County, California to rainwater harvesting and air conditioning condensate recovery throughout the United States. The food processing industry also has many examples of reusing effluent for crop production.

5. **Change to waterless process**
There are many examples of BMPs where water using equipment is replaced with equipment that does not use water. From the section on Thermodynamics, using air cooling and ground effect (geothermal) air conditioning systems eliminates cooling tower water use entirely. In conventional cooling towers, approximately 2.5 gallons of water is used per ton-hour of cooling. A large office building with a cooling tower can require 20,000 to 30,000 gallons of water per day during the hottest part of the summer.

The use of dry vacuum pumps in laboratories and medical facilities offers another waterless process example. In recent years, most major radiology departments in hospitals have converted to digital imaging because of its superior medical diagnostic capabilities, eliminating water used by large plate X-ray film development. This can save as much as 500,000 gallons of water per year per film developer.

The reader is urged to read the many examples in the text of this document and in the case studies.

6.1.3 Calculation of Water Saving Potentials

Pacific Institute (2003) provided the following method to estimate the Percentage Water Conservation Potential (S):

Equation 6.2

$$S = [(1-p)c]/(1-pc)$$

Where p is the Penetration Potential (percent); and c is the Technical Saving (percent).

Using the water saving for toilets as an example to illustrate the above formula, suppose a small community has 50 toilets total with ten toilets at 1.6 gallons per flush and 40 toilets at 3.5 gallons per flush. Also suppose that the lower flush rate above (1.6 gallons) meets the best management practice. The Technical Saving, c, is calculated as (3.5-1.6)/3.5 = 0.543, and the Penetration Rate, p, is calculated as 10/50 = 20 percent. We can thus calculate the Percentage Water Conservation Potential:

Equation 6.3

$$S = [(1 - 20\%) \times 0.543]/(1 - 20\% \times 0.543) = 48.7\%.$$

After obtaining S, we can calculate the Annual Water Saving of the community by multiplying S by the Current Annual Water Use. Now assuming the Current Annual Water Use is 0.5 million gallons (MG), we get the Annual Water Saving Potential = 0.5 MG x 48.7% = 0.2435 MG or 243,500 gallons per year.

In order to calculate the Percent Water Conservation Potential, S, and the Annual Water Saving Potential in 2010 statewide in CII sectors, we need the current Penetration Rate, p, and Technical Potential, c, as well as the current water use in each NAICS sector.

Correct! ✓ I even derived that they assumed 8.78 times of flush per day per toilet.

6.2 Cost Analysis Approach

The legislation stated that the final report should contain "identification of technical feasibility and cost effectiveness of the BMPs to achieve more efficient water use statewide in the commercial, industrial and institutional section." Because each use site is unique, cost effectiveness and the feasibility of using BMPs must be determined on a case by case basis. While all of the BMPs in this document are technically feasible and are cost effective in certain situations, the appropriateness of using any one BMP must be assessed for each site. The CII user will need to conduct a site audit to determine which BMP(s) would be technically feasible. This would be followed by a cost/benefit analysis to determine if implementing the BMP(s) would be cost effective. Organizations representing business and industry, water service providers, the CUWCC and DWR should educate CII businesses on the BMPs and approaches to doing audits and performing a cost effectiveness analysis.

6.2.1 Economic Analysis Approach

Economic analyses are often viewed from different perspectives, including those of the utility, customer, and community/society. The perspective determines which costs and benefits to include in the analysis. The utility, and customer/business performs analyses based on costs and benefits to themselves. The societal perspective is based on costs and benefits to the water utility and its customers and may also include external costs and benefits, such as recreational benefits to downstream communities created by leaving more water in streams and rivers. This chapter focuses on the customer/business perspective.

The varying degrees of complexity, size, type of water use, technical needs, and inherent barriers to analyzing BMP costs for industrial equipment, processes, and plants, make a one-size-fits-all statewide assessment of costs to implement BMPs impossible. Therefore, this report outlines an approach that businesses may use to evaluate the costs and benefits of a particular BMP.

Installed cost of BMP/Total Savings of BMP to business per year = payback in years

Completing this calculation requires knowing the unit value of water. The following examples show how to calculate the unit value of heated water:

Calculating the Unit Value of Water:

Obtain the unit cost of water, which is usually expressed in dollars per thousand gallons, or dollars per 100 cubic feet. Do the same for wastewater if it is charged based on the volume. Add the costs for water and wastewater to obtain the total cost of water. (If costs are expressed in hundreds of cubic feet (CCF), ~~convert it to gallons by multiplying by 0.748.)~~ use the conversion factor of 1 CCF = 748 gallons.)

X

EXAMPLE 1:

Question – If a business used 52 CCF in a month, how many gallons did it consume?

