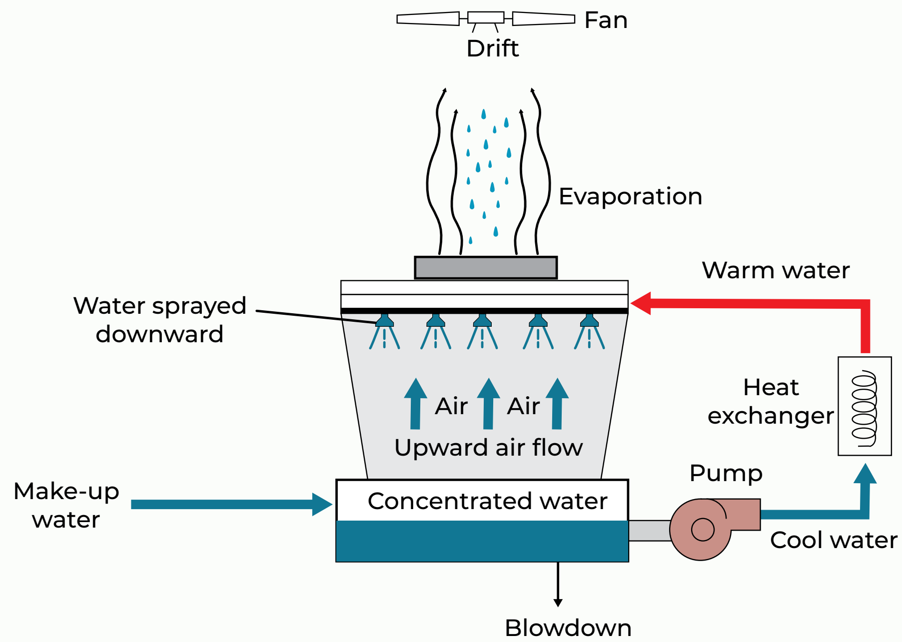


Figure 2: Cooling Tower Diagram[2]

Here's how a typical open-recirculating cooling tower system works:

- The process begins at the heat exchanger, where heat from a chiller condenser or compressor is transferred into the recirculating cooling water and returned to the cooling tower.
- The warm water is evenly sprayed across the top of the tower and flows counter-currently to air that is pushed (forced draft) or pulled (induced draft) through the tower by a fan.
- The water then collects in a basin, where it can be recirculated back into the system.

Water must be discharged (blowdown) to keep the minerals and salts, that remain behind as the water evaporates, from building to levels that cause both scaling (hardness) and corrosion of metal components of the cooling tower. Water must be continuously added to make up for the evaporation and blowdown water losses.

2 Cooling Towers: Understanding Key Components of Cooling Towers and How to Improve Water Efficiency. DOE/PNNL-SA-75820. Feb 2011.

Where is Water Lost in a Cooling Tower System?

The total water used in a standard cooling water system is the amount of makeup water consumed by:

- Evaporation
- Blowdown
- Drift
- System leaks

Makeup water is necessary to replace water lost through these four factors.

Cooling Tower Makeup Water (gallons)

Cooling Tower Water Use (Makeup) = Evaporation + Blowdown + Drift + Leaks/Overflow

In cooling tower systems, most water loss is through evaporation. Due to the laws of thermodynamics, the amount lost to evaporation is constant and therefore not much can be done to reduce this use besides replacing the cooling towers with an alternative technology.

The second highest use of water is for cooling tower blowdown. As water evaporates, it leaves behind dissolved solids such as calcium, magnesium, and chloride that were present in the makeup water. As the recirculating cooling water becomes more concentrated over time, this may cause scale formation or corrosion. To combat this problem, operators must routinely remove water with high total dissolved solids (TDS) by discharging this water to the sewer system (blowdown). High TDS water is replaced by lower TDS water (makeup water).

The third way that cooling towers lose water is through drift, which is the release of water droplets from the cooling tower due to system air flow and wind effects. Drift is common to almost all open-recirculating cooling tower systems; though it can be minimized through drift eliminators, cooling tower drift is typically not recovered.

Water leaks are the fourth cause of cooling tower water loss. Leaks can occur in a number of places, such as overflow from failed collection basin float valves, improperly operating blowdown or bypass valves, faulty spray nozzles, and seals.

Key Terminology

Blowdown – Water discharged to remove high mineral content system water, impurities, and sediment.

Makeup – Water supply needed to replace all losses due to evaporation, leaks, or discharge in cooling systems.

Cycles of Concentration (COC) – the ratio of solids in the blowdown water to solids in the makeup water, is a metric used to represent water consumption in cooling towers; high COC are related to low levels of blowdown and vice versa. Typically, COC for to many facilities using traditional chemical water treatment COC between 3 and 4, indicating a relatively high volume of cooling tower water consumption, mostly in the form of blowdown.

Dissolved Solids – The amount of dissolved minerals present in the water.

Drift – Droplets of water entrained in the air leaving the top of the tower, or blown from the side of the tower by crosswinds.

Why Does Water Quality Matter?

The quality of the makeup water source is perhaps the most important factor in operating and maintaining a water-efficient cooling tower system.

If the water is from surface water sources, it can carry high levels of suspended solids, including dirt (silt), organic material, and debris. Operators may need to use pre-filtration systems or aggressive treatment to avoid fouling and plugging of the cooling tower system. Makeup water from groundwater sources usually has very low suspended solid levels. However, it often contains high dissolved solids that can cause scale formation or corrosion in the cooling system.

Water quality is the number one limiting factor in how many cycles of concentration a cooling system can achieve which translates to the system's water efficiency.

When left unattended, water supports biological growth, and corrodes or scales equipment.

Proper ongoing treatment is critical to system operation and efficiency.

What are the Critical Water Quality Constituents and Parameters?

Following are a few water quality constituents and parameters that are critical to understand in order to manage cooling towers efficiently and protect the overall cooling system.

Conductivity – Conductivity is a measure of how easily electricity flows through water. This is measured in microSiemens (µS/cm) or micromhos (umho/cm). The higher the conductivity level of water, the more dissolved solids it contains. Conversely, lower conductivity levels correlate to fewer dissolved solids in water. Conductivity in a cooling tower system should range from 50-600 uS/cm. The lower the conductivity the greater the opportunity for maximizing system water efficiency. Certain types of water treatment processes (e.g., reverse osmosis) reduce total dissolved solids, resulting in low conductivity water, while groundwater sources will have elevated TDS. Water with high TDS can cause scale formation or corrosion.

pH – pH measures how acidic or basic (alkaline) water is. The pH scale ranges from zero to 14, with seven being neutral. A pH of less than seven indicates acidity and greater than seven indicates alkaline. pH is reported in logarithmic units, which means that each number is a 10-fold change in the acidity or baseness of the water. Water that is used for cooling towers should have a neutral pH to reduce corrosion and scale formation and maintain heat transfer efficiency.

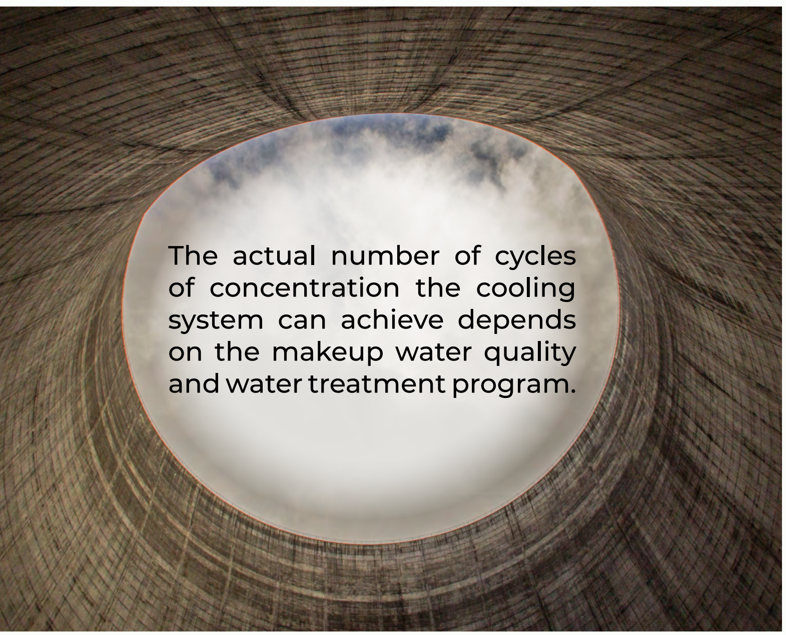
Hardness – Hardness refers to dissolved calcium and magnesium in the water. When hard water is heated, solid deposits of these minerals can form. These deposits reduce the life of the equipment, forming along the warmest parts of the system such as the tubes or plates of heat exchangers.

Alkalinity – Alkalinity is the measure of alkaline material such as carbonates, bicarbonates, and hydroxides in water. This alkaline material acts as a buffer that neutralizes acids and plays an important role in maintaining proper pH.

What are Cycles of Concentration?

Cycles of concentration (COC), also referred to as the concentration ratio, describes the relationship between the amount of system makeup water entering the cooling tower system, and the amount of blowdown removed.

From a water efficiency standpoint, it's critical to maximize cycles of concentration. This will minimize blowdown water quantity and reduce makeup water demand. **However, this can only be done within the constraints of the makeup water and cooling tower water chemistry.**



How Does Evaporation and Water Loss Effect Cycles of Concentration?

In a cooling tower system, water is constantly evaporating and being replaced. This results in a concentration of minerals in the remaining water.

Consider a pot of boiling water maintained at a constant level of 1,000 gallons by the addition of tap water. If the tap water used for makeup contains one pound of solids in every 1,000 gallons, and initially the pot is filled with 1,000 gallons of tap water, the system water is said to be at one cycle. This is because no evaporation has occurred yet. If 1,000 gallons of water has been removed by boiling and 1,000 gallons of tap water was added to keep the level constant, there will be an additional one pound of dissolved solids in the pot. As a result, the system is said to be at two cycles. The cycles of concentration increase by one for each system volume of water that is evaporated.

The same calculation applies to a cooling tower system. If the recirculating cooling tower water is 1500 microSiemens (μS) and 500 microSiemens (μS) makeup water is added, then this would be equivalent to three COC.

Conductivity of blowdown water ÷ Conductivity of makeup water
= Cycles of concentration

Cycles of Concentration - The Water Efficiency Relationship

For each cycle of concentration, one pound of solids must be discharged through blowdown for every pound of solids brought in with the makeup water. The following shows the relationship between the cycles, makeup, and blowdown rate.

2 cycles: 1/2 the amount of water is discharged as blowdown
4 cycles: 1/4 the amount of water is discharged as blowdown

Controlling COC Through Cooling System Blowdown

As levels of dissolved solids increase with higher cycles of concentration, scaling and corrosion potential also increase. All dissolved minerals have a saturation limit that, if exceeded and not treated, can lead to scale formation. Certain dissolved minerals (such as calcium) are more troublesome than others because they have low saturation limits and they become less soluble at elevated temperatures that are commonly found in heat exchange equipment. Alternatively, very high levels of certain dissolved minerals such as chloride can increase water's tendency to be corrosive.

As the cooling tower system continues to evaporate water and makeup water is added to maintain system volume, the dissolved solid concentration and the COC will continue to increase. Eventually, the recirculating cooling water will become saturated and precipitation occurs which can produce scale-forming deposits. To limit the concentration of dissolved solids and prevent problems, a portion of the now higher TDS recirculating cooling water must be discharged as blowdown.

It is also important to note that the savings in water use diminish as cycles increase.

For example, as depicted in Figure 3, increasing the cycles of concentration from three to five results in 0.37 gallons per ton-hour reduction in makeup and blowdown, but increasing from eight to 10 only reduces makeup and blowdown by 0.05 gallons per ton-hour. This is illustrated in the chart on the right.

Cooling Tower Water Use per Ton-Hour Cooling (gallons)

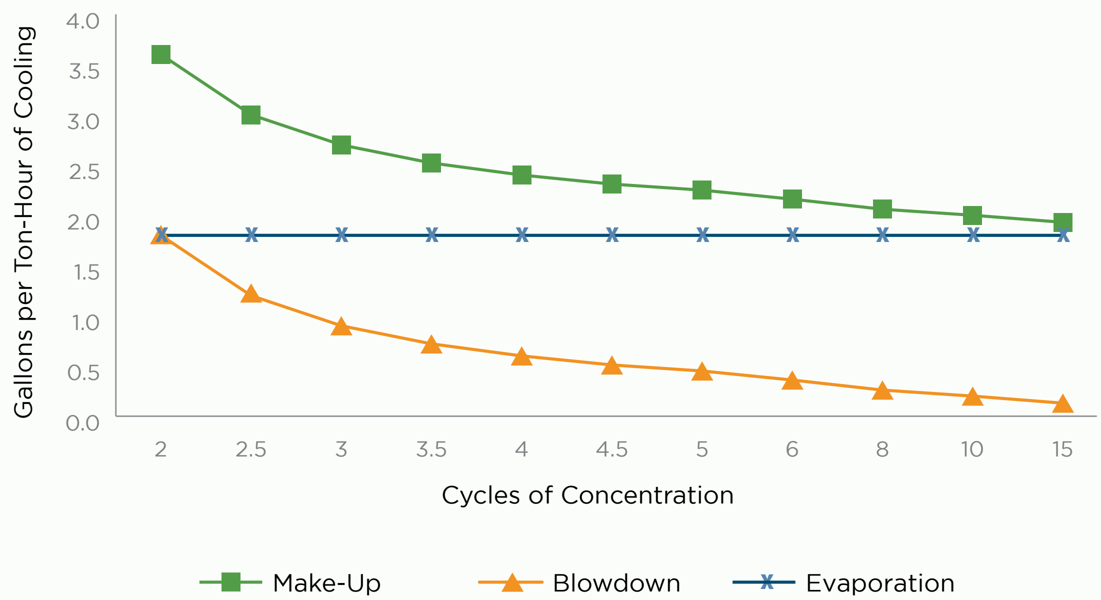


Figure 3: Cooling tower water usage showing the effect of increased cycles of concentration

Tip:

Calculate COC two different ways and if there is a big difference, then the system is likely losing water to leaks and/or drift.

Basic Cooling System Water Balance Calculations

The following are examples of common mathematical relationships between cooling system water efficiency variables such as evaporation rate, blowdown rate, makeup rate, and cycles of concentration. These basic formulas are useful to understand and confirm the principal water flow rates in the cooling system. Operators use these formulas to identify anomalies and system inefficiencies.

The first equation describes the overall water balance for an open, recirculating, cooling system. It shows that makeup water demand is equal to the combined water loss from evaporation and blowdown. In this case, the blowdown accounts for all system losses except for evaporation, including leaks.

Makeup = Evaporation + Blowdown

The second relationship defines cycles of concentration in terms of makeup water volume and blowdown water volume in gallons per minute (gpm).

Cycles of Concentration = Makeup ÷ Blowdown

Combining the two equations, the Table 1. provides examples of the cooling system water balance and COC.

Table 1: Cycles of Concentration Calculations

Makeup (gpm)	Evaporation (gpm)	Blowdown (gpm)	COC
500	250	250	2
750	500	250	3
1000	800	200	4
1500	1300	200	7.5
2000	1800	200	10

When operating a cooling system, often times an operator will not have access to all water quality and quantity measurements. This may be due to lack of metering and measurement instruments. Therefore, the following equations can be utilized to solve for one or more of the unknown variables. The below example depicts a cooling system with an average makeup water demand of 20 gallons per minute, a blowdown of five gallons per minute, and solving for an unknown variable denoted by (X or Y).

Makeup = Evaporation + Blowdown

20 gpm = X + 5 gpm. Evaporation (X) is estimated to be equal to 15 gpm

Blowdown = Makeup ÷ Cycles of Concentration

Y = 20/5. Cycles of concentration (Y) is estimated to be equal to 4

Best Practices

- Install meters on makeup and blowdown lines
- Check the ratio of makeup flow to blowdown flow
- If meters are not installed you can check the ratio of conductivity of blowdown water and the makeup water via handheld conductivity meter

The cooling tower diagram below illustrates how these equations are applied.