Answer - 52 X 748 = 38,896 gallons per month ✓

EXAMPLE 2:

Question – If water costs $7.50 per CCF (748 gallons), what is that cost in dollars per thousand gallons.

Answer - $7.50/ 0.748 = $10.03 per thousand gallons

Total annual water and wastewater cost would then be equal to [(38,898 X 12)/1000] X $10.03 = $4,681.76 per year ✓

For heated water, determine the type of energy used to heat the water (gas, electric, solar, or other) and its cost per unit (cents per kilowatt hour, dollars per therm, dollars per MCF [thousand cubic feet] of natural gas, etc.) For calculation purposes assume water is heated from 55°F to 120°F, which is typical of water heated either for domestic use. High temperature use in a commercial dishwasher in Southern California typically requires a temperature rise from 125°F to 180°F.

?? missing text? either ... or ... where is "or" part?

If the gas is billed in therms, convert the cost to dollars per thousand cubic feet (MCF) of gas by multiplying the cost of the gas, in therms, by ten to convert it to dollars per MCF.

One MCF of propane contains approximately one million BTUs, which is equivalent to approximately 11 gallons. A propane cost of $2.00 per gallon is equivalent to natural gas costing $22.00 per MCF.

EXAMPLE 3:

Question – If natural gas costs $0.80 per therm, what is the cost of raising the water's temperature by 55°F?

Answer - $0.80 X 10 = $8.00 per MCF which is equal to approximately $5.00 per thousand gallons.

Additional costs, such as for softening or other treatments, must also be estimated.

EXAMPLE 4:

Question – If water costs $3.50 per CCF and wastewater cost $4.00 per CCF, and the water is heated with electricity that costs ten cents per kilowatt hour, what is the cost of heating the water by 55°F?

Answer - The water and wastewater cost $7.50 per CCF ($3.50 + $4.00) or $10.03 per thousand gallons ($7.50 / 0.748 = $10.03).

The cost of heating the water by 55°F is $14.20 per thousand gallons.

Total water costs include energy plus water plus wastewater:

Total Cost = $10.03 + $14.20 = $24.23 per thousand gallons or 2.423 cents per gallon.

Calculating Payback, Return on Investment and Net Present Value

Replacing a 3.5-gallon per flush toilet with a 1.28-gallon per flush toilet saves 2.22 gallons per flush. The combined water and sewer cost for that toilet is $6.50 per CCF, or $8.69 per thousand gallons, or 0.9 cents per gallon. Therefore, this saves $1.93 cents per gallon. If the toilet is flushed an average of 35 times per day and the building is open 255 days a year, installing the 1.28 gallons per flush toilet will save $171.36 in water and sewer costs each year. If the total installed cost of the toilet (toilet and labor) is $275.00, the payback is 1.6 years ($275 / $171.36). The return on investment is the percent of payback the BMP produces per year. In this example, the ROI is 62.5 percent per year (100 / 1.6). Additional costs, such as energy, chemicals, or labor and insurance, must be included in the denominator.

The National Utility Service, Inc. (NUS Consulting Group) annual survey shows that between 2004 and 2008, water and wastewater costs nationwide have increased by an average of 6.5 percent per year, far more than consumer price index inflation. To take this increase into account, all costs should be converted to present value. In this situation, the cost of the retrofit will remain the same, but the actual savings will include expected increases in water and wastewater costs over the anticipated useful life of the BMP. Additional costs and savings, such as energy, chemical, labor, tax, insurance must also be included. The general formula for calculating present value is:

Equation 6.4

$$PV\,Costs = \sum Costs_t/(1 + discount\,rate)^t$$

Estimates of costs and benefits can reflect complicated math, and each business or industry must decide how much detail they want in their payback. For most businesses, simple payback is sufficient to determine the cost effectiveness of a measure.

The above discussion shows that determining a payback for any given measure depends on a variety of factors including local water and energy rates, the type and volume of business, the type of equipment used, and previous BMP measures.

- Purchase a garbage grinder with a load sensor that regulates the amount of water conveyed through the unit based upon its use.
- Install a food pulper or food pulper/strainer combination system, which can recirculate 75 percent of the water used for the food disposal process.
- Replace mechanical food disposal systems with food strainers, which use little to no water.

Savings Potential

A conventional garbage grinder connected to a sluice trough can use more than 650,000 gallons per year and cost a facility more than $4,500[7] in water and sewer bills. This water use can be significantly reduced either through a retrofit with a load sensor to regulate and reduce the amount of water used by the existing garbage grinder during idle mode *or* by replacing the unit with a food pulper or food strainer. To estimate facility-specific water savings and payback from retrofits and replacements, use the following information:

Current Water Use

To estimate the current water use of an existing garbage disposal during idle periods, identify the following information and use Equation 7.1 below:

- Flow rate of water through the garbage disposal: this flow rate typically ranges from two to fifteen gpm.
- Average daily idle period of the garbage grinder: idle period is the time when the unit is turned on but not in use. While this time will vary by facility, some estimates indicate that garbage grinders are typically in a fully operating mode about three hours per day. For a commercial food service facility operating 12 hours a day, this would mean an idle period of nine hours if the garbage disposal is kept on throughout the day.[8]
- Days of facility operation per year.

Equation 7.1

Water Use of a Garbage Disposal During Idle Use (gallons/year) =
Flow Rate (gallons/minute) X Daily Idle Period (minutes/day) X Days of Facility Operation (days/year)

[7] Assumes a water and sewer rate of $7.16 per 1,000 gallons; from Raftelis Financial Consulting. 2008. *Water and Wastewater Rate Survey*. American Water Works Association.
[8] East Bay Municipal Utility District. 2008. *Watersmart Guidebook—A Water-Use Efficiency Plan Review Guide for New Businesses*. Pages FOOD 9-11. www.ebmud.com/for-customers/conservation-rebates-and-services/commercial/watersmart-guidebook

Water Use After Retrofit

To estimate the water use from an existing garbage grinder that is retrofitted with a load sensor during idle period, use Equation 7.1, substituting the reduced idle flow rate. A load sensor can reduce the idle flow rate when the unit is not in use to as little as 1.0 gpm.

Water Savings

The expected water savings is determined by subtracting the water use after retrofit from the current water use.

Payback

To calculate the simple payback for retrofitting an existing conventional garbage grinder, identify the following information and use Equation 7.2 below:

- Equipment and installation cost of the retrofit load sensor
- Water savings as calculated in Equation 7.1
- Facility-specific cost of water and wastewater

Equation 7.2

Payback (years) = Equipment and Installation Cost ($) / (Water Savings (gallons/year) X Cost of Water and Wastewater ($/gallon))

Kent, change the outside ( ) to [ ]. This will make the equation clearly (more) defined.

Conventional Garbage Grinder Replacement – Food Pulper

Conventional garbage grinders can be replaced with a food pulper. A food pulper can recirculate and reuse up to 75 percent of the water used for the food disposal process, thus reducing the potable water required to operate the garbage disposal unit.

Current Water Use

To estimate the current water use of an existing garbage disposal, identify the following information and use Equation 7.3 below:

- Flow rate of water through the garbage disposal: this flow rate typically ranges from two to fifteen gpm.
- Average daily use time of the garbage disposal: while this time of use will vary by facility, some estimates indicate that garbage disposals are typically in full operation a total of three hours per day.
- Days of facility operation per year.

Equation 7.3

Water Use of a Garbage Disposal In Use (gallons/year) =
Flow Rate (gallons/minute) X Daily Use Time (minutes/day) X Days of Facility Operation (days/year)

Water Use After Replacement

To estimate the water use of a replacement food pulper, use Equation 7.3, substituting the flow rate of fresh water through the food pulper. Fresh water flow rate through a food pulper is typically two gpm.[9]

Water Savings

The expected water savings is determined by subtracting the water use after replacement from the current water use.

Payback

To calculate the simple payback from replacing a conventional garbage grinder, identify the following information and use below:

- Equipment and installation cost of the replacement food pulper
- Water savings as calculated using Equation 7.3
- Facility-specific cost of water and wastewater

Equation 7.4

Payback (years) = Equipment and Installation Cost ($) /
[Water Savings (gallons/year) X Cost of Water and Wastewater ($/gallon)]

This Equation (7.4) is the same. Of course, one is for garbage grinder and another is for food pulper.

Conventional Garbage Grinder Replacement – Food Strainer

Conventional garbage disposals can be replaced with a food strainer. Since a food strainer does not use water, installing a food strainer to replace an existing garbage disposal can completely eliminate water use.

Current Water Use

To estimate the current water use of an existing garbage grinder, use Equation 7.3.

[9] East Bay Municipal Utility District. 2008. Watersmart Guidebook—*A Water-Use Efficiency Plan Review Guide for New Businesses*. Pages FOOD 9-11. www.ebmud.com/for-customers/conservation-rebates-and-services/commercial/watersmart-guidebook

Savings Potential

Sizable water savings can be achieved by replacing existing PRSVs. Because water use of PRSVs depends on facility operations, such as average throughput, water savings will vary by facility. To estimate facility-specific water savings and payback, use the following information:

PRSV Replacement

Current Water Use

To estimate the current water use of a pre-rinse spray valve, identify the following information and use Equation 7.5 below:

- Flow rate of the existing pre-rinse spray valve. Pre-rinse spray valves installed after 2005 may operate at 1.6 gpm or less, although older higher flow rate valves may still be in place. Pre-rinse spray valves installed before 2005 can have flow rates of up to 4.5 gpm. In both cases, it is prudent to determine the flow rate by collecting the valve output in a containment vessel for a defined period of time and measuring the volume of the collected water.
- Average daily use time. This will vary by facility, but PRSVs are generally operating in the "on" position for no more than 90 minutes per day.[13]
- Days of facility operation per year.