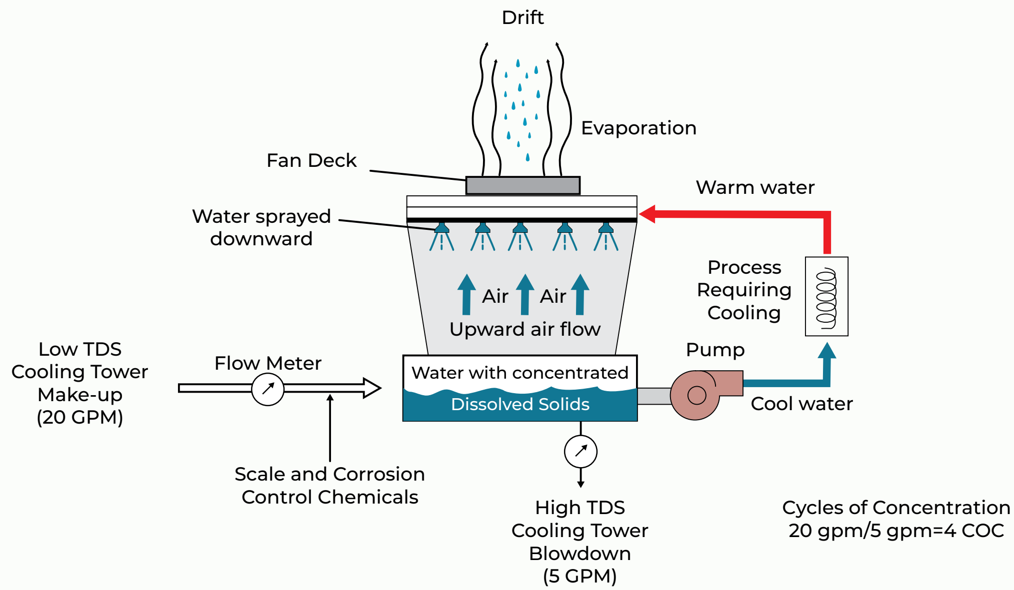


Figure 4: Cooling Tower Operations

COOLING TOWER WATER TREATMENT & MAINTENANCE

Treating cooling tower water is similar to treating municipal drinking water. Without treatment, water quality suffers and can cause significant health and system damage.

Proper water treatment in cooling tower systems is required **to minimize the risk of corrosion, scaling, and microbiological buildup**. These issues can reduce productivity, impact a building's comfort, and require costly equipment replacements if conditions get out of control. Additionally, inadequately maintained cooling towers can create aerosols (droplets of water in the air) that contain Legionella bacteria. The heat-rejection fans in cooling towers can then spread these bacteria.

Standard cooling tower water treatment, done effectively with routine monitoring, can achieve high levels of water efficiency depending upon the local water quality.

Conventional water treatment programs use chemicals to properly maintain the cooling system and protect public health. These include scale inhibitors, corrosion inhibitors, dispersants, and biocides. Specific treatment varies depend upon the local water quality, but most treatment programs involve the use of filtration technologies and chemical products in order to remove toxic or otherwise damaging impurities from the cooling tower system.

With balanced water treatment and control, a cooling tower system can effectively maximize the cycles of concentration and operate at high levels of water and energy efficiency.

On the following pages is a brief discussion on the **four primary water treatment challenges** encountered in cooling tower systems and their respective treatment strategies.

Scale

Hard water has been causing issues for ages, whether it is water spots on cars or scale deposits on showerheads. These same issues impact cooling systems.

Hardness scale is typically the combination of calcium and magnesium compounds that have precipitated out of water (e.g., calcium carbonate, magnesium silicate). This tough deposit forms in cooling systems and can wreak havoc by decreasing system life and increasing energy usage, maintenance, and operational costs.

Water quality, hardness of water, pH and temperature are factors that contribute to scale formation. Scale is more likely to form at high pH levels and high temperatures. This reduces the heat exchanger's capacity and makes it run hotter and less efficiently.

Preventing Scale –

The overall goal of chemical scale control is to keep hardness from depositing on the cooling water system surfaces. This is accomplished through a combination of:

Threshold Inhibitors: which chemically increase the amount of the scale ions that can be maintained in solution

Crystal Growth Modification Polymers: which change the shape of the formation of hardness scale making it less stable and more likely to re-dissolve

Dispersants: which change the attractive forces between the scale particles

Low levels of threshold inhibitors, like phosphonates, greatly increase the amount of hardness the system water can hold. The presence of a threshold inhibitor allows cooling systems to achieve higher cycles of concentration with less scale deposition occurring.

Crystal Growth Modification polymers can also be added into cooling system water to help keep scale from depositing onto surfaces. This is accomplished by adjusting the shape of the scale's formation, making it more difficult to form deposits that attach to the system surfaces. These polymers help keep the hardness from depositing on heat transfer surfaces.

Dispersants work in a similar fashion to crystal growth modification polymers in that they prevent the scale molecules from sticking together and forming deposits on the system surfaces, but they use a different mechanism to accomplish this. Dispersants attach to the scale molecules forming a unified charge around them. This causes the molecules to repel each other instead of attaching to each other and depositing on heat transfer surfaces.

Calcium Carbonate Scale

The photograph shows calcium carbonate scale clogging a section of pipe in a heat exchanger.

Corrosion

Corrosion is essentially an electrochemical oxidation process that destroys the basic metals from which most cooling systems are constructed. The metal loss resulting from corrosion reduces system life and increases maintenance costs. Corrosion can also produce deposits that impede water flow, foul heat exchange surfaces, and reduce overall water system efficiency.

Corrosion is typically categorized as either general or localized. Generalized corrosion proceeds uniformly over an exposed metal surface. With generalized corrosion, fouling is usually a more serious problem than equipment failure.

In contrast, localized corrosion is characterized by depressions or pits on metal surfaces. It usually is a more serious problem than generalized corrosion. Forms of localized corrosion include pitting, galvanic corrosion, under-deposit corrosion, and microbiologically influenced corrosion. Localized corrosion can lead to rapid metal perforation and system failure.

Minimizing Corrosion –

Corrosion control methods vary depending on makeup water quality, pH control, and biological activity. No one corrosion control chemical can adequately address the broad range of conditions.

Some scale control chemicals such as phosphate may provide corrosion protection, particularly when combined with modest levels of calcium. In mixed metallurgy systems, corrosion protection can come from using phosphates and zinc, or all-organic phosphonate water treatment programs.

Film-forming azoles are commonly used to prevent corrosion in heat exchange equipment containing yellow metals such as copper.

Microbiologically Influenced Corrosion

Pitting Corrosion

The photographs show different types of corrosion on cooling tower metals.

Biological Activity

Cooling towers provide a warm, moist environment that offer ideal conditions for the growth of problem-causing microorganisms. Biological growth, if allowed to grow unchecked, can cause severe corrosion and slime deposits in water.

There are two types of bioactivity in cooling tower systems: planktonic (suspended and moving throughout the system) and sessile (stationary and found in low/no flow areas and surfaces). Both types if left uncontrolled can contribute to the formation of biofilms. Biofilm can contribute to increased corrosion which can reduce heat transfer efficiency and cause equipment failures.

Furthermore, if the conditions are just right, disease-causing bacteria such as Legionella can thrive in cooling water systems. Legionnaire's Disease is a bacterial infection spread by inhaling particles containing legionella bacteria. One of the recognized primary sources of such particles is the windage, or drift, produced by the operation of a cooling tower, where cooling water in the airstream is subsequently discharged into the atmosphere.

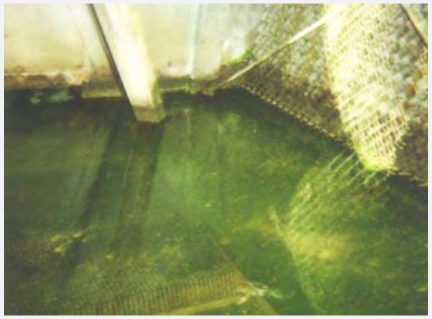
Minimizing Biologic Activity –

The standard treatment for biological growth is to periodically dose the cooling system with a biocide to kill as many of the organisms as possible. The treatment is effective only when a critical dosage is reached and maintained for an extended period of time. The most commonly used biocides can be separated into two major classes: oxidizing and nonoxidizing.

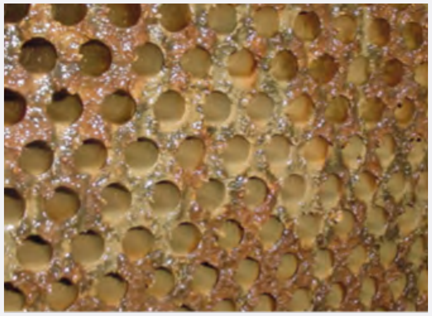
Oxidizing biocides function by chemically oxidizing -- and thereby destroying -- the cellular structure of the organism. Examples of biocides include chlorine, chlorine dioxide, hydrogen peroxide, bromine and ozone.

Nonoxidizing biocides function by interfering with the metabolism of the organism. Examples of non-oxidizing biocides include glutaraldehyde, isothiazolone, DBNPA, polyquat compounds, carbamates, and THPS.

A standard practice by many cooling water treatment vendors is to use both an oxidizing and nonoxidizing biocides.



Algae Growth



Biofilm Formation

The photographs illustrate the growth of algae and the formation of biofilm in cooling systems.

Foreign Material Fouling

Foreign material fouling occurs when contaminants (soluble and insoluble) mix with other chemicals or group together and settle out or deposit in the cooling system. Common foulants include organic matter, process oils, and silt or fine dirt particles.

Factors that lead to fouling are low water velocities, corrosion, and leaks. Fouling deposits, like scale deposits, can form an insulating barrier in the cooling system making it operate less efficiently. Fouling in the cooling tower fill can reduce the heat transfer efficiency.

Debris buildup

The photograph shows the buildup of debris in cooling tower system

Minimizing Foreign Materials or Fouling (Management of Dissolved and Suspended Solids) –

Polymer-based dispersants are used to help prevent deposition and fouling from both scale forming (e.g., calcium carbonate) and non-scale forming (e.g., silt, algae) contaminants.

Chemical dispersants function by keeping solids floating so they can be removed through blowdown or collected in system specific filters such as side-stream filtration. Surfactants may also be used in conjunction with dispersants to further reduce fouling.

How Mineral Saturation is Measured, the Langelier Saturation Index

A primary measure of how much mineral content water can hold (i.e., scaling tendency) in a cooling system is defined by the Langelier Saturation Index (LSI). LSI is determined by the following primary scale forming components:

1. pH
2. Calcium concentration
3. Carbonate concentration
4. Total dissolved solids
5. Water temperature

Typically, water treatment programs are managed to an LSI of 2.7-3.0 because that represents the limit of top-shelf scale inhibition programs and the higher the scaling tendency of the water the higher the risk of losing energy efficiency if some aspect of the water treatment program goes out of conformance.

Who Manages and Maintains Cooling Towers?

Industrial facilities, building owners and operators and other companies hire water treatment companies to help them manage this critical component of their heating, ventilation and air conditioning systems or industrial processes. Because source water and operating conditions vary widely, these companies work directly with facility staff to implement tailored water treatment programs.

It's important to understand the key role water treatment companies play in water efficiency upgrades. Many times, building owners and operators rely upon water treatment companies for direction on how to best manage their cooling tower system. If a water supplier is promoting water efficiency upgrades, they will likely need to get the buy-in from the water treatment company. These companies can either be a strong proponent or an obstacle to the upgrade process.

It's recommended to build relationships with water treatment companies in your area. Many of these companies offer water efficiency products and services and know the building's equipment, the operations manager, and, most likely, the other key decision makers. By fostering a good working relationship with water treatment companies, the more progressive companies will recognize the benefits of an water-efficient program and will promote water supplier programs and provide access to the decision makers.

Where to Find Water Treatment Companies in Your Service Area

Water treatment companies can be found through internet searches as well as asking building owners and operators the names of the companies they utilize. Below are a few of the top national water treatment companies.

Table 2: National Water Treatment Companies

Water Treatment Company	Website
ChemAqua	www.chemaqua.com/en-us
ChemTreat	www.chemtreat.com
Ecolab/Nalco Water	www.ecolab.com/nalco-water
Kurita	www.kuritaamerica.com
Suez/GE Water	www.suezwatertechnologies.com

COOLING TOWER WATER EFFICIENCY UPGRADES

Cooling tower systems and water treatment programs can be cost-effectively upgraded with improved controls, monitoring, and treatment strategies.

The following section details common water efficiency upgrades that can result in significant water, energy, and chemical use reduction; improved heat transfer efficiencies; and in many cases, can provide a strong return on investment.

Most cooling tower systems are unique to their specific location and purpose. Due to the many variables of cooling tower equipment, operational oversight, space limitations, and budgets, it is important to obtain site specific information for the cooling tower equipment when evaluating potential water efficiency upgrades. Information to collect and assess include:

1. How much water the cooling tower system uses
2. Local water quality and limiting factors
3. Current cycles of concentration
4. Potential water savings with improved cycles of concentration
5. Potential alternative water sources
6. Cost of water and wastewater

Each of these data points factor into the best upgrade solution for a given cooling system. For example, a larger cooling system in an area with high water cost may justify the investment of water softening pretreatment to maximize COC. On the other hand, a medium-sized system in an area with high water quality will only require system monitoring and controls to improve COC. More information on cooling tower water audits and assessing the return on investment can be found in Section 7.

Top Cooling Tower Water Efficiency Upgrades

The top cooling tower water efficiency upgrades fall into five major categories:

Top Cooling Tower Water Treatment Efficiency Upgrades

System Monitoring & COC Management	Acid Treatment	Water Softening and Filtration	Electro-Chemical Treatment	Alternative Water Sources
- Utilize Conductivity Controllers -Install Makeup and Blowdown Meters	- Utilize Acid in Water treatment (often called pH control or partial pH control)	Pretreat Source Water options include: - ION Exchange/ Water softening - Micro-, Ultra- & Nano-Filtration - Reverse Osmosis	- Employ Electrolysis or Partial Electrolysis	Utilize Alternative Water Sources options include: - Blowdown recovery and reuse - Recycled water - Condensate recovery

Each of the above options has the same intended purpose – to optimally manage system water quality and maximize cycles of concentration. This will minimize blowdown water quantity and reduce makeup water demand.

The various approaches are included for general awareness, it's not necessary to be an expert in any of these technologies to run an effective program.

System Monitoring and COC Management

The first and most important step in reducing water use is monitoring water quality and consumption in order to effectively maximize the cycles of concentration.

Controllers that actively monitor the cooling system should be considered as a baseline investment. Use of controllers still requires monitoring, data trending and analysis to achieve maximum water savings and system efficiency.

Conductivity Controllers – Conductivity controllers continuously measure the conductivity of the cooling tower water and discharge water only when the conductivity set point is exceeded, maximizing cycles of concentration and water efficiency. Controllers are commercially available equipment from numerous suppliers and offer a range of capabilities from simple conductivity and blowdown control to chemical dosing. Most controllers can incorporate both hardwired and digital metering, alarming, and data trending. It is necessary to regularly calibrate controllers in order to ensure its ability to measure conductivity accurately.

pH Controllers – pH control is the process of adding an acidic substance (such as sulfuric acid) in order to bring the measured pH within a desired range. Through pH control, operators can increase the cycles of concentration while still protecting against scale. A pH controller consists of a probe to measure the current pH, injection pumps, and a controller that calculates the required injection rate and activates the injection system.

Controller Type	Estimated Cost	Ideal Tonnage	Potential COC	Savings and Payback
Conductivity Controller	\$200 - \$1,000	All cooling tower systems	2 – 4 depending on local water quality	Immediate depending on current COC and water local costs
pH Controller	\$2,000- \$4,000 per tower	All cooling tower systems	3 – 5 depending on local water quality	Immediate depending on current COC and water local costs

Metering Makeup and Blowdown Water Use – Water meters can help track, trend, and validate water use in a cooling water system. Most current building code requires installation of meters on makeup lines. Metering makeup water provides water use data from varying operational uses (# of chillers operating) and seasonal conditions (daily/weekly/monthly). This data can also be used to identify irregular water use and changes due to leaks.

Metering blowdown water use enables tracking cycles of concentration as well as overall system water use.

It's recommended to connect meters to a building automation or management system so that use is automatically recorded, and alerts are sent when abnormal water use is detected.

Estimated Cost	Ideal Tonnage	Potential COC	Savings and Payback
$200 - $1,000 per meter depending on signal (local, wired, remote)	All cooling tower systems	3 – 5 depending on local water quality	Immediate depending on current COC

Requiring or incentivizing meter installations is a best practice for water supplier programs.

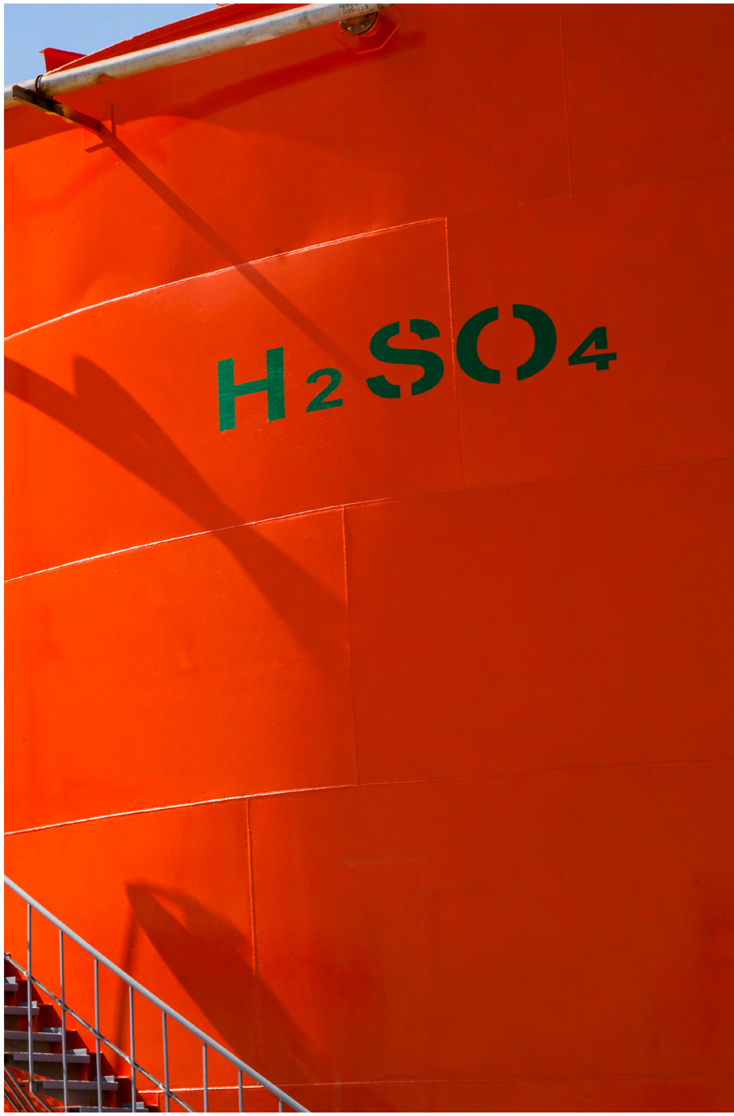
Acid Treatment

Acid treatment (sometimes referred to as pH control) is the addition of acid to the recirculating water, which reduces the scale buildup potential from mineral deposits and allows the system to run at higher cycles of concentration.

Most makeup water contains significant concentrations of dissolved minerals, which tend to change the pH of the tower water. In cooling towers, the main mineral accumulation is calcium carbonate. This occurs through reactions between calcium, heat, and bicarbonate. Calcium carbonate tends to increase the pH of the water, making it more alkaline. Acids like ascorbic acid, hydrochloric acid and sulfuric acid can be added to combat the rise in pH and allow for higher cycles of concentration.

Estimated Cost	Ideal Tonnage	Potential COC	Savings and Payback
$1,500 - $3,000 for controller only	500 – 2,000 tons	4 – 5 depending on local water quality	2 – 6 months

Considerations: Acid treatment may require additional site visits. Many times it is the easiest upgrade with the quickest payback. Requires automatic injection which may add costs. It also requires a pH controller pH controller to ensure pH stays within control points. Acid overdose can severely damage cooling system. Adding Acid is a hazardous material and requires workers to be fully trained in proper handling of acids.



Water Softening and Filtration

A common technology used to increase cycles of concentration is through the pretreatment of water to remove minerals in the makeup water.

Ion Exchange / Water Softening

Water softeners treat hard water through a process called ion exchange. The water softener runs the water through resin beads where the calcium and magnesium molecules switch places with sodium molecules, leaving the water soft. In more basic terms, the softener removes the hardness minerals – calcium and magnesium – from the water and replaces them with sodium.

In full deionization processes, both cations and anions are selectively removed from the makeup water resulting in "high-purity" water. Resin beds are regenerated using salt, acid, or hydroxide solutions, and the liquid waste is discharged into the sewer.

Pre-treatment Solution	Estimated Cost	Ideal Tonnage	Potential COC	Savings and Payback
Water Softeners	$10,000 - $25,000 per Tower	1,000+ tons	6 – 8 COC	2 – 4 years
Deionization	$10,000 - $25,000 per Tower	1,000+ tons	8 – 10 COC	3 – 5 years

Considerations: Water softeners require onsite space for water softener equipment including resin and brine vessels and manpower resources to monitor the system and add salt for brine production. Water softeners also use additional water to flush the brine. Discharge of salt brines has a negative impact on the quality of water in groundwater basins, recycled water, and wastewater systems. Higher sodium and chloride content increases the treatment costs and reduces the potential reuse of wastewater. A growing number of communities limit or restrict water softeners.

Membrane-Driven Filtration

Membrane-driven filtration methods are used in a variety of water treatment applications, from point-of-use units in a home to very large industrial water treatment. These technologies range from removal of suspended solids using micro-filtration (MF) to removal of 100% of contaminants through reverse osmosis (RO).

Micro-Filtration (MF) and Ultra-Filtration (UF) produce high quality water through mechanical removal of suspended solids and bacteria utilizing membranes and pressure. Ultra-filtration has a pore size around 0.01 micron. Micro-filtration has a pore size of around 0.1 micron, so when water undergoes micro-filtration, many organisms are removed, but viruses remain in the water. These filter technologies are not used to lower dissolved solid concentration unless used with a precipitation process.

Nano-Filtration (NF) and Reverse Osmosis (RO) operate similarly to MF and UF technologies, however they have much smaller pore sizes. Nano-filtration has a pore size around 0.001 micron. Nano-filtration removes most organic molecules and nearly all viruses. Reverse osmosis has a pore size around 0.0001 micron. After water passes through RO it is essentially pure water.

Due to pore size restrictions, both NF and RO operate at higher pressure (and therefore increased energy consumption) and can reject dissolved as well as suspended solids.

Pre-treatment Solution	Estimated Cost	Ideal Tonnage	Potential COC	Savings and Payback
Ultra- and Micro-Filtration	Prices range depending on size and design	Over 2,000 tons	8 + COC	4 – 6 years
Nano-Filtration and Reverse Osmosis	Prices range depending on size and design	Over 2,000 tons	10+ COC	4 – 8 years

Considerations: All membrane-type systems produce a continuous flow of waste that is discharged to the sewer. NF and RO can be prohibitively expensive for use in cooling systems because the entirety of makeup water is treated through an energy-intensive process and the majority of this water is lost through evaporation.

Electro-Chemical Water Treatment

Electro-chemical is a water treatment process that uses electricity to remove dissolved solids from water. The electro-chemical system's reactor uses amps of direct current to create an acidic solution at the anode (a titanium rod) and a basic solution at the cathode (the reactor shell). The process promotes scaling of hard minerals and silica in the reactor instead of in the chiller condenser tubes and the cooling tower itself. This allows for increased cycles of concentration.

Additionally, the process strips hydrogen ions from the chloride naturally present in water and creates chlorine, which acts as a biocide and eliminates the need to add other chemicals to the water. The technology does not treat the entire cooling water stream, but only a fraction of the total flow, through a side stream.

The system can effectively separate dissolved solids that carry a positive or negative charge through use of selective electrodes, leaving low TDS/high quality water to be used in the cooling system.

Estimated Cost	Ideal Tonnage	Potential COC	Savings and Payback
$10,000 - $50,000+ per tower	2,000+ tons	10+ COC	2 – 5 years

Considerations: Uses additional energy to operate. Although system can operate without chemicals most treatment programs add small amounts of biocide.

Alternative Water Sources

Using alternative water sources in cooling water systems can reduce the demand of makeup water supplies. Though not exhaustive, the following describes potential alternative sources. When considering potential alternative sources owners and operators must evaluate the technical, operational, regulatory, and financial drivers and barriers. In particular, access and use of alternative water sources almost always includes additions to the water system infrastructure including piping, valving, pumping, and controls.

Recycled or Reclaimed Wastewater. Treated municipal wastewater is water that has been treated and can be reused for a variety of purposes including process cooling and cooling tower systems. Wastewater streams commonly contain relatively high dissolved solid content as well as treatment by-products that must be addressed to meet fit-for-use specifications depending on a system's water quality requirements. Availability of recycled water or the cost connecting to the municipal system can be barriers to implementation.

Air Handler Condensate. This source of water can be readily obtained from existing air-handling units which collect and discharge condensate from the cooling coils. The production of condensate is directly related to air humidity, and the recovered high-purity water can be reused immediately in the cooling system without additional treatment. Using this condensate can offset a significant percentage of makeup water requirements. Often, the equipment is close by or co-located with chillers or cooling tower supply lines and can be incorporated at minimal cost.

Rainwater Capture. In areas with significant rainfall, rainwater capture systems can be retrofitted to existing infrastructure to collect, filter, store, and pump water for alternative uses such as cooling tower makeup. Rainwater is a non-potable water source and its piping needs to be separated and distinguishable from potable water service lines. Rainwater may require additional treatment as it can be corrosive due to the lack of dissolved solids and bioactivity.

Blowdown Recovery or Other Onsite Water Reuse. Different from recycled or reclaimed wastewater that is fully treated, onsite water reuse is recoverable water within a facility to supply the cooling system. An example is recovery of blowdown water from the cooling system.

Cooling Tower Technology Overview

	System Monitoring and Management	Acid Treatment	Ion Exchange / Water Softening	Membrane Based Systems	Electrochemical Water Treatment	Alternative Water Sources
Description	Conductivity and pH Controllers Makeup and blowdown meters Use data to monitor water quality parameters and setpoint, maximize COC, and manage use.	Treat water with acid, such as sulfuric acid, to increase cycles of concentration to 4-5.	Pretreat makeup water through ion exchange to remove hardness and increase cycles to 6-8.	Utilize membrane filter to remove hardness and increase cycles to 8-10+.	Uses electricity to create a chemical reaction which reduces scale and creates chlorine, which acts as a biocide and increase cycles to 10+.	Offset potable water use through the use of alternative sources such as blowdown, condensate recovery or recycled water.
Benefits	Enable continuous monitoring and tracking. Can improve control regardless of treatment program and staff knowledge. Low cost of entry.	Fast, easy upgrade with quickest payback.	Eliminates the need for acid and supplemental chemical scale inhibitors. Maximizes COC for the price point.	Higher purity waste streams can be reclaimed for other uses.	Reduces or eliminates the need for added chemical. Lack of chemicals allows for easy reuse of blowdown water.	Reduces water and wastewater costs.

	System Monitoring and Management	Acid Treatment	Ion Exchange / Water Softening	Membrane Based Systems	Electrochemical Water Treatment	Alternative Water Sources
Risks	Relies on routine attention to system set points and parameters, meter and instrument calibration, data verification and validation once operating.	May require additional site visits. Acid overdose can severely damage cooling system. Requires pH controller to ensure pH stays within control points. Acid is a hazardous material and requires workers to be fully trained in proper handling of acids.	Requires water to recharge softeners and salt for resin regeneration, Spent brine is discharged to sewer. Requires on-site space for softeners. Requires management of regeneration process (salt, chemicals, cleaning, etc.).	Membrane use requires energy for pumping, Additional chemicals for cleaning and maintenance, and regular operational attention. Waste stream is discharged to sewer. Higher overall cost.	Increased energy use to operate the system. Might require treatment for biologic control.	Alternative water sources inherently have varying water quality and may require additional treatment.
COC Impacts	3-4 depending on makeup water quality	4-5	6-8 for standard softening 10+ for high efficiency softening and/or demineralization.	10+	10+	NA

The following table provides a qualitative assessment of costs and return on investment for each water efficiency upgrade. The assessment reflects an estimated order of magnitude given by dollar sign ($).

1. **Initial cost:** cost incurred for implementation of the initial program including controls, chemical, equipment, and installation.
2. **Annual operations and maintenance:** costs incurred reflective of O&M requirements including routine purchases (e.g., chemical and equipment), testing and calibration, O&M labor.
3. **Overall return on investment:** overall return on investment estimated based upon annual water and wastewater savings, reduction in chemical and maintenance costs.

General Rule of Thumb - ROI for Water Efficiency Upgrades

	System Monitoring and Management	Acid Treatment	Ion Exchange / Water Softening	Membrane Based Systems	Electrochemical Water Treatment	Alternative Water Sources
Initial Cost	Zero - $	Zero - $	$ - $$	$$$	$$$	$ - $$$
Annual O&M Costs	Zero - $	Zero - $	$ - $$	$ - $$	$ - $$	$ - $$
Return on Investment	0-6 months	0-6 months	1 – 3 years	2 – 4 years	3 – 5 years	3 – 5 years

HOW TO BUILD A SUCCESSFUL PROGRAM

With a basic understanding of cooling tower operations, you can now look to designing a program for your service area that results in long-term, robust water savings.

Cooling tower programs are challenging to design and operate effectively. Cooling towers and decision makers can be difficult to identify, and, once pinpointed, the sales process may involve multiple individuals and require a lengthy period of time.

Despite these complexities, the water-savings opportunities make it a worthwhile undertaking. With smart program design and adequate planning time, water suppliers can achieve significant, highly cost effective water savings The following section provides options and examples for how a water supplier might design and operate a program or a service to reduce water use in cooling towers.

This guide is not intended to be definitive nor comprehensive. It is understood that each water supplier will need to customize their program, and not all suggestions will work for everyone.

A first step is to determine if a cooling tower program is viable for your service area. This can be achieved by utilizing AWE's Cooling Tower Estimating Model to determine the approximate number of cooling towers in your service area, their estimated water use, and the potential for water savings. You'll also have to consider whether you have the staff, resources, and budget to manage a cooling tower program. If of concern, start small and adjust the program and approach as you learn.

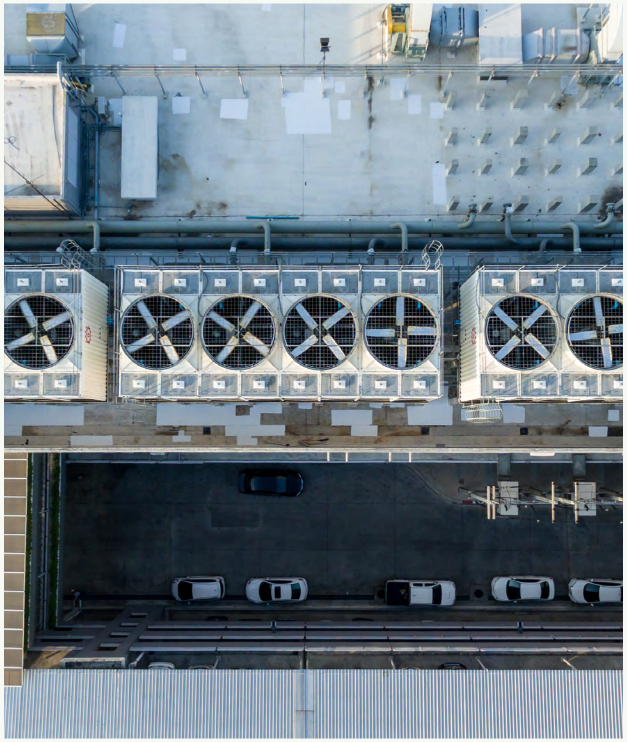
If a cooling tower program makes sense for your service area, the next step is to understand the barriers to project implementation and design a program that overcomes these barriers.

It's important to note that you do not need to be an expert in cooling technologies to achieve water savings through cooling tower upgrades.

With a basic understanding of cooling tower systems, sound support resources, and a well-executed process you can achieve meaningful water savings.

Barriers to Upgrades

One of the most important design considerations for any water efficiency program is to understand the major barriers to success. Without this knowledge, it will be difficult to construct a program that overcomes the obstacles and achieves its goals. By understanding the common barriers below, water suppliers can develop strategies to address them and improve chances for success.



Typical program barriers:

- Inventory of buildings is too broad; a well-researched master source of high-likelihood cooling tower sites is not available
- Program personnel cannot identify or reach decision makers
- Marketing does not draw interest
- Customers don't understand how much water they're using in the cooling system and whether they are operating efficiently
- Customers are unaware of available technologies and the benefits of each
- Program requirements can be confusing, too lengthy, or complicated
- Incentive levels are many times too low to drive participation
- The incentive payment process can be cumbersome
- Water savings is not always a high priority for customers and is not a motivating sales pitch for most business owners and operators

With an understanding of these obstacles, water suppliers can focus efforts into designing program features and services to minimize these traditional barriers.

The Five Key Activities of a Successful Program

To achieve program success, it's critical to execute five disciplined activities. The absence of any of these activities will most likely limit program response and customer project implementation.

	1	2	3	4	5
Activity	**Find Properties with Cooling Towers**	**Locate the Decision Makers and Influencer**	**Conduct Multi-pronged Outreach**	**Help Customers Assess Opportunities and Implement Projects**	**Offer Incentives that Drive Participation**
Reasoning	A large building does not necessarily have a cooling tower. It takes research, good data sources, and follow up verification to confirm cooling tower presence.	Often there are 5-10 individuals that influence a go / no go decision regarding cooling tower upgrades. You may need to secure buy in from multiple parties.	Each individual role tied to a property has unique motivations for implementing projects. Marketing must include all individuals with tailored messaging and outreach for each.	Customers require hand-holding along the way or they will drop off at some place in the process. They typically need help assessing the viability of upgrades, securing technology vendors, and applying for incentives.	Water savings alone does not drive projects. Incentives and benefits must be enticing and the program process needs to be reasonable.

Figure __. Five Key Activities of Cooling Tower Water Use Efficiency Programs

Key Activity #1:
Finding Properties With Cooling Towers

Identifying cooling tower sites takes investigation and time. Your inventory list will, most likely, be built by accessing several data sources and employing multiple methods of research. Typical properties with cooling towers include:

- Multi-story office buildings
- Hospitals
- Data centers
- Universities and campuses
- Large multi-family
- Large hotels
- Industrial sites (e.g., cold storage, dye houses, food processors)

The place to start is by utilizing AWE's Cooling Tower Estimating Model for two key functions:

1) To generate an estimate of the number of cooling towers in your service, and
2) To begin building an inventory of cooling tower locations.

To the right is an overview of the steps for generating CTEM estimates.