?? These two flow rates are different. one is 1.6 gpm, and another 1.3 gpm.

Equation 7.5

Water Use of a Pre-Rinse Spray Valve (gallons/year) =
Flow Rate (gallons/minute) X Daily Use Time (minutes/day) X Days of Facility Operation (days/year)

Water Use After Replacement

To estimate the water use of a more efficient replacement pre-rinse spray valve, substitute the flow rate of the replacement pre-rinse spray valve into the above equation. Efficient pre-rinse spray valves use 1.3 gpm or less.

Water Savings

Determine the expected water savings by subtracting the water use after replacement from the current water use.

[13] Pre-rinse spray valve use time data was collected from facilities that participated in EPA's Pre-Rinse Spray Valves Field Study in 2010.

Payback

To calculate the simple payback from replacing an existing PRSV, identify the following information and use the equation below:

- Equipment and installation cost of the replacement pre-rinse spray valve. Pre-rinse spray valves typically cost less than $100. Installation cost is negligible.
- Water savings as calculated above.
- Facility-specific cost of water and wastewater.

Equation 7.6

Payback (years) = Equipment and Installation Cost ($) / [Water Savings (gallons/year) X Cost of Water and Wastewater ($/gallon)]

Facilities may also save a significant amount of energy due to the reduction in hot water use with replacement of a pre-rinse spray valve with a lower flow model. This energy savings will further reduce the payback time and increase replacement cost-effectiveness.

Water Savings - California Potential

As of 2009, the California State Board of Equalization had issued sales tax permits to 91,000 restaurants and similar food establishments in the state.[14] This figure does not include food service operations within a larger commercial or industrial entity (such as company cafeterias or food service operations within hospitals or schools, for example), firms whose business is to manufacture and/or prepare food for sale by others,[15] and other similar operations. On the other hand, this figure does include very small restaurants that do not use a pre-rinse spray valve.

With very limited information on the current number of installed pre-rinse spray valves in California, the above inventory information was coupled with the experience gained through the CUWCC's Rinse 'n Save Program (for statewide PRSV replacement) to arrive at an estimate of approximately 120,000 installed hot water valves, with a range of between 100,000 and 130,000.

Through implementation of the CUWCC's Program and subsequent natural PRSV replacement, the estimated statewide saturation rate (as of 2007) of water efficient valves is about 70 percent.

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[14] California State Board of Equalization, Taxable Sales in California (Sales & Use Tax), 2009 Fourth Quarter, no date.

[15] Food product processors and manufacturers, catering firms, etc.

We estimate the potential water-savings benefit of replacing the remaining 30 percent of the 120,000 hot water PRSVs in California to be as follows:

Equation 7.7

30% X 120,000 valves X 0.874 acre-feet average savings per average valve = 31,000 acre-feet total, or approximately 6,000 acre-feet per year.

this part is ok!

But what does this part mean? ~~what~~ How 6,000 AF/y is related to 31,000 AF ??

Additional Resources and References

Alliance for Water Efficiency. Commercial Food Service Introduction. www.allianceforwaterefficiency.org/Commercial_Food_Service_Introduction.aspx

California State Board of Equalization, Taxable Sales in California (Sales & Use Tax), 2009 Fourth Quarter, no date.

Federal Energy Management Program. Buying Low-Flow Pre-Rinse Spray Valves. www1.eere.energy.gov/femp/technologies/eep_low-flow_valves.html

Food Service Technology Center. Pre-Rinse Spray Valves. www.fishnick.com/equipment/sprayvalves/

East Bay Municipal Utility District. 2008. *Watersmart Guidebook—A Water-Use Efficiency Plan Review Guide for New Businesses*. Pages FOOD 9-11. www.ebmud.com/for-customers/conservation-rebates-and-services/commercial/watersmart-guidebook

Koeller and Company, 2010. *A Report on Potential Best Management Practices—Commercial Dishwashers*, by Bill Hoffman, P.E., for the California Urban Water Conservation Council. June.

Raftelis Financial Consulting. 2008. *Water and Wastewater Rate Survey*. American Water Works Association.

Sydney Water, 2001. *Save Water, Money, and the Environment – Kitchens.* http://www.sydneywater.com.au/Publications/FactSheets/SavingWaterKitchens.pdf

Sydney Water, 2006. *The Conserver: Water Cuts are on the Menu at McDonalds.* http://www.sydneywater.com.au/Publications/CaseStudies/HiltonConserver13.pdf

Sydney Water, 2007. *The Conserver: No Water Wasted at the Mandarin.* http://www.sydneywater.com.au/Publications/CaseStudies/MandarinShoppingCentreConserver12.pdf

higher quality than required will use water unnecessarily. Consider selecting flake or nugget ice machines, which use less water and energy than cube ice machines.[39] Choose only Energy Star® qualified models.[40] Also consider only air-cooled ice machines that meet the efficiency specifications outlined by the Consortium for Energy Efficiency (CEE).[41]

Savings Potential

A facility will see varying levels of water savings, depending on whether it is replacing an existing air-cooled ice machine or an existing water-cooled model. To estimate facility-specific water savings and payback, use the following information.

Air-Cooled Ice Machine Replacement

On average, Energy Star® qualified air-cooled cube ice machines are 15 percent more energy-efficient and ten percent more water-efficient than standard air-cooled models. Total savings depend on the type of machine selected. Switching to a 137-pound capacity Energy Star® qualified air-cooled ice-making head unit from an equivalent conventional unit, for example, can result in water savings of 1,000 gallons per year. Energy savings of 1,600 kWh per year can also be expected, resulting in net cost savings of about $170 per year.[42]

$170 / 1600 kWh ≈ $0.106/kWh ≈ 11¢/kWh. OK!

Use Energy Star's® Commercial Kitchen Equipment Savings Calculator[43] to estimate facility-specific water, energy, and cost savings for replacing an existing ice machine with an Energy Star® qualified model. The Calculator estimates savings for the Energy Star® suite of commercial kitchen products, but it can also be used to calculate individual savings from replacing an existing ice machine.

Water-Cooled Ice Machine Replacement

A facility will see the most water savings from replacing a water-cooled ice machine with an Energy Star® qualified air-cooled model. Only cube ice machines currently qualify to earn the Energy Star® label.

Current Water Use

To estimate the current water use from a water-cooled ice machine, identify the following information and use Equation 7.8 below:

[39] East Bay Municipal Utility District. 2008. *Watersmart Guidebook—A Water-Use Efficiency Plan Review Guide for New Businesses.* www.ebmud.com/for-customers/conservation-rebates-and-services/commercial/watersmart-guidebook.

[40] www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=CIM

[41] www.cee1.org/com/com-kit/com-kit-equip.php3

[42] U.S. Environmental Protection Agency's Energy Star Program. Energy Star Life Cycle Cost Estimate for Qualified Commercial Ice Machine(s).

[43] www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/commercial_kitchen_equipment_calculator.xls

- Ice machine's harvest rate, or how many pounds of ice it produces per day
- The ice machine's maximum water use: this figure can be derived from EPAct 2005 requirements.
- Days of facility operation per year

Equation 7.8

Water Use of a Water-Cooled Ice Machine (gallons/year) = Harvest Rate (lbs ice/day) X Water Use (gallons/100 lbs of ice) X Days of Facility Operation (days/year)

if water use is in (gallons/100 lbs of ice), Harvest rate must also be in (100 lbs ice/day)

Water Use After Replacement

To estimate the water use of a replacement Energy Star® qualified air-cooled model, use Equation 7.8, substituting the harvest rate (if it will change) and the new water use per hundred pounds of ice.

Water Savings

Determine the expected water savings by subtracting the water use after replacement from the current water use.

Payback

To calculate the simple payback from replacing a water-cooled ice machine, identify the following information and use Equation 7.9 below:

- Equipment and installation cost of the replacement Energy Star® qualified air-cooled model. New ice machines may range in cost between $2,000 and $4,000.
- Water savings as calculated using Equation 7.8.
- Facility-specific cost of water and wastewater.

Equation 7.9

Payback (years) = Equipment and Installation Cost ($) / [Water Savings (gallons/year) X Cost of Water and Wastewater ($/gallon)]

- Days of facility operation per year

Equation 7.14

Water Use of a Metering Faucet (gallons/year) = Flow Rate per Cycle (gallons/cycle) X Use per Hour (cycles/hour) X Daily Use Time (hours/day) X Days of Operation per Year (days/year)

Water Savings

Determine the expected water savings by subtracting the water use after faucet replacement from the current water use.

Payback

Use a similar Equation ~~7.XX~~ as 7.13 to calculate the simple payback from replacing an existing dipper well with a push-button, metered faucet, and substitute the cost of replacing the existing faucet with a new metering faucet for the cost of the in-line flow restrictor.

Dipper Well Replacement with Energy Star® Qualified Commercial Dishwasher

Though retrofitting an existing dipper well with a flow restrictor is likely the most cost-effective choice for a facility, significant water savings may also be achieved by replacing a dipper well with an Energy Star® qualified commercial under-counter dishwasher *and* altering the practices of those individuals responsible for utensils.