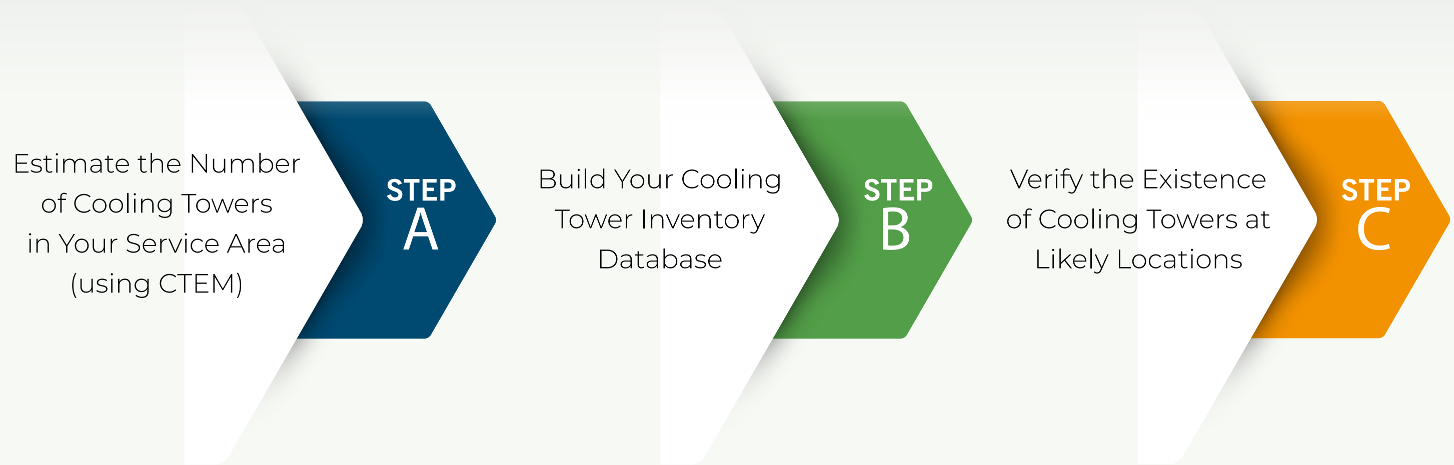


Figure __. Steps to Estimating Number of Cooling Towers and Developing an Inventory

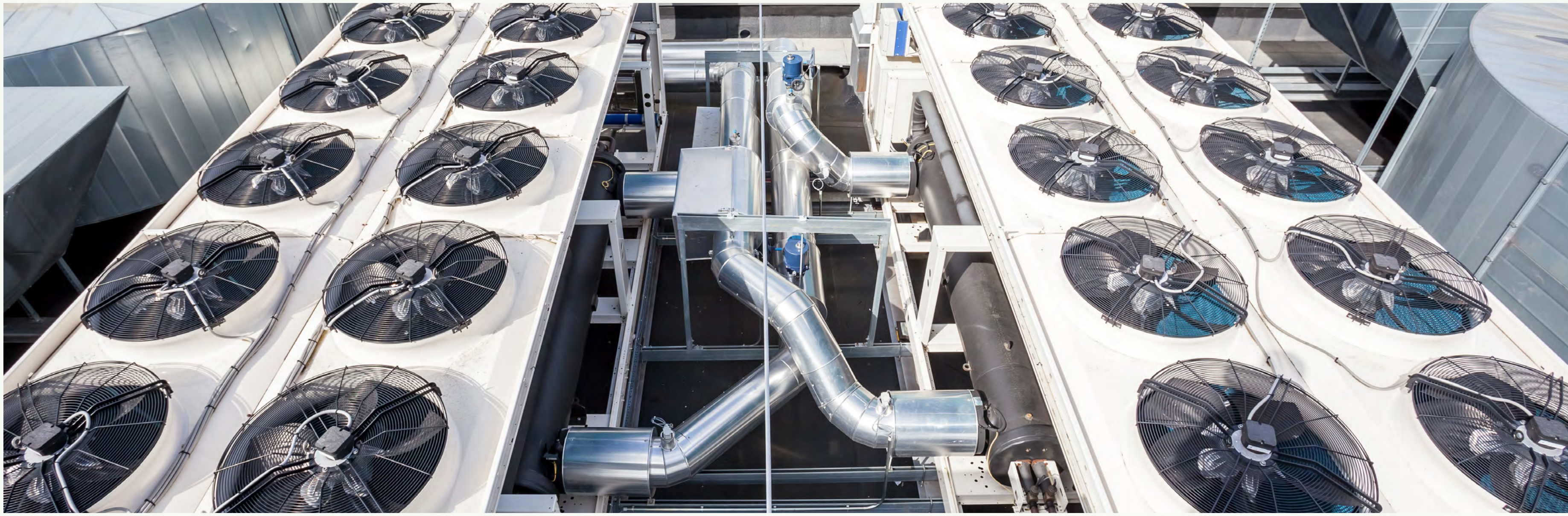
STEP A

Estimate the Number of Cooling Towers in Your Service Area

Your first step will be to develop an estimate of the number of cooling towers that are likely to be located within your service territory. The Base Inputs module of CTEM accomplishes this by generating estimated ranges for:

- Number of facilities with cooling towers
- Total number of cooling towers
- Total cooling capacity
- Consumptive and non-consumptive water use
- Large-scale facilities that are likely to have cooling towers (e.g., airports, data centers, universities, and thermoelectric plants)

Based upon the results, you may determine that the number of sites is minimal and does not justify the development of a robust program. If through other efforts, a building is identified as having a cooling tower, you may opt to address their site on an individual basis.



STEP B

Build Your Cooling Tower Inventory Database

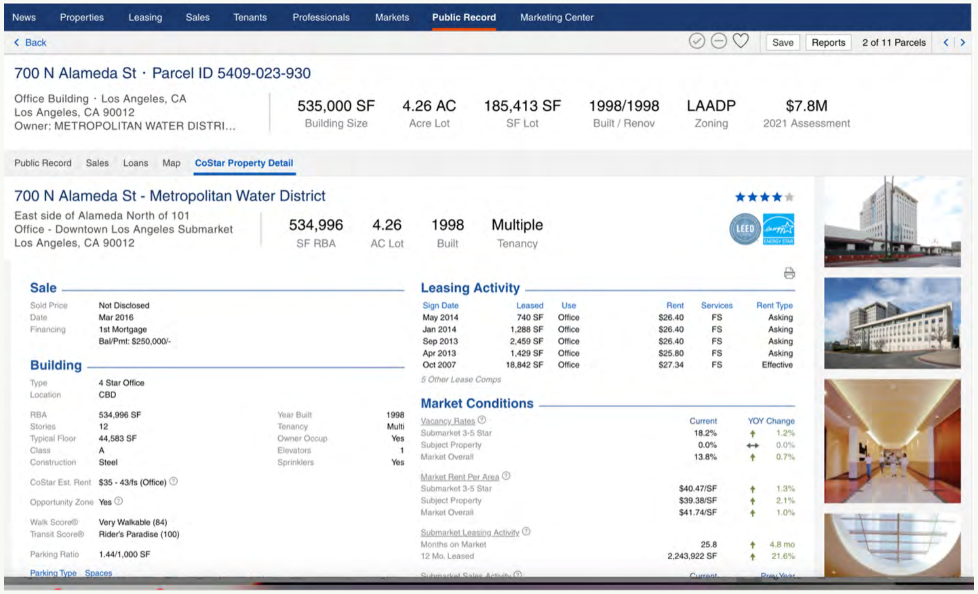
Now that you have your estimate, the next step is to begin building your inventory. Start by downloading cooling tower sites identified by CTEM. As stated, the Base Inputs module generates an auto-populated list of select categories of large facilities likely to have cooling towers.

Next, identify commercial real estate or real property data sources. Organizations that may hold real property data include agencies that assess taxes or issue permits, as well as real estate companies. These can be city, county, or state agencies or private organizations. Examples include:

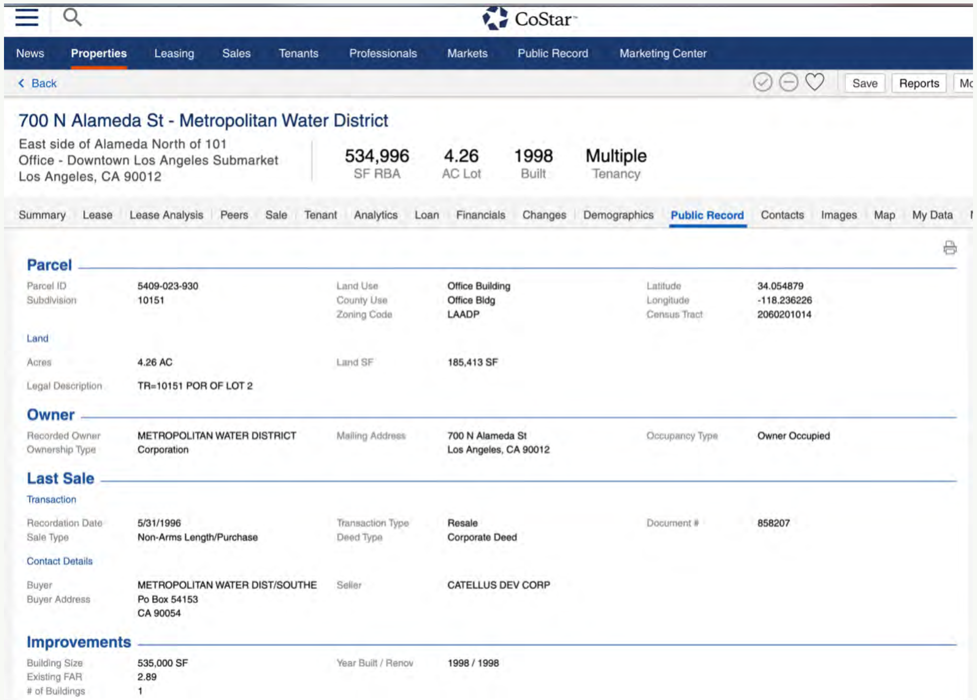
- Tax assessor agencies
- Planning and zoning agencies
- Building and safety agencies
- Community and business development agencies
- Backflow permitting agencies
- City and County open data portals
- Commercial real estate information, analytics, and marketing companies

A great source for building data is commercial real estate data companies that sell data such as CoStar and Reonomy. These subscription services can be expensive however, they provide additional and current information on property ownership and management, as well as contact information for those individuals. On this and the following pages are snapshots of data available through CoStar.

CoStar Building Data Snapshots (Metropolitan Water District's Headquarters)



CoStar Building Data Snapshots (Metropolitan Water District's Headquarters)



Collecting building data can be complicated and time-intensive. Often datasets from multiple agencies will need to be sorted and combined. Agencies also vary in how quickly and willing they are to provide data. A few tips for efficient collection of property data are to:

- Ask internally first - maybe someone else in your organization has already compiled this information for a different purpose.
- Contact and request building data from city, county, and state agencies that maintain real property data for your service area.
- Conduct an internet search to research commercial property databases.
- Select best option for the most complete and accurate dataset. This may require combining datasets. Example: The planning agency data may have all required fields except the number of floors and the tax assessor's agency may have the number of floors.

Note that cooling tower water treatment companies have lists of properties they service or are prospecting. However, they are not likely to share this proprietary information.

STEP C

Verify the Existence of Cooling Towers at Likely Locations

CTEM combines the list of large-scale facilities and individual commercial buildings into one master list that provides the initial cooling tower inventory of high-likelihood locations. Although these results are believed to be robust, they are not 100% accurate. When a building is designed by architects and engineers, no clear processes specify whether a cooling tower must be used. Buildings may be designed with numerous packaged, rooftop units or a cooling tower. For this reason, it is impossible to be absolute about the existence of a cooling tower without physical or visual verification.

Verification of cooling towers can be accomplished in several ways.
Two common methods are:

1. Onsite inspections
2. Visual inspections using satellite imagery

Onsite inspections clearly provide the most accurate verification. Not only will you be able to verify the presence of cooling towers, you can also collect information on cooling tower size, actual use, contact information for the property management and water treatment service provider. In addition, this presents an opportunity to market and enlist customers in efficiency programs. The downside to onsite inspections is that scheduling and visiting each site may be cost-prohibitive.

Tip:
You'll need to verify if the sites do, in fact, have a cooling tower. Aerial imagery review is a good technique to verify the presence of cooling tower equipment. More information on how to identify cooling towers through aerial imagery can be found on page __add link to CTEM

Another available option is visual inspection of properties using satellite imagery. Imagery can be accessed via apps such as Google Earth or your internal GIS platform. Satellite imagery is extremely useful for quickly verifying if a building or facility has cooling towers, however, there can be issues with accuracy. Cooling towers may be hard to identify if they are small, hidden, or if the cooling tower fans are located on the side of the unit.

For many water suppliers the most cost-effective option is to conduct an initial verification using aerial imagery and follow up with onsite inspection for the top priority sites.

The *CTEM User Guide - Appendix A* provides guidance on basic characteristics of cooling towers and how to locate cooling towers in satellite imagery, visually distinguish cooling towers from other cooling technologies, and where to look for cooling towers at commonly encountered building types.

Key Activity #2:
Locate The Decision Makers And Influencers

While it's necessary to know where cooling towers exist in your service area, it's also essential to know who the decision makers are and how to best contact them. Ideally, the program outreach cross-markets to all the key decision makers to increase the chances of contact with an interested individual who is willing to explore program benefits for their property.

Who Makes Decisions about Cooling Tower Upgrades

There are a number of individuals who are integral to the management or operation of a building and play a decision-making or influencer role in whether to participate in a cooling tower program. All should be the focus of your marketing efforts, each with their own motivations for supporting/rejecting participation.

Property Cooling Towers - Decision Makers and Influencers

Figure __. Cooling Tower Project Decision Makers.

Where to Find a Property's Decision Maker Contact Information

The decision maker information may be found through various resources. The following are a few recommended sources to identify ownership, management, tenants, and other property stakeholders:

Real property databases such as CoStar	• Real estate databases many times have contact information for property owners and managers • Requires monthly or annual subscription • If your service area has a substantial number of buildings (or you could use the data for other programs) consider purchasing access to database
Water account information or Utility Account Representatives	• Contact information may be available in your billing system • Account contact information may not be the decision maker but can be a good starting point • Account representatives may already have a relationship with the customer and can introduce you to the decision maker
Professional associations such as Building Owners and Managers Association	• Joining active organizations and participating at events gains you access to your target customers • By being a member of an association, you become a more trusted resource
Local property management firms	• Information on local property management can be found through internet searches • Many of these companies represent multiple properties • Meet with top firms to enlist program support
Local water treatment companies	• Information on water treatment companies can be found through internet searches and asking building owners and operators • Many of these companies serve multiple customers and properties • Meet with top firms to enlist program support and/or identify co-selling opportunities
Local utility counterparts or other public agencies	• Energy utilities, sewer/wastewater district, and public health agencies interact with your target customers and have additional knowledge regarding the property equipment and contact information • Contact these agencies to determine available information and potential partnerships
Internet searches	• There is an abundance of information regarding property ownership on the internet • Spend the time to research best opportunity properties
Cold call site visits	• Although this is time intensive, cold call visits often yield face-to-face opportunities with local facility management and building engineers and operators • Onsite individuals typically can provide ownership and management names and contact information

Again, this may take time to gradually build the dataset. However, this information is useful for all water efficiency outreach efforts.

Now that the key stakeholders have been identified, you'll need a strategy to connect with these individuals and motivate them to take action.

Each decision-maker or influencer has their own reasons whether or not to participate in a cooling tower program. When marketing to each, it is important to understand their motivations in order to develop a "sales pitch" that will best resonate best with them.

Motivations of Decision Makers and Influencers:

- **Owners and investors** look for ways to increase the value of the property and net profit. More recently, they may be interested in their company's Environmental, Social, and Governance (ESG) rating.
- **Property management firms and/or asset managers** often focus on reducing operating costs and improving building safety.
- **Facility managers and building engineers** work to maintain optimal system performance, equipment longevity, cost efficiency, and a system free from health and safety issues. These individuals will often know the most about a building and its equipment. They can be the biggest proponent or a major barrier.
- **Tenants** care about comfort, health, and safety. A subset of tenants may have triple net lease agreements making them responsible for utility costs, therefore are interested in achieving lower water and wastewater billings.
- **Sustainability officers or managers** are charged with maintaining full environmental and regulatory compliance for the site, as well as implementation of future sustainability goals. If a company has this role these individuals can be a project champion.
- **Water treatment vendors** provide water treatment services for properties with cooling towers. Many vendors are committed to adding value for their clients, such as water efficiency upgrades, as long as they don't comprise their profits or cooling system reliability.

In general, building owners and operators care about building performance with optimized operational costs, enhanced building health and safety, and a viable resilience strategy.

To connect most effectively with customers, it's important to "speak their language" and show you understand their business motivations. Program marketing should highlight and promote the following benefits:

- Improved building performance
- Reduced operating costs
- Improved building health and safety
- Increased building resilience
- Advancement of climate-proofing strategies
- Raised Environmental, Social, and Governance (ESG) rating

Use Others to Help You Sell Your Program

As stated, there are businesses, organizations, and public agencies that have relationships with your target customer. Much time and effort can be saved by leveraging these groups. They also can become a sales proponent if they see value for their members or customers in the program you are providing.