Current Water Use

Use a similar Equation ~~7.XX~~ as 7.12 to estimate the current water use of an existing dipper well.

Water Use After Replacement with Energy Star® Dishwasher

Identify the following information and use Equation 7.15 below to estimate the water use after replacing an existing dipper well with an Energy Star® qualified commercial under counter dishwasher:

- Water use per rack washed. A high-temperature, Energy Star® qualified commercial under-counter dishwasher uses 1.0 gallons per rack or less. A low-temperature model uses 1.7 gallons per rack or less.[59]

[59] U.S. Environmental Protection Agency, Energy Star program. Commercial Dishwashers Key Product Criteria. www.energystar.gov/index.cfm?c=comm_dishwashers.pr_crit_comm_dishwashers

- Average estimate of racks washed per day.
- Days of facility operation per year.

√ ***Equation 7.15***

Water Use of an Energy Star® Qualified Commercial Under-Counter Dishwasher (gallons/year) = Water Use per Rack (gallons/rack) X Racks Washed per Day (racks/day) X Days of Operation per Year (days/year)

Water Savings

Determine the expected water savings by subtracting the water use after dishwasher installation from the current water use.

Payback

Use Equation 7.XX to calculate the simple payback from replacing an existing dipper well with an Energy Star® qualified commercial under counter dishwasher, and substitute the cost of installing an Energy Star® qualified dishwasher for the cost of the in-line flow restrictor. Purchasing and installing a new Energy Star® qualified commercial under-counter dishwasher can cost approximately $6,000.[60]

Additional Resources and References

Arizona Water. Implementing a Water Management Plan Checklist for Facility Managers. Page 8. www.azwater.gov/AzDWR/StatewidePlanning/Conservation2/Documents/documents/ImplementingaWaterManagementPlanChecklistforManagers.pdf

East Bay Municipal Utility District. 2008. Watersmart Guidebook—A Water-Use Efficiency Plan Review Guide for New Businesses. Pages FOOD8-FOOD9. www.ebmud.com/for-customers/conservation-rebates-and-services/commercial/watersmart-guidebook

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Las Vegas Review-Journal. 2010. UNLV Professor Targets 'Wasteful' Dipper Wells. www.lvrj.com/news/47195482.html

Sydney Water, 2001. *Save Water, Money, and the Environment – Kitchens.* http://www.sydneywater.com.au/Publications/FactSheets/SavingWaterKitchens.pdf

Sydney Water, 2006. The Conserver: *Water Cuts are on the Menu at McDonalds.* http://www.sydneywater.com.au/Publications/CaseStudies/HiltonConserver13.pdf

60 U.S. Environmental Protection Agency, Energy Star program. Energy Star® Life Cycle Cost Estimate for Energy Star Qualified Commercial Dishwasher(s). www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorCommercialDishwasher.xls

Identify the following information and use Equation 7.16 below to estimate the current water use of a steam cooker:

- Flow rate of the existing steam cooker
- Average daily use time
- Days of food service operation per year

Equation 7.16

Water Use of Steam Cooker (gallons/year) = Flow Rate per Hour (gallons/~~cycle~~) X Daily Use Time (hours/day) X Days of Operation per Year (days/year)

Water Use After Retrofit or Replacement with Energy Star® Qualified Steam Cooker

Use Equation ~~7.XX~~ to estimate the water use after retrofitting a boiler-based system or replacing an existing steam cooker, and substitute the flow rate of the new recirculating configuration or the Energy Star® qualified steam cooker for the flow rate of the existing steam cooker.

Equation 7.17

Water Use of Retrofitted System or Energy Star® Qualified Steam Cooker (gallons/year) = Flow Rate per Hour (gallons/~~cycle~~) X Daily Use Time (hours/day) X Days of Operation per Year (days/year)

Water Savings

Determine the expected water savings by subtracting the water use after steam cooker retrofit or replacement from the current cooker water use.

Potential Future Water Savings for California

A 2005 report by the Food Service Technology Center[67] estimated that approximately 25,000 compartment food steamers were installed in the state of California. As of 2005, the FSTC went on to estimate that the boilerless (connectionless) equipment only represented less than five percent of that total, the remainder being boiler-based units. The FSTC concluded that about 60 percent of the installed base were viable candidates for replacement with the very efficient units, or about 15,000 steamers,[68] and, if replaced, could yield an estimated 3,750 acre-feet of annual water savings.

Payback

Use Equation 7.18 below to calculate the simple payback from retrofitting or replacing an existing steam cooker, and identify the following information:

- Purchase and installation cost of the retrofit or replacement steam cooker
- Water savings as calculated in Equation 7.xx
- Facility-specific cost of water and wastewater

Equation 7.18

Payback (years) = Equipment and Installation Cost ($) / [(Water Savings (gallons/year) X Cost of Water and Wastewater ($/gallon)]

Additional Resources and References

Alliance for Water Efficiency. Food Steamers Introduction. www.allianceforwaterefficiency.org/1Column.aspx?id=642&terms=steam

East Bay Municipal Utility District. *Watersmart Guidebook—A Water-Use Efficiency Plan Review Guide for New Businesses*. 2008. www.ebmud.com/for-customers/conservation-rebates-and-services/commercial/watersmart-guidebook

Fisher-Nickel, Inc. and Koeller and Company, 2005. *Evaluating the Water Savings Potential of Commercial "Connectionless" Food Steamers, Final Report*. June.

Food Service Technology Center. Steamers. www.fishnick.com/savewater/appliances/steamers/

Sydney Water, 2001. *Save Water, Money, and the Environment – Kitchens.* http://www.sydneywater.com.au/Publications/FactSheets/SavingWaterKitchens.pdf

[67] Fisher-Nickel, Inc. and Koeller and Company, 2005. Evaluating the Water Savings Potential of Commercial "Connectionless" Food Steamers, Final Report, June. This report describes the very comprehensive field study of actual steamer installations and their water and energy consumption. Funded by Pacific Gas & Electric, East Bay Municipal Utilities District, and the Metropolitan Water District of Southern California, the fieldwork tracked water and energy consumption at 12 different food service operations in northern and southern California.

[68] It should be noted that not all boiler-based units could be replaced, due the need in some establishments for high production capacity, something the boilerless steamers are not yet equipped to provide.

Savings Potential

Retrofitting or replacing existing steam kettles can yield operational water savings. For a boiler-based steam kettle, water savings achieved by returning the condensate to the boiler can be substantial. However, actual water savings are difficult to approximate because the water use of a steam kettle varies based upon its size and the pressure of the steam. According to the East Bay Municipal Utility District, condensate return systems cost approximately $3,000 and have an estimated product life of ten years.[72]

Current Water Use

Identify the following information and use Equation 7.19 below to estimate the water use of a steam kettle:

- Flow rate of the existing steam kettle calculated using the capacity of the kettle (gal) and the pressure of the steam (psi)
- Average daily use time in the food service operation
- Days of food service operation per year

Equation 7.19

Water Use of Boiler-Based Steam Cooker (gallons/year) =
Flow Rate per Hour (gallons/cycle) X Daily Use Time (hours/day)
X Days of Operation per Year (days/year)

Water Use After Retrofit or Replacement

Use Equation 7.19 to estimate the water use after retrofitting or replacing an existing steam kettle, and substitute the flow rate of the new configuration or new system for the flow rate of the existing steam kettle.

Water Savings

Determine the expected water savings by subtracting the water use after steam kettle retrofit or replacement from the current kettle water use.

Payback

Use Equation 7.20 below to calculate the simple payback from replacing an existing steam kettle, identify the following information:

- Purchase and installation cost of the replacement steam kettle
- Water savings as calculated above

[72] East Bay Municipal Utility District. 2008. *Watersmart Guidebook—A Water-Use Efficiency Plan Review Guide for New Businesses*. Page FOOD6.

- Facility-specific cost of water and wastewater

Equation 7.20

Payback (years) = Equipment and Installation Cost ($) / [Water Savings (gallons/year) X Cost of Water and Wastewater ($/gallon)]

Additional Resources and References

Cornell University New York State Agricultural Experiment Station. 2007. *Steam Kettles in Food Processing: Small Scale Food Entrepreneur.* www.nysaes.cornell.edu/necfe/pubs/pdf/FactSheets/FS_SteamKettles.pdf

East Bay Municipal Utility District. 2008. *Watersmart Guidebook—A Water-Use Efficiency Plan Review Guide for New Businesses.* www.ebmud.com/for-customers/conservation-rebates-and-services/commercial/watersmart-guidebook

Food Service Technology Center. 2009. *Steam Kettles.* http://www.fishnick.com/equipment/appliancetypes/steamkettles

Robert M. Kerr Food & Agricultural Products Center. *Food Technology Fact Sheet – Steam Kettle Hookup.* www.fapc.okstate.edu/files/factsheets/fapc120.pdf

Sydney Water, 2001. *Save Water, Money, and the Environment – Kitchens* http://www.sydneywater.com.au/Publications/FactSheets/SavingWaterKitchens.pdf

Sydney Water, 2007. *The Conserver: No Water Wasted at the Mandarin.* http://www.sydneywater.com.au/Publications/CaseStudies/MandarinShoppingCentreConserver12.pdf

U.S. Department of Energy, Energy Efficiency & Renewable Energy, Federal Energy Management Program. 2009. *Best Management Practice: Commercial Kitchen Equipment.* www1.eere.energy.gov/femp/program/waterefficiency_bmp11.html

Wok Stoves

Overview

A wok stove is a Chinese pit-style stove that has a wok (or multiple woks) recessed into the stove top, allowing heat to be fully directed onto the bottom of the wok. Conventional wok stoves use water for both cooling and cleaning.[73] In a conventional wok stove, the burner chimney and ring are affixed to the top of the stove; as a result, heat is trapped under the cook top. Water jets are installed to enable cooling water to flow at approximately 1.0 gpm per burner across the cook top to absorb the heat. Figure 7.6 illustrates the design of a water-cooled wok stove.