Leverage the Water Treatment Industry

Water treatment companies offer water efficiency products and services to your target customers and know the building's equipment, the operations manager, and, most likely, the other key decision makers. By fostering a good working relationship with water treatment companies, the more progressive companies will recognize the benefits of a cooling tower program and work with you to promote the program and gain access to the decision makers.

Leverage Business and Trade Organizations

Property management companies, building investors/owners, and sustainability and operations managers typically participate in business and trade organizations. By joining regional organizations and attending local conferences, program personnel have access to key decision makers for your target sites.

Business and trade organizations examples:

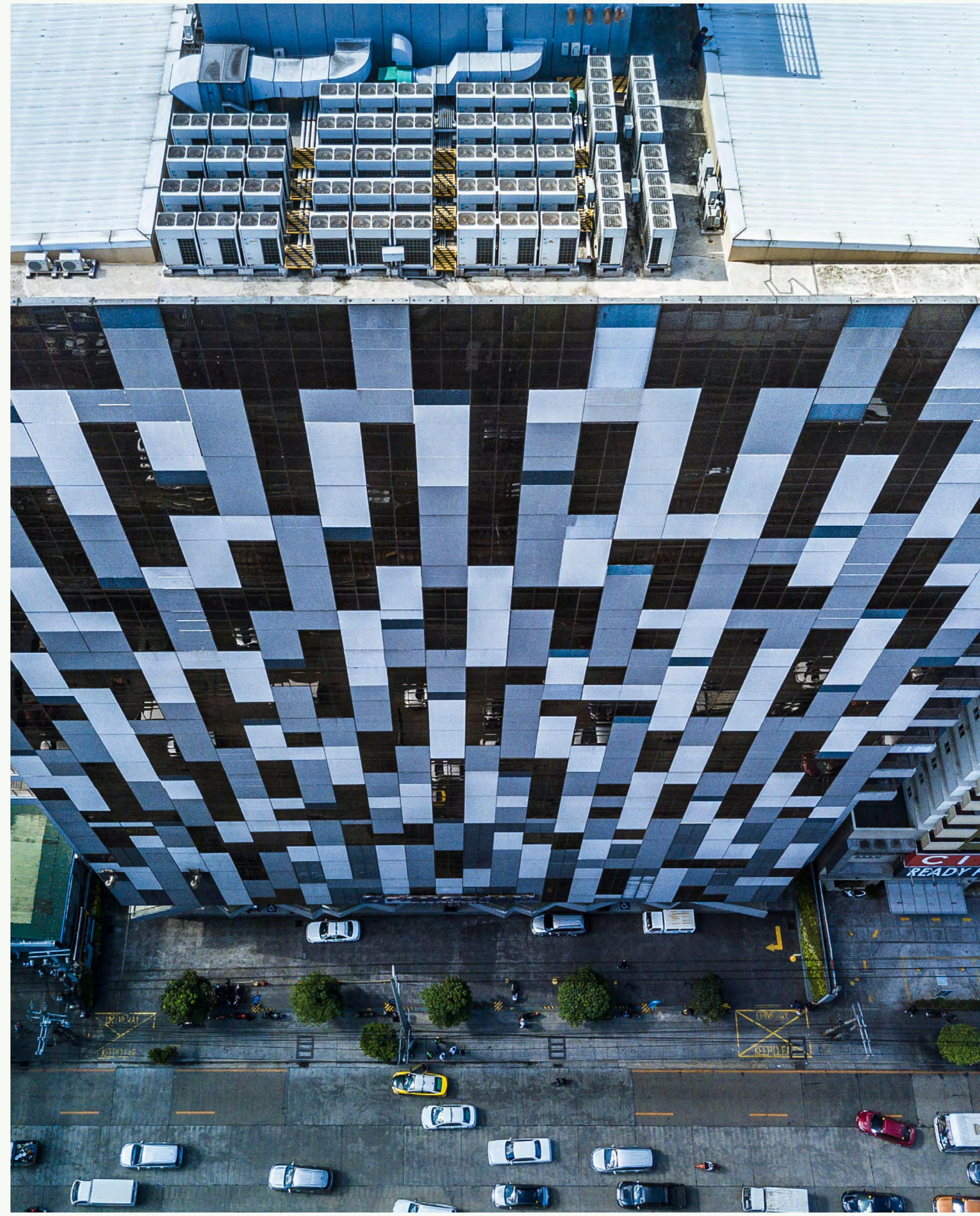
- Building Owner and Maintenance Association (BOMA)
- US Green Building Council Regional Chapters
- Green Building Organizations
- Property Management Associations
- Sustainability Manager Organizations
- Apartment Owner Associations
- Chambers of Commerce

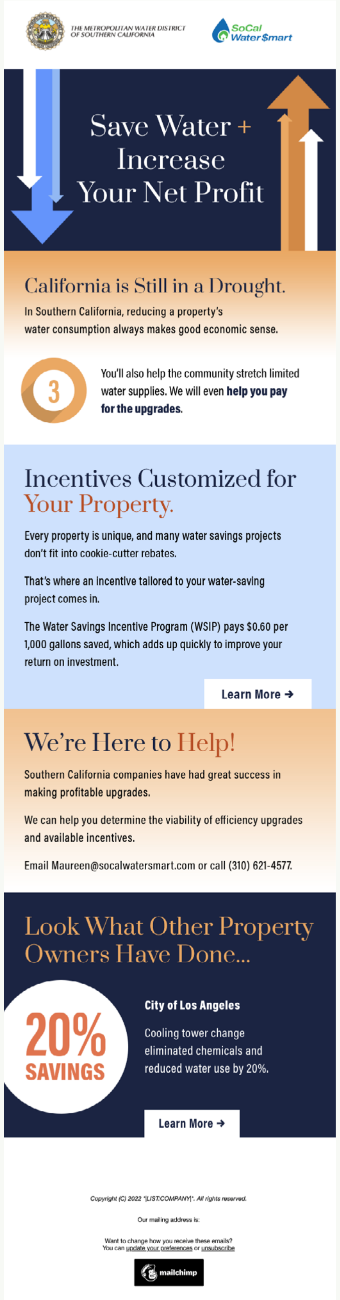
Leverage Utilities and Public Agencies

There are also numerous public agencies and private companies that have established relationships with your target customers. It makes sense to reach out to these organizations and take advantage of their knowledge and contacts. Below are a few examples of these organizations.

- **Energy utilities or your energy supplier counterpart** - energy utilities may have HVAC rebates and CII rebates that complement a cooling tower upgrade.
- **Energy Service Companies (ESCOs)** - develop, build, and arrange financing for energy efficiency projects and many times they will target HVAC systems and offer water efficiency upgrades.
- **Sewer/Wastewater/Sanitation Districts** – may have list of customers that have applied for permits or evaporative cooling sewer credits.
- **Public health agencies** – may have, or be building, an inventory of cooling towers to control and manage legionella outbreaks in cooling tower systems.

Many public health agencies are working to register cooling towers in order to verify cooling towers are being operated to meet health standards and track and control for legionella outbreaks. New York City, New York State and Vancouver BC are examples of locations with cooling tower registries. Water suppliers should contact their local public health agency to see if they have a registry (or one in the works) and are willing to share the property information.





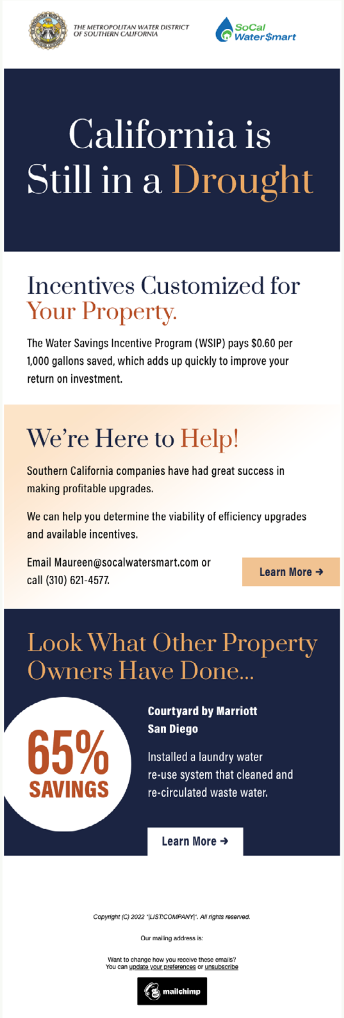
Conduct Multi-pronged Outreach

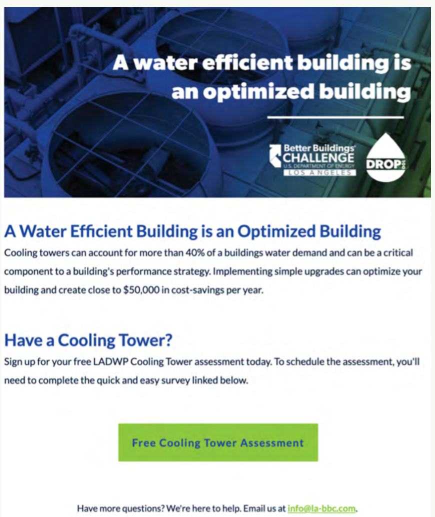
Complex sales processes require multiple contacts with multiple individuals before a go / no decision is made. Typically, numerous forms of outreach, such as emails, phone calls, meetings, and onsite visits are necessary to close the deal. No matter what means is utilized, the outreach needs to be personalized.

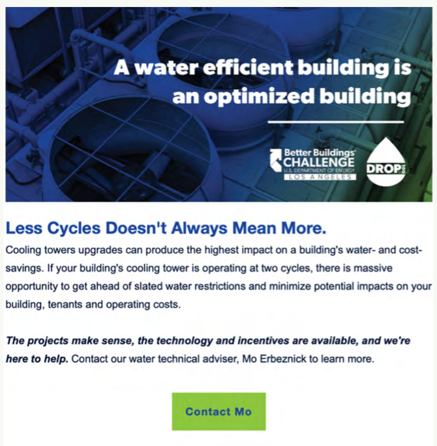
When making initial contact, emails and phone calls work better than direct mail and postcard collateral. When personalized, this outreach provides an opportunity to speak to the customer's specific goals and concerns.

Start the outreach process via email. Develop an eye-catching design with clean, straightforward messaging about the program's offer and benefits for the email's reader. Examples are provided on this and the next page. Offer online tools (if available), website links, and a contact phone number that connects live to a program individual skilled in communicating with building professionals. If your water supplier does not have the marketing, sales, or manpower resources it may be beneficial to utilize outside consultants.

The following are sample emails utilized by the Metropolitan Water District and Los Angeles Department to Water and Power cooling tower programs:







Within a week or two following delivery of the program emails, initiate telephone calls to your contact list of names. Develop a script and practice prior to initiating phone contact, ensuring that the interaction is professional and effective. You will want to secure the decision makers' interest and provide something of value to them. This may be accomplished by extending an offer for a cooling tower audit, in-person assessment, or online self-assessment. Consider the call a win if there's a next step.

Tip:

Be sure to document your efforts, even ones that failed or no one answered. It can sometimes take a lot of effort to find the right "in" and you'll want to have a paper trail for yourself. This is even more important if multiple people are working on the program. Create a system where everyone can stay on the same page and come across as a cohesive team when interacting with the customer.

Emails and telephone solicitations typically do not result in a high percentage of "sales." You'll likely send numerous emails and make multiple calls before securing an interested customer. Despite this, many of these individuals own or operate multiple buildings. Once secured, this can lead to upgrades in multiple buildings resulting in significant water savings.

Tip:

Don't give up. You may need to contact many individuals many time before finding success.

Key Activity #4:
Help Customers Assess Opportunities and Implement Projects

Once you've gained the interest of a decision maker, it's likely that they will need further support and information before agreeing to participate in the program or take any action.

The following chart outlines a recommended sales and customer support process. Just like with landscape programs, customers often "get stuck" in the decision-making and implementation process. Customers require hand-holding along the way in order to ensure project completion. This may include the need for: site specific assessments, investment analysis, proof of technology, connection to technology providers, and continuous check-ins to overcome obstacles.

Recommended Sales Process

Form relationships to promote programs with:

- Cooling tower water treatment vendors
- Professional business associations
- Other partners

01 Offer water audits and assessments

02 Present upgrade options, incentive package, and ROI

03 Share proof of technology through case studies and peer-to-peer networking

04 Connect customers with technology and service providers

05 Provide customer support through the decision making and installation process

Conduct periodic customer contact to facilitate project advancement

Cooling Tower Audits

Decision makers will only invest their time on an upgrade project that they recognize as having the potential for substantial benefits.

Cooling tower audit programs can provide quick and easy assessment tools to estimate cost, savings, and payback potential for the customer.

A standard cooling tower audit is an assessment of how a building could reduce its water usage by upgrading its cooling tower water treatment and systems. Audits provide building owners with actionable information on the financial impacts of a range of potential improvements to their cooling tower system. The audit should include an inspection of the cooling water system and testing the water quality of the makeup and blowdown water. In addition, it is a good practice to review records such as service reports from the property's water treatment provider.

In-person audits establish relationships with the customer and, knowing the site specifics, allows for tailored recommendations. However, these audits can be expensive and time consuming. Water suppliers need to balance provision of this, and the level of detail done through the audit. Many water suppliers find extensive, engineering-level audits do not typically result in completed projects. Most customers need only a basic analysis to assess the investment and understand risks.

Tip:
Bring water consumption history to the audit. Not all individuals involved may have access to that data. Can be used to engage customer.

Key information to collect:

1. Is the makeup and blowdown water metered?
2. For what process is the cooling tower used?
3. Total tonnage of chillers associated with the cooling system
4. Typical operating cycles of concentration of the system
5. Typical number of hours and days the system operates
6. Typical percent of capacity utilized over the cooling season

This data is sufficient to identity the water savings and demonstrate to the customer the opportunity for water, wastewater, and monetary savings. If you don't have the staff or technical expertise, a third-party vendor can be contracted to perform audits.

AWE Cooling Tower Upgrade Simple Return on Investment Calculator

AWE has created a simple return on investment calculator available at https://www.a4we.org/impact/our-work/awe-cooling-technology-study.

TREATMENT PROGRAM DETAILS				
Treatment Setup	Water Treatment (Use dropdown menus & estimate CoCs for improved setups)	Blowdown Recovery	If using Blowdown Recovery, what percentage of blowdown is recovered?	Estimated Cycles of Concentration (CoC) (based on treatment)
Existing Treatment Program	Acid/pH Control [CoC ~4-5]			4.5
Improved Treatment Program Setup A	Advanced Pretreatment (e.g., filtration, RO, etc.) [CoC ~10+]			25.0
Improved Treatment Program Setup B	Electrochemical [CoC ~10+]			10.0
Improved Treatment Program Setup C	None	Yes [Enter Blowdown Recovery percentage to the right]	55%	8.0

TREATMENT PROGRAM COSTS AND WATER USE ESTIMATES									
Treatment Setup	Annual Operation and Maintenance Cost ($/year)	Annual Total Water & Wastewater Cost ($/year)	Total Annual Cost ($/year)	Annual O&M Savings from Existing Program ($/year)	Annual Evaporative (Consumptive) Water Use (HCF/year)	Annual Blowdown (Non-Consumptive) Water Use (HCF/year)	Annual Makeup (Total) Water Use (HCF/year)	Annual Makeup (Total) Water Demand Reduction (HCF/year)	Annual Demand Reduction (GAL/year)
Existing Treatment Program	$250,000	$293,584	$543,584	$0	26,915	7,690	34,605	0	--
Improved Treatment Program Setup A	$250,000	$208,226	$458,226	$85,358	26,915	1,121	28,036	6,569	4,913,254
Improved Treatment Program Setup B	$250,000	$232,515	$482,515	$61,069	26,915	2,991	29,905	4,699	3,515,173
Improved Treatment Program Setup C	$250,000	$243,618	$493,618	$49,966	26,915	1,730	28,645	5,960	4,457,879

SIMPLE RETURN ON INVESTMENT (ROI) CALCULATOR*									
Treatment Setup	Capital Cost ($/upgrade)	Pay-for-Performance Incentive ($/HCF saved)	Period of Pay-for-Performance Incentive (years)	Total Incentive over Full Period of Pay-for Performance Incentive	Annual Incentive over Period of Pay-for-Performance Incentive ($)	Annual Savings for Period of Pay-for-Performance Incentive* ($/year)	Annual Savings Without Pay for Performance Incentive* ($/year)	Fixed One-Time Equipment Rebate Incentive ($/upgrade)	Simple Payback Period** (years)
Improved Treatment Program Setup A	$125,000	$6.36	4	$167,103	$41,776	$127,134	$85,358	$3,000	0.96
Improved Treatment Program Setup B	$200,000	$6.36	4	$119,553	$29,888	$90,957	$61,069	$3,000	2.17
Improved Treatment Program Setup B	$200,000	$6.36	4	$151,616	$37,904	$87,870	$49,966	$3,000	2.24

* Does not include discount rate or cost escalations

Online Audits

The audit can be made available either through an online or onsite format. Water suppliers should consider developing an online audit tool. The immediacy of results provides quick information and keeps the customer engaged. An online tool should incorporate a return on investment calculator. Based upon recommended upgrades, an investment calculator should provide immediate estimate of cost, savings, and payback. AWE has created a simple return on investment calculator available at https://www.a4we.org/impact/our-work/awe-cooling-technology-study.

There are a number of benefits to developing and utilizing an online audit tool with an investment calculator. These include:

- Easy to offer to a larger audience of customers
- Less costly than in-person visits
- Automated communication can be generated to offer further customer support
- Water supplier can follow up with customers on high potential sites
- Allows customers to model different upgrade options

Sample Audit Templates and Guidance Documents

LADWP Audit Template
https://www.a4we.org/impact/our-work/awe-cooling-technology-study

San Antonio Water System Audit Template
https://www.a4we.org/impact/our-work/awe-cooling-technology-study

***City Energy Project Water Audit Guidance for Commercial** Buildings https://www.cityenergyproject.org/resources/water-audit-guidance-for-commercial-buildings/*

Customer Reports

Customers often desire some type of written documentation regarding the potential opportunity. Generally speaking, highly technical reports are not desired by customers. They prefer easy-to-read reports with key data points and visuals. Reports should provide more in-depth information on the recommended upgrades including the average cost range, annual water and wastewater savings, current and projected cycles of concentration, and typical ROI. The report could also provide highlights of the retrofit process, metering requirements, technology pros and cons, available incentives, and program requirements for incentive payments.

It is also valuable to provide a graphic depiction of the potential savings as cycles of concentration are increased.

WATER AGENCY LOGO

SAMPLE

Cooling Tower Report

PROPERTY INFORMATION

Name: ABC Company
Address: 123 Main Street
City: Some City
Zip: 90000

REPORT PREPARED FOR

Name: Hugo First
Title: Chief Engineer
Cell Phone: (213) 231-1234
Email: hfirst@abccompany.com

EFFICIENCY RATING

Your Cooling Tower Water Efficiency Rating for this property is:

AVERAGE

For this property the CoC could be increased to:

10-20 CoC, saving 1.5 - 6 MGY

COOLING TOWER INFORMATION

Thermal Load: 12,500 tons
Percent Load: 17%

CURRENT WATER TREATMENT AND USAGE

Current Program: Acid Treatment for pH Control
Annual Water Usage: 22,443,400 Gallons
Annual Blowdown: 6,412,200 Gallons
Estimated Cycles of Concentration: 3.5

Water Efficiency Opportunities for Your Property

	ESTIMATED ANNUAL WATER SAVINGS	ESTIMATED CAPITAL COSTS	ESTIMATED INCENTIVE	ESTIMATED ANNUAL UTILITY SAVINGS	SIMPLE PAYBACK
WATER SOFTENING Pretreat makeup water through ion exchange to remove hardness and increase cycles to 6-8.	1.4 MGY	$50,000	$47,600	$28,851	1 month

Considerations:
Water softeners require onsite space for water softener equipment including resin and brine vessels and manpower resources to monitor the system and add salt for brine production. Water softeners also use additional water to flush the brine. Eliminates the need for acid and supplemental chemical scale inhibitors. Maximizes COC for the price point.

Technology Provider: Existing water treatment vendor offers softening as a water management solution.

Case Studies: Other great companies

Customer Testimonials and Case Studies

Testimonials and case studies are powerful sales tools. Testimonials increase a reader's confidence in technologies, services, and financial performance incentivized through a program. Case studies are shown to be more effective than brochures and traditional sales collateral. They tell the story of real-world experience with the program. These case studies provide customers with proof of technology and/or proof of program success. Customers need proof before they elect to move forward with a project.

It's recommended to include contact information for the profiled customer or service vendor in the case study. This allows the prospective customer to make direct contact and talk openly about the project pros and cons. Below are case studies from Metropollitan Water District's Water Savings Incentive Program.

CaseStudy | LA City Hall East

LA City Hall East achieves **20% Water Savings** and **85% Reduction in Sewer Charges** Through Electrochemical Cooling Tower Water Treatment System

Water Savings Incentive Program

IMPACT + RETURN ON INVESTMENT

1.2 MILLION GALLONS per year in water savings

$34K SAVINGS in reduced annual water, sewer and maintenance costs

85% REDUCTION in sewer charges

+

- Significant maintenance cost savings
- Eliminated need for corrosion-inhibiting chemicals
- Extended the life of the equipment

PROJECT DESCRIPTION

The City of Los Angeles has set aggressive goals in its Sustainability pLAn, which applies to both the private and public sectors. Specific to water, LA plans to source 70% locally and recycle 100% of all wastewater by 2035, as well as reduce potable water use per capita by 22.5 percent by 2025.

Cooling towers often represent the greatest potential water savings in large buildings. LA's source water can contain high amounts of dissolved minerals, so chemical-based approaches are often used to protect equipment. With a portfolio of large buildings, the City identified new cooling tower technologies as a key opportunity to reduce water usage. Beyond saving water, the City wanted to reduce sewer discharges and annual maintenance costs, expand the life of cooling towers, and eliminate the use of chemicals for worker safety and environmental reasons.

The City partnered with Dynamic Water Technologies – Universal Environmental Technology (DWT–UET) to implement the technology that could accomplish these goals.

The Dynamic Water Technology uses a carefully controlled electrolysis process to split water into H+ and OH- ions, creating a dynamic equilibrium between the pH and alkalinity to minimize corrosion and better manage mineral scaling in the cooling tower. The process promotes mineral and silica scaling in the reactor instead of the tower and heat exchanger tubes. This process also facilitates combination of hydrogen ions and chloride naturally present in the water creating chlorine, which acts as a biocide to prevent fouling.

The City achieved 20 percent overall water savings (1.2 million gallons), 85 percent reduction in sewer charges, significantly reduced maintenance costs, and eliminated the need for corrosion-inhibiting chemicals -- all while extending the life of the equipment.

Pre-Dynamic Water Installation

Post-Dynamic Water Installation

THE METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

SoCal Water$mart

PROGRAM CONTACT

Maureen Erbeznik ▸ (310) 621-4577

Maureen@socalwatersmart.com

CaseStudy | Kaiser Permanente Harbor

Kaiser Permanent Harbor Implements TDS-Reducing Technology in Cooling Towers and **Saves 4 Million Gallons per Year**, Lowers Chemical Usage, and Preserves Equipment Life

Water Savings Incentive Program

IMPACT + RETURN ON INVESTMENT

4 MILLION GALLONS per year in water savings

$82K SAVINGS in reduced water and sewer costs

$10K SAVINGS in lowered water treatment and chemical costs

$20K IN UTILITY INCENTIVES

+

No measurable performance losses in heat transfer efficiency, corrosion rates of their chiller systems, or Legionella risk management

PROJECT DESCRIPTION

Kaiser Permanente (Kaiser) is one of the largest nonprofit healthcare providers in the United States. As a part of their overall environmental stewardship effort, Kaiser committed to reducing water consumption at their facilities by 25 percent per square foot by 2021. The Harbor City hospital was using over 16 million gallons of water per year for evaporative cooling, providing a prime opportunity for water savings. The incoming water quality at the Harbor City site is high in mineral content, typically requiring a higher bleed-off rate from cooling towers to the sewer in order to prevent equipment damage from excess mineral scaling.

Kaiser implemented EAI Water's radial deionization technology to reduce the total dissolved solids (TDS) in cooling tower make-up water. By lowering the TDS in the make-up water, EAI was able to increase the number of cycles of concentration and reduce the blowdown, which decreased both water consumption and sewer discharge laden with waste contaminants and chemicals.

THE METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

SoCal Water$mart

PROGRAM CONTACT

Maureen Erbeznik ▸ (310) 621-4577

Maureen@socalwatersmart.com

Webinars and Presentations

When executed well, a webinar or an in-person presentation provides an interesting and informative platform for delivery of valuable content while allowing dialogue about real-world experiences with cooling technology upgrades. These events can be done in collaboration with a local Chamber of Commerce or other business associations.

Webinars make it easy for participants to attend without having to leave their desk and can be recorded and made available for later viewing to increase reach. Topics could include:

- General education on how cooling towers work and the opportunity for water savings
- Specific information regarding new and innovative technologies
- Peer-to-peer information sharing through case studies and panel discussions
- Local incentive program information

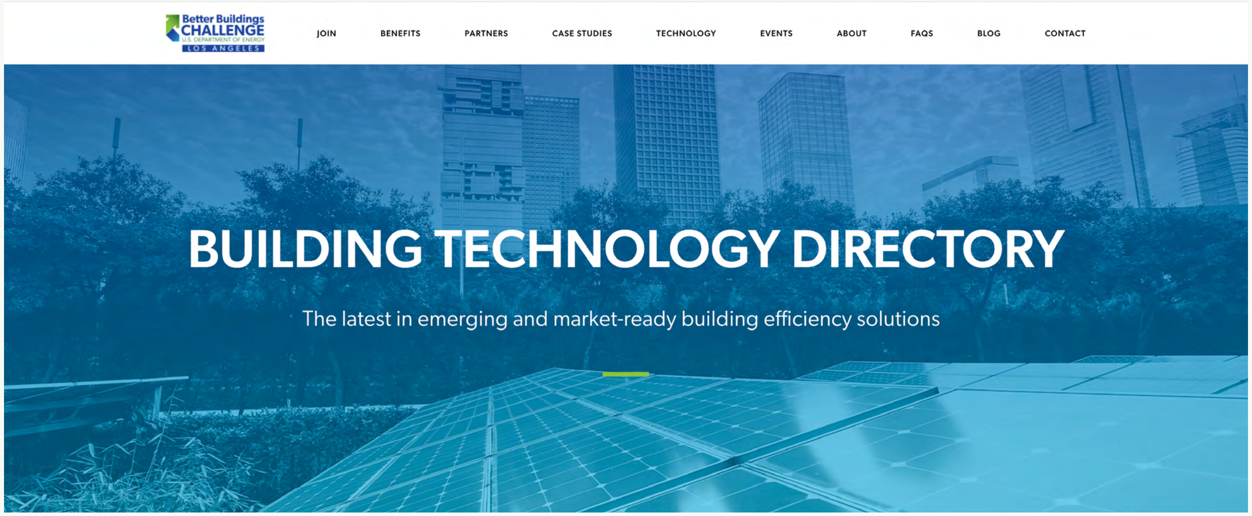
Directory of Technology Providers

A major sticking point for customers is not knowing where to find vendors that offer water efficiency products and services. Customers want easily searchable directories of vetted water treatment companies and technology providers. As such, water suppliers should consider the future development of a directory of technology providers. Companies and technologies could be vetted through an RFQ process.

The water suppliers should also consider creating a Cooling Tower WUE Certification for vendors and technicians. This could be possible through the Alliance for Water Efficiency, WaterSense, or other industry organizations.

The Los Angeles Better Buildings Challenge, funded through the Los Angeles Department of Water and Power, recently assembled a directory of technology providers. The directory not only provides information about businesses and organizations that can help, but it's also an interactive resource providing detailed information on technologies.

https://www.la-bbc.com/technology-directory



Customer Support Services

Water suppliers should strive to support a "one-stop shop" for building owners to access integrated program services. By consolidating services such as water audits, retrofit analysis and recommendations, incentive programs and educational resources, water suppliers will be able to better motivate and lead customers along the pathway to increased water use efficiency. The easier it is for building owners and decision makers to take action, the higher participation will be.

Effective customer support services accomplish this through the following means:

- Continually communicate the value of the upgrade and program to the individual customer
- Stop "breakdowns" from occurring
- Get a customer started OR back on track

Program experience shows that building owners benefit from access to people who can help navigate program offerings and provide project development and technical assistance, such as initial assessments, audits, and project support.

The individuals in a "one-stop shop" can become trusted advisors to customers. The people in this function should be specialists and empowered to build relationships with local partners, such as vendors, business associations, and local public agencies.

Key Activity #5:
Offer Incentives That Drive Participation

Incentives help customers increase their return on investment and lower the upfront cost. The higher the incentive amount, the better the project ROI, and lower the payback period. Most customers are looking for a payback period of less than two years and often less than one year.

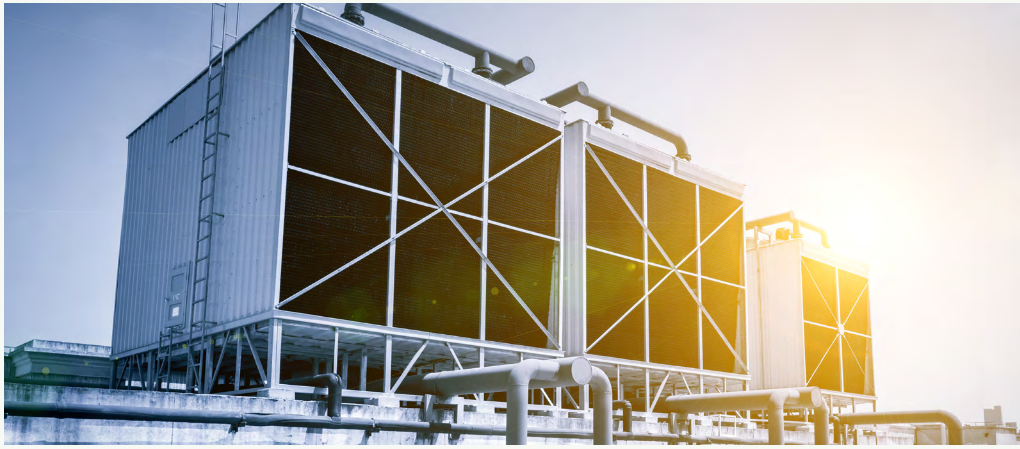
However, not every water supplier is able to offer incentives. These water suppliers will need to focus on customer education and rely on the value of the project's water and wastewater savings.

Cooling tower upgrades are different than standard water efficiency measures. They are not a one-for-one replacement like toilets, showerheads, or even irrigation equipment. There are a multitude of considerations per project including:

- What cycles of concentration is the cooling tower currently operating?
- What is the current water treatment program?
- What is the cooling tower size and cooling load?
- What is the quality of the local water supply? Does that change throughout the year?
- Does the customer have onsite maintenance staff knowledgeable in cooling tower system management?
- Are there meters on makeup and blowdown water use?
- Are there local restrictions regarding wastewater discharge?
- Where is the tower located and are there any accessibility issues?

All of these factors combine to make it a challenge to create a standardized one-size-fits-all incentive.

Cooling tower incentives need to be large enough to motivate customers, while at the same time ensuring the water supplier gets verified and cost-effective water savings. The incentive payment structure is ideally simple with a reasonable monitoring period allowing the customer to get paid expeditiously. When program payments are overly complicated, response rates are negatively impacted.



Incentive Program Structure Options

There are a number of formats for cooling tower program incentive structures. Each design has its benefits and drawbacks. Below are the most common incentive structures currently being used by water suppliers.

Custom Incentive Based Upon Engineering Savings Calculations – Non-monitored

One payment option is a custom incentive that is calculated by using an engineering estimating model to predict water savings for the implementation of the water efficiency technology. The savings calculation is based upon the size of the cooling tower system, the hours of operation, current operating COC, target COC, and the system upgrade technology. Savings are calculated based on the engineering estimating model, with no metering of before and after water usage.

This payment design is straightforward and the least administratively burdensome option. The customer is paid quickly and in full. The risk associated with this option is that the engineering model is wrong, and the predicted savings numbers are not accurate. Savings could be lower than expected and the water supplier overpays for savings OR the water savings is higher, and the water supplier gets a greater benefit from the project but is not aware of those savings.

Custom Incentive Based Upon Measured Savings – Monitored (Pay for Performance)

With this payment option similar to the non-monitored incentive model, the customer has an engineering report demonstating the expected water savings numbers for the cooling tower upgrade. However, the customer gets paid the full incentive if there are documented savings.

Most water suppliers are paying up to 50% of the incentive upfront (based upon the engineering model) and the remaining percentage after a specific period of monitored water use. This design provides the customer with some immediate incentive money but ultimately pays for delivered water savings.

This option is best for larger projects with multiple variables and/or emerging technologies where water savings is more difficult to estimate upfront.

Standard Equipment Rebates for Controllers

Fixed incentives are the easiest for water suppliers to administer and the most favored by customers. It makes sense to provide a fixed incentive for cooling tower controllers. Controllers are industry-standard devices for monitoring pH and conductivity. They may not always directly save water because their function is to measure and monitor water quality. Incentives typically range between $650 - $1,750 per controller.

Water suppliers should consider incentivizing the installation of meters for makeup and blowdown water use. With more information on actual use, customers are more likely to take action.

Service Vendor Direct Incentive

Savvy service vendors use water supplier incentives as a selling point when encouraging customers to invest in cooling system upgrades. When these vendors are directly paid the incentive, they more actively promote the incentive programs. That's for two reasons: first, the incentives are an economic selling tool and second, direct payment results in better cash flow. For this payment structure there should be a screening process to verify that the vendor operates with integrity and professionalism. This is to mitigate the risk of a vendor collecting the incentive and leaving the customer without the agreed-upon services.

Split Incentives between Customer and Service Vendor

A hybrid incentive structure is to split the incentive payment between the customer and their service vendor. This format allows the customer to be part of the incentive agreement and payment process while still providing the vendor with improved cash flows from partial direct incentive payment. The downside to this incentive structure is that the water provider may be contacted more often with vendor/customer disputes.

Incentive Structure	Pros	Cons
Custom Incentive Based Upon Engineering Savings Calculations – Non-monitored	▸ Quick customer payment ▸ Straightforward program process ▸ No need for protracted monitoring and multiple payments over time ▸ Customer-preferred payment structure and likely increases response rate	▸ Water savings not measured and could be higher or lower than estimates ▸ System operation can change after incentive is paid and may impact water savings
Custom Incentive Based upon Measured Savings – Monitored	▸ Incentives only paid if there are verified savings	▸ Payment process can be complicated and lengthy, discouraging program participation
Standard Equipment Rebates for Controllers	▸ Fixed incentive programs are easier to implement ▸ Less complicated for customer to participate	▸ Installation of controller does not ensure water savings
Service Vendor or Third Party Direct Incentive	▸ Contractor or third party becomes de facto program sales agent and can help drive program participation	▸ Relying on integrity and professionalism of the service vendor ▸ Vendor could cease to operate, stranding customers and impacting water savings
Split Incentives Between Customer and Service Vendor	▸ Provides motivation for both customer and service vendor	▸ More complicated payment process ▸ Could result in water supplier getting involved in customer/vendor dispute

Other Program Options

Cooling Tower System Efficiency Certifications

Much like the **WaterSense labeling** for products or **LEED green building rating**, a well-promoted certification program adds value to the product or equipment that meets performance standards of excellence. A certification of water efficiency for a cooling tower system may boost economic and environmental values for the site.

Mandatory Cooling Tower Registration

Water suppliers can greatly increase their ability to achieve water savings in commercial buildings when there is a city, regional, or state requirement for a cooling tower registry. By requiring commercial cooling towers to be registered, water suppliers would gain a better understanding of where cooling towers are located, how many there are and what types of cooling tower optimization technologies are being used. It also could allow water suppliers to track cooling tower performance over time, identify emerging trends and share best practices with building owners and operators.

PROGRAM EXAMPLES

Numerous water suppliers have existing cooling tower programs from audits to rebates to customized incentives. Many water suppliers offer "custom rebate" or "pay-for-performance" type incentive, where cooling tower improvements qualify, but isn't necessarily a specific cooling tower focused program. Others offer device-based rebate and audits or assessments. Below is a list of several programs, the program description, incentive level, and water supplier contact.

Water Supplier	Program Name and Website	Program Description	Incentive Level	Water Supplier Contact
City of Austin	**Cooling Tower Registration Program** https://www.austintexas.gov/page/cooling-tower-efficiency-program	All existing cooling towers must be registered. New cooling towers should be registered prior to the start of operation.	NA	**Daniel Cavazos, REM** Environmental Compliance Specialist, Senior (512) 974-3534 Daniel.Cavazos@austintexas.gov
City of Austin	**Water Savings Incentive Program (WSIP)** https://www.austintexas.gov/page/cooling-tower-efficiency-program	Pay-for-performance	$1.00 for every 1,000 gallons saved annually over a 10 year life	**Daniel Cavazos, REM** Environmental Compliance Specialist, Senior (512) 974-3534 Daniel.Cavazos@austintexas.gov
Los Angeles Department of Water and Power	**Cooling Tower Assessment Program**	Brief on-site evaluation of cooling tower system cooling tower system	FREE Service	**Mark Gentili** Manager – Water Conservation Programs (213) 367-8556 mark.gentili@ladwp.com
Los Angeles Department of Water and Power	**Technical Assistance Program (TAP)** https://bit.y/3a6xNFQLADWPTAP	Pay-for-performance	$2.50 per 1,000 gallons saved over 2-4 year period **Increased during periods of water shortage*	**Mark Gentili** Manager – Water Conservation Programs (213) 367-8556 mark.gentili@ladwp.com

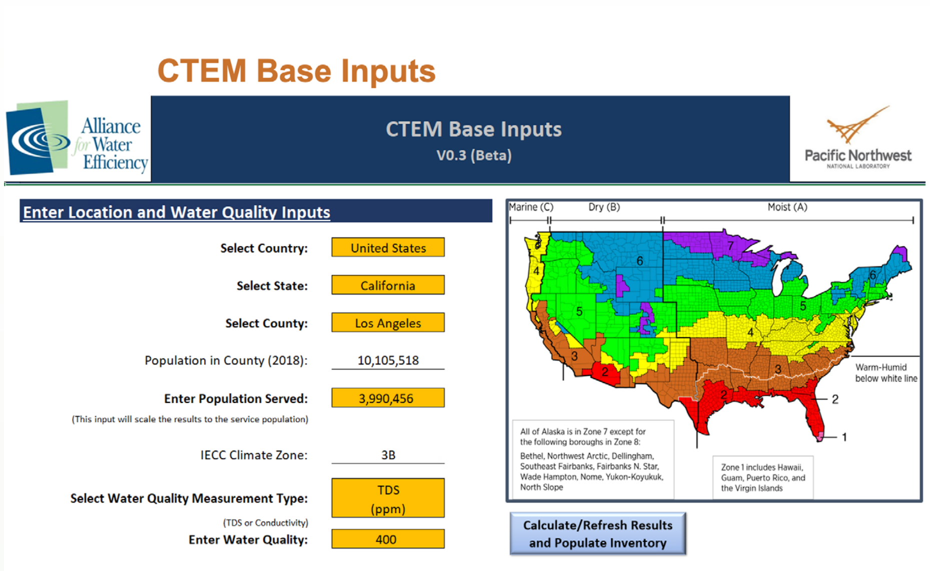
Water Supplier	Program Name and Website	Program Description	Incentive Level	Water Supplier Contact
Metropolitan Water District	**SoCal WaterSmart Rebate Program** https://socalwatersmart.com/en/commercial/	Rebate for cooling tower conductivity and pH controllers	Base Rebate: Conductivity Controller: $625 pH Controller: $1,750 **Retail Water Suppliers can add monies to base incentive*	**Gary Tilkian** (213) 217-6088 Resource Specialist gtilkian@mwdh2o.com
Metropolitan Water District	**Water Savings Incentive Program (WSIP)** https://socalwatersmart.com/en/commercial/water-savings-incentive-program/	Pay-for-performance	$0.60 per 1,000 saved over a 10 year life	**Gary Tilkian** (213) 217-6088 Resource Specialist gtilkian@mwdh2o.com
San Antonio Water System	**Cooling Tower Registration Program** https://apps.saws.org/Conservation/Commercial/CoolingTower/index.cfm	All existing cooling towers must be registered. New cooling towers should be registered with SAWS prior to the start of operation.	NA	**Brandon Leister** Conservation Planner (210) 233-3620 bleister@saws.org
San Antonio Water System	**Cooling Tower Audit Program** https://www.saws.org/conservation/commercial-programs-rebates/cooling-tower-program/	Brief on-site evaluation of cooling tower system	Free Service	**Brandon Leister** Conservation Planner (210) 233-3620 bleister@saws.org
San Antonio Water System	**Commercial Custom Rebate** https://www.saws.org/conservation/commercial-programs-rebates/commercial-custom-rebate/	Pay-for-performance	$0.60 per 1,000 saved over a 10 year life	**Brandon Leister** Conservation Planner (210) 233-3620 bleister@saws.org

Water Supplier	Program Name and Website	Program Description	Incentive Level	Water Supplier Contact
Santa Clara Valley Water District	**Water Efficient Technology Rebate (WET)** https://www.valleywater.org/commercial-facility-rebate-program	Pay-for-performance	$4.00 per HCF per annual savings	**Phil Dolan** Water Conservation Specialist II (408) 630-2205 pdolan@valleywater.org
San Francisco Public Utilities Commission	**Commercial Equipment Retrofit Program** https://sfpuc.org/accounts-services/sign-up-for-savings/commercial-equipment-retrofit	Equipment Rebates through the Fixed Water Savings Retrofits Pay-for-performance through the Custom Retrofit Projects	Cooling tower pH controller: 50% of costs up to $8,000	**Julie Ortiz** Water Conservation Manager (415) 551-4739 jnortiz@sfwater.org **Taylor Nokhoudian** Water Resources Program Manager (415) 516-0145 TNokhoudian@sfwater.org
Saving Water Partnership-Multiple Utilities in the utilities in King and Snohomish counties of Washington State	**Saving Water Partnership** https://www.savingwater.org/businesses/commercial-industrial/	Cooling tower educational manual and videos	NA	greenbusiness@seattle.gov
Southern Nevada Water Authority	**Water Efficient Technologies Program**	Custom incentives based on amount of water customers save (pay-for-performance)	Up to $8.00 per 1,000 gallons saved annually for non-consumptive water saving technologies	**Kent Sovocool** Sr. Resource Conservation Analyst (702) 862-3738 Kent.sovocool@snwa.com
City of Spokane	**Water Wise Rebate**	Rebate for cooling tower conductivity controllers	Up to $695	**Kristen Zimmer** Water Stewardship Educator 509.625.6573 kzimmer@spokanecity.org

SECTION 6

ALLIANCE FOR WATER EFFICIENCY RESOURCES FOR COOLING TECHNOLOGIES

The Alliance for Water Efficiency developed numerous resources to assist water suppliers in evaluating the potential of cooling tower water efficiency upgrades in their service area and to assist with implementation of cooling tower programs.



Cooling Tower Estimating Model

The Cooling Tower Estimating Model (CTEM) helps assess the opportunity for cooling tower upgrades in a water supplier's service area. With five inputs a water supplier can get an estimate of the number of towers, total cooling capacity, water use, and the potential for water savings. It estimates both the consumptive and non-consumptive water use from cooling towers and potential water saving opportunities from efficiency upgrades. It also generates an auto-populated list of select large facilities likely to have cooling towers in the given service area.

The User-Input Inventory module allows water suppliers to further develop and refine their inventory by inputting commercial building data. The model infers whether each property is likely to have a cooling tower based on the building characteristics. The user can also use the tool to create an inventory and keep track of which buildings are verified to have a cooling tower.

The accompanying CTEM guide provides a detailed explanation of the underlying calculations used in the model and walks users through the inputs and outputs of the tool.

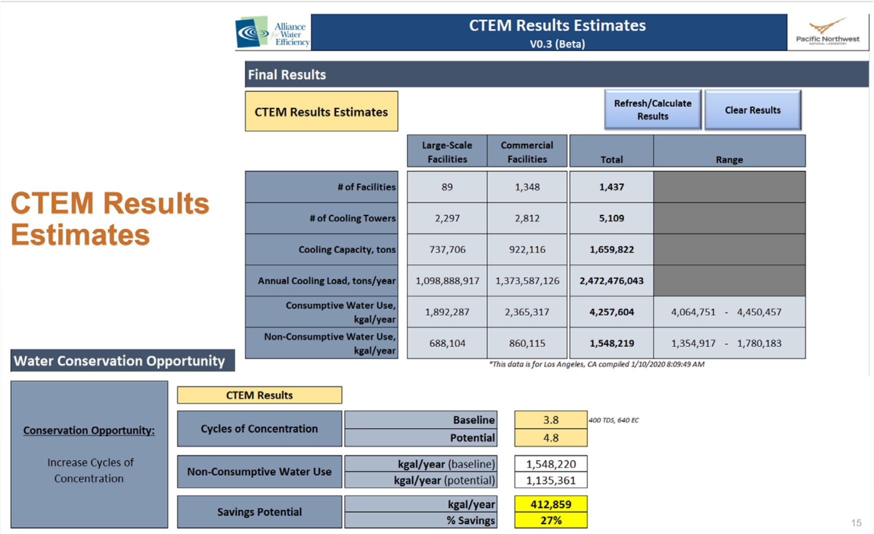
CTEM and the accompanying guide can be found at ______.

Tool Features

- CTEM estimates:
  - Number of large scale and commercial facilities with cooling towers in a water supplier's service area based upon six simple inputs
  - Number of cooling towers in total at those facilities
  - Total cooling capacity from cooling towers in the water supplier's service area
  - Total annual cooling load from cooling towers in the water supplier's service area
  - Total consumptive (evaporative) water use from cooling towers in the water supplier's service area
  - Total non-consumptive (blowdown) water use from cooling towers in the water supplier's service area
  - CTEM estimates high level water savings potential from increased cooling tower water efficiency in the water supplier's service area
- *Added value* - the tool includes a module to initiate a cooling tower inventory including:
  - Auto-populated list of business names and addresses of large facilities likely to have cooling towers
  - Module for users to input commercial property data and the model will infer whether that property is likely to have a cooling tower
  - Data is exportable for creating of master cooling tower inventory

Application of CTEM

- CTEM can be utilized by utilities to determine whether there are an adequate number of potential cooling tower sites to consider a water efficiency program
- CTEM identifies the universe of savings potential for planning purposes
- Once a program is decided upon, the tool can be used to begin building and refining the water supplier's cooling tower inventory
- CTEM gives utilities the ability to understand the makeup of their cooling tower market (i.e. a few large scale sites or many commercial sites) to design an appropriate program format



Water Quality Helper

The Water Quality Helper was designed to help water suppliers (or specific facilities) understand how water quality impacts water efficiency opportunities. The Water Quality Helper is available as a standalone resource and as an integrated tab in CTEM. The tool helps users identify limiting factors based on the local water quality and points the user to potential solutions to improve the cycles of concentration, thereby reducing the amount of blowdown lost from the system. This tool provides high-level estimates for water quality parameters of concern and their effects on potential COC as a planning and modeling tool.

The water quality parameters included are total dissolved solids, conductivity, hardness, chloride, silica, alkalinity, and pH. These parameters can be determined by water quality testing or obtaining reports from the source water supplier. When water quality parameters are entered, the tool automatically estimates that water quality parameter's industry standard threshold to determine the limiting COC for that respective impurity. It displays the top water quality challenges and provides direction on next steps to help improve cooling tower efficiency.

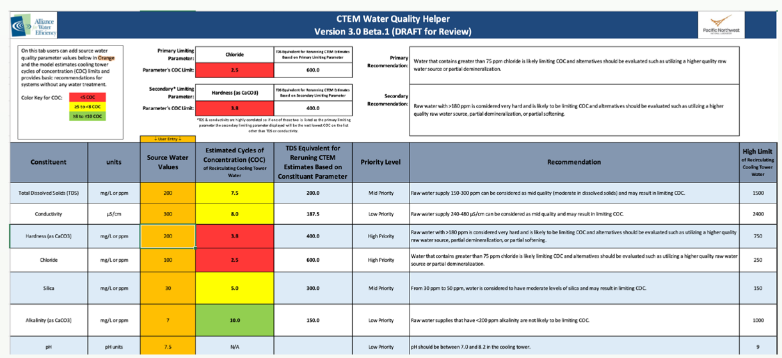
The Water Quality Helper can be found at https://www.a4we.org/impact/our-work/awe-cooling-technology-study.

Tool Features

- Water Quality Helper identifies limiting factors in improving water efficiency based upon local water quality
- Knowing the water quality parameters, the Water Quality Helper tool points the user to solutions to improve efficiency (Cycles of Concentration)
- Refines water savings potential estimate

Application of Water Quality Helper Tool

- Provides the water supplier a more in-depth understanding the water savings potential by general area as well specific locations.
- With this understanding of water quality factors, utilities can provide the most effective water efficiency solutions for those conditions.
- Water suppliers can also rate the priority level of concern for each water quality constituent and provide customers with a recommended course of actions to improve water efficiency.



CTEM Water Quality Helper
Version 3.0 Beta.1 (DRAFT for Review)

On this tab users can add source water quality parameter values below in Orange and the model estimates cooling tower cycles of concentration (COC) limits and provides basic recommendations for systems without any water treatment.

Color Key for COC: <5 COC; ≥5 to <8 COC; ≥8 to ≤10 COC

Primary Limiting Parameter:	Chloride	TDS Equivalent for Rerunning CTEM Estimates Based on Primary Limiting Parameter
Parameter's COC Limit:	2.5	600.0
Secondary* Limiting Parameter:	Hardness (as CaCO3)	TDS Equivalent for Rerunning CTEM Estimates Based on Secondary Limiting Parameter
Parameter's COC Limit:	3.8	400.0

*TDS & conductivity are highly correlated so if one of those two is listed as the primary limiting parameter the secondary limiting parameter displayed will be the next lowest COC on the list other than TDS or conductivity.

Primary Recommendation: Water that contains greater than 75 ppm chloride is likely limiting COC and alternatives should be evaluated such as utilizing a higher quality raw water source or partial demineralization.

Secondary Recommendation: Raw water with >180 ppm is considered very hard and is likely to be limiting COC and alternatives should be evaluated such as utilizing a higher quality raw water source, partial demineralization, or partial softening.

Constituent	units	Source Water Values (↓ User Entry ↓)	Estimated Cycles of Concentration (COC) of Recirculating Cooling Tower Water	TDS Equivalent for Reruning CTEM Estimates Based on Constituant Parameter	Priority Level	Recommendation	High Limit of Recirculating Cooling Tower Water
Total Dissolved Solids (TDS)	mg/L or ppm	200	7.5	200.0	Mid Priority	Raw water supply 150-300 ppm can be considered as mid quality (moderate in dissolved solids) and may result in limiting COC.	1500
Conductivity	µS/cm	300	8.0	187.5	Low Priority	Raw water supply 240-480 µS/cm can be considered as mid quality and may result in limiting COC.	2400
Hardness (as CaCO3)	mg/L or ppm	200	3.8	400.0	High Priority	Raw water with >180 ppm is considered very hard and is likely to be limiting COC and alternatives should be evaluated such as utilizing a higher quality raw water source, partial demineralization, or partial softening.	750
Chloride	mg/L or ppm	100	2.5	600.0	High Priority	Water that contains greater than 75 ppm chloride is likely limiting COC and alternatives should be evaluated such as utilizing a higher quality raw water source or partial demineralization.	250
Silica	mg/L or ppm	30	5.0	300.0	Mid Priority	From 30 ppm to 50 ppm, water is considered to have moderate levels of silica and may result in limiting COC.	150
Alkalinity (as CaCO3)	mg/L or ppm	7	10.0	150.0	Low Priority	Raw water supplies that have <200 ppm alkalinity are not likely to be limiting COC.	1000
pH	pH units	7.5	N/A		Low Priority	pH should be between 7.0 and 8.2 in the cooling tower.	9

Comparing Alternatives Tool

Water savings may also be achieved by integrating alternative technologies. The Comparing Alternatives Tool (CAT) was developed to help water suppliers assess the potential of alternative technologies. CAT provides water-savings potential based on projected growth of the cooling demand in a water supplier's service territory and varying levels of market adoption for a given technology. The tool can also be used to evaluate potential conventional water efficiency upgrades such water softening.

As part of the AWE Cooling Technologies Study four alternative cooling technologies were assessed utilizing CAT including:

1. Thermosyphon hybrid cooling
2. Hygroscopic cooling
3. Thermal membrane distillation
4. Adiabatic cooling

To the right is a description of each of these technologies.

Thermosyphon cooling is an advanced dry cooler that uses refrigerant in a passive cycle to dissipate heat. This type of technology is a hybrid heat-rejection system, which optimizes the use of two cooling technologies—one wet (an open cooling tower) and one dry (a thermosyphon cooler unit)—in a single, integrated operating system.

Hygroscopic cooling works similarly to a traditional cooling tower, but instead of pure water as the cooling fluid, a hygroscopic liquid desiccant fluid is used, such as calcium chloride (CaCl2) mixed with water. In a traditional cooling tower, most of the heat is transferred through evaporation, mainly driven by outdoor conditions such as relative humidity. Hygroscopic coolers however transfer more heat through convection rather than evaporation when the outdoor air is cooler than the temperature set point of the system. When outdoor air temperature exceeds this threshold, the system switches to evaporative cooling.

Adiabatic cooling systems work by using evaporation to pre-cool the air flowing through a closed loop coil. Adiabatic coolers run in two modes: wet (or "pre-cooler") operation and dry operation. Wet operation is only activated during peak demand conditions (e.g. times of high outdoor temperatures and/or during high internal cooling loads conditions). A fan draws warm air through an adiabatic unit where humidity is added to the air. When the humidity comes into contact with the warm air, water evaporates and heat is dissipated, similar to how a swamp cooler works. When outdoor temperatures are low and cooling loads are minimal, the system operates in dry mode, operating similar to a conventional finned dry cooler where heat is dissipated to the ambient air via convection.

Thermal membrane distillation is a water treatment option for cooling-tower blowdown water, which can be reused in cooling-tower makeup thereby reducing the use of freshwater supply. Membrane distillation is a separation process that works by filtering water through a hydrophobic membrane, which only allows the passage of water vapor through the membrane's pores. The process works by heating the blowdown water, which causes a phase change from vapor to liquid, resulting in a pressure change that drives the vapor across the membrane. The vapor condenses to clean liquid water as "product water", which can be reused in the system.

The Water Savings Potential of Implementing Alternative Cooling Technologies document provides more in-depth information regarding each of these technologies and their savings potential. The report and Comparing Alternatives Tool can be found a https://www.a4we.org/impact/our-work/awe-cooling-technology-study.

Tool Features

- Alternative Technologies Report includes the list of 21 potential alternative technologies considered for review that could replace cooling towers
- Alternative Technologies Report provides in-depth information on the four selected technology for assessment (must be commercially available, verified water savings performance, and published cost). The four technologies assessed were:
  - Thermal Membrane Distillation (TMD)
  - Hygroscopic Cooler (HSC) – Hybrid System
  - Adiabatic Cooler (AC)
  - Thermal Membrane Distillation (TMD)
- The Comparing Alternatives Tool assesses the water savings potential of these technologies as they are adopted over time.

Application of Comparing Alternatives Tool

- In-depth information on the four most viable, commercially available alternative technologies and the water savings at various levels of savings for the water supplier's building population
- Provides water suppliers with the ability to assess the water savings potential of different technologies over time based upon various adoption rates

Comparing Alternatives Tool
a CTEM Companion

Technologies for Reducing Cooling Tower Water Use **Select from Dropdown Menus Below** (Model can process only 4 technologies at a time)	Capacity (tons)	Water Savings (mid)	Water Savings (low)	Water Savings (high)	Energy Net (kWh/year)	Duty Factor	Capital Cost (USD2020)	Additional Annual Operating Costs Net (USD2020)	Anticipated Years in Operation	% Evaporative Savings	Capital $ per Ton (USD2020)	Operating $ per Ton (USD2020)	Total $ per Ton (USD2020)	kWh per year per ton
Thermosyphon Cooler (TSC) – Hybrid System	500	50%	11%	87%	27768	17.0%	$200,000	$0	15	71%	$400	$0	$400	833
Continuous Monitoring and Partial Water Softening	500	15%	14%	16%	15466	17.0%	$38,375	$738	15	0%	$77	$22	$99	464
Salt-Based Ion Exchange	500	24%	23%	24%	345	17.0%	$9,867	$7,441	15	0%	$20	$223	$243	10
Water Recapture System	500	20%	10%	30%	830	17.0%	$437,500	$4,355	15	100%	$875	$131	$1,006	25

COOLING TOWER RESOURCES

COOLING
TECHNOLOGY
INSTITUTE

The Cooling Technology Institute (CTI) is an industry association focused on the promotion of environmentally responsible commercial cooling technologies such as wet cooling towers, air-cooled condensers, dry coolers, indirect cooling, and hybrid systems by encouraging:

- Education on these technologies
- Development of codes, standards, and guidelines
- Development, use, and oversight of independent performance verification and certification programs
- Research to improve these technologies
- Advocacy and dialog on the benefits of cooling technologies with government agencies and other organizations with shared interests
- Technical information exchange

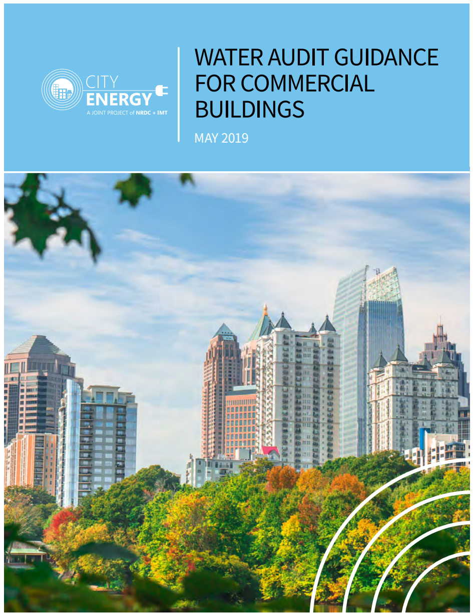
The forum brings together manufacturers, suppliers, and owners and operators.
https://www.cti.org

City Energy Project

The City Energy Project partnered with 20 cities and counties across the U.S. to create and implement customized, impactful energy efficiency policies and programs. The lessons learned, and best-in-class practices are now distilled into the City Energy Project Resource Library.

As part of this work, the City Energy's Project developed a *Water Audit Guidance for Commercial Buildings* that provides both an outline for procedural execution of audits and a detailed format for audit reports. The goals of this document are to:

- Provide a common basis for conducting water audits.
- Define levels of effort for water audits.
- Establish a standard for water audit reports.
- Provide guidance for building owners, managers, and governments for conducting water audits.
- Serve as a guide to best practices for water auditors.



https://www.cityenergyproject.org/resources/water-audit-guidance-for-commercial-buildings/

EPA WaterSense

WaterSense provides facility managers, building owners, and other stakeholders with a variety of resources and initiatives to help them save water, energy, and operating costs.

WaterSense developed *WaterSense at Work*, a compilation of water-efficiency best management practices (BMPs), to help commercial and institutional facilities understand and manage their water use, help facilities establish an effective water management program, and identify projects and practices that can reduce facility water use.

Commercial & Institutional Facilities Fact Sheet
(2 pp, 500 K, About PDF)

Download the full WaterSense at Work guide
(308 pp, 6 MB, About PDF)

Each of the 36 BMPs in the guide provides an overview of the technology, tips for operation, maintenance, and user education, options for retrofits and replacements, and calculations for potential water, energy, and dollar savings and payback periods.

Section 6 of WaterSense at Work, Mechanical Systems, provides an overview of and guidance for effectively reducing the water use of:

- Single-pass cooling
- Cooling towers
- Chilled water systems
- Boiler and steam systems

General Service Administration Green Proving Ground

The Green Proving Ground (GPG) program leverages the Federal General Services Administration's (GSA) real estate portfolio to evaluate innovative building technologies. The General Services Administration manages federal property and provides contracting options for government agencies.

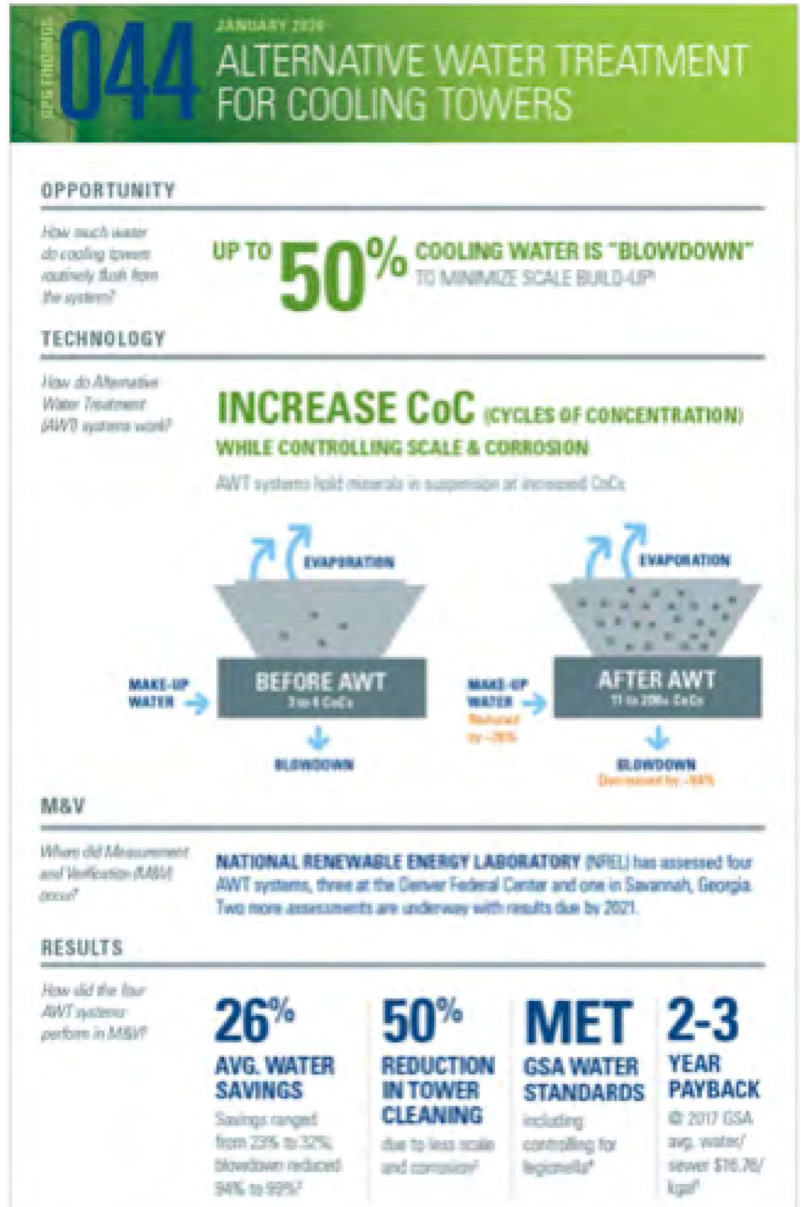
The GPG program aims to drive down operational costs in federal buildings and help lead market transformation through the deployment of new technologies.

GSA tested six alternative water treatment (AWT) technologies. On average, these AWT technologies have reduced cooling tower water use by 26%. The evaluated technologies include:

- Advanced oxidation
- Catalyst-based scale prevention
- Electrochemical
- Monitoring and partial softening
- Salt-based and chemical inhibition

The GSA Guidance for Cooling Towers report summarizes the first four evaluations. Two more evaluations will be completed by December, 2022. The report and technology evaluations can be found at:

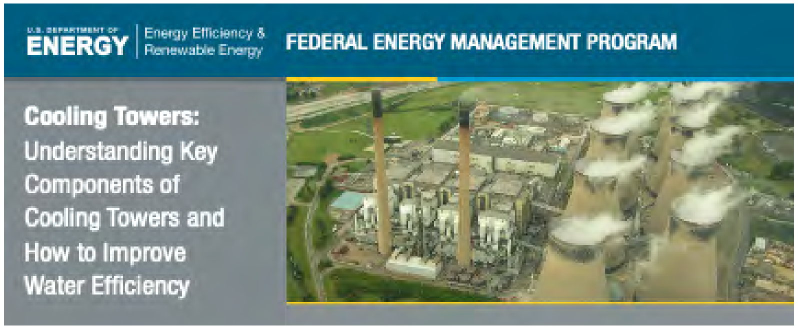
https://www.gsa.gov/governmentwide-initiatives/climate-action-and-sustainability/center-for-emerging-building-technologies/published-findings/water



Federal Energy Management Program

The Federal Energy Management Program (FEMP) works with its stakeholders to enable federal agencies to meet energy-related goals, identify affordable solutions, facilitate public-private partnerships, and provide energy leadership to the country by identifying and leveraging government best practices.

As part of these efforts, FEMP has developed several guides and fact sheets for cooling towers including:



Best Management Practice #10: Cooling Tower Management
Highlights best practices for water-efficient cooling tower management in federal facilities.
https://www.energy.gov/eere/femp/best-management-practice-10-cooling-tower-management

Water-Efficient Technology Opportunity: Advanced Cooling Tower Controls
Highlights cooling tower controls as a commercially available water-saving technology relevant to the federal sector.
https://www.energy.gov/eere/femp/water-efficient-technology-opportunity-advanced-cooling-tower-controls

Cooling Water Efficiency Opportunities for Federal Data Centers
Offers strategies for water efficiency in cooling towers in new and existing federal data centers.
https://www.energy.gov/eere/femp/cooling-water-efficiency-opportunities-federal-data-centers

Cooling Towers: Understanding Key Components of Cooling Towers and How to Improve Water Efficiency
Fact sheet highlights key components of cooling towers and how to improve their water efficiency.
https://www.energy.gov/eere/femp/downloads/cooling-towers-understanding-key-components-cooling-towers-and-how-improve-water

Technical Evaluation of Side Stream Filtration for Cooling Towers
Fact sheet provides an overview of side stream filtration options for cooling towers.
https://www.energy.gov/eere/femp/downloads/technical-evaluation-side-stream-filtration-cooling-towers

Side Stream Filtration for Cooling Towers
Guide discusses cooling tower side stream filtration options to assist federal sites in optimizing energy and water savings.
https://www.energy.gov/eere/femp/downloads/side-stream-filtration-cooling-towers

Los Angeles Better Buildings Challenge

The Better Building Challenge is a Department of Energy (DOE) sponsored, voluntary leadership initiative that asks building owners and managers to make a public commitment to energy efficiency.

The Los Angeles Better Building Challenge (LABBC) has asked LA building owners to commit to reducing their energy and **water use by 20%**. LABBC provides numerous resources to assist building owners in evaluating and implementing efficiency projects.

As part of those resources, LABBC has vetted numerous companies providing solutions for cooling towers including:

- Aqualogix
- Capture H2O
- ChemPro
- EAI Water
- H2O Vortex
- Nalco

Detailed information on these technologies can be found at:

https://www.la-bbc.com/technology-directory

In addition, LABBC has developed several cooling tower water efficiency case studies. Detailed case studies can be found at: https://www.la-bbc.com/case-studies-summary

Los Angeles City Hall East Achieves 20% Water Savings and 85% Reduction in Sewer Charges Through Electrochemical Treatment System