[73] Sydney Water. *Wok Stoves.* www.sydneywater.com.au/Publications/Factsheets/Wok_stove_fact_sheet.pdf

of water per day, particularly if the rinsing spout is left constantly running. Studies have shown that daily average water use of a conventional wok stove is 1,400 to 2,000 gallons per day.[76] The savings could add up to more than $3,500 in avoided water and sewer costs each year, which could provide payback for the cost of the new equipment in as few as one to two years.[77]

Water savings can be achieved through two mechanisms: eliminating the use of cooling water by switching from a water-cooled to an air-cooled waterless wok stove *or* by reducing the flow rate and duration of use of rinse and reservoir spouts. To estimate facility-specific water savings and payback, use the following information:

Wok Stove Retrofit

Woks must be rinsed between uses and reservoir spouts are often filled to provide water used in cooking. Reducing the flow rate of rinse and reservoir spouts and the duration of their use can significantly reduce this water use. Use the following information to estimate water savings and payback potential that may be achieved with this type of retrofit:

Current Water Use

Use Equation 7.21 below to estimate the current water use of the existing wok stove rinse and reservoir spouts, identify the following information:

- Flow rate of each rinse and reservoir spout
- Average daily use time of rinse and reservoir spouts
- Days of food service operation per year.

Equation 7.21

Water Use of a Wok Stove Rinse and Reservoir Spout (gallons/year) = Flow Rate (gpm) X Daily Use Time (minutes/day) X Days of Facility Operation (days/year)

Water Use After Retrofit

(7.21) ⇒ 6k!

Use Equation 7.21 to estimate the water use of more efficient rinse and reservoir spouts, and substitute the flow rate of the retrofit rinse and reservoir spouts.

[76] Sydney Water. *Wok Stoves.* www.sydneywater.com.au/Publications/Factsheets/Wok_stove_fact_sheet.pdf.

[77] Estimate assumes an annual savings of approximately 500,000 gallons; from Sydney Water. Wok Stoves. www.sydneywater.com.au/Publications/Factsheets/Wok_stove_fact_sheet.pdf. Also assumes a water and sewer rate of $7.16 per 1,000 gallons; from Raftelis Financial Consulting. 2008. *Water and Wastewater Rate Survey.* American Water Works Association.

Water Savings

Determine the expected water savings by subtracting the water use after retrofit of the spouts from the current water use.

Payback

Use Equation 7.XX to calculate the simple payback from retrofitting an existing wok stove with more efficient rinse and reservoir spouts, identify the following information:

- Equipment and installation cost of the retrofit rinse and reservoir spouts
- Water savings as calculated using Equation 7.XX
- Facility-specific cost of water and wastewater

Equation 7.22

Payback (years) = Equipment and Installation Cost ($) / Water Savings (gallons/year) X Cost of Water and Wastewater ($/gallon)

Wok Stove Replacement

During the course of a 12-hour day, a conventional water-cooled wok stove can use more than 700 gallons of water. Switching to a waterless wok or one that uses recirculated chilled water can eliminate the use of single-pass cooling water, thereby reducing the wok stove's total water use by as much as 90 percent, resulting in savings of over 250,000 gallons per year. Waterless wok stoves cost approximately $10,000 to $12,000, excluding installation. As such, it is unlikely that a conventional food service operation can recoup the initial cost of the equipment in an acceptable period of time. Use the following information to estimate water savings and payback potential that may be achieved by replacing a conventional wok stove with a waterless wok stove or one that uses recirculated chilled water.

Current Water Use

Use Equation 7.23 to estimate the water used for cooling of a waterless wok stove, identify the following information:

- Flow rate of the cooling water: this flow rate is typically one gpm

Current Water Use

Use Equation 7.24 below to estimate the current water use of an existing wash-down sprayer without a nozzle, identify the following information:

- Flow rate of the existing, high-flowing wash-down sprayer without a nozzle. Most high-flowing wash-down sprayers have flow rates between 9 and 20 gpm.[82]
- Average daily use time in the food service operation.
- Days of food service operation per year.

Equation 7.24

Water Use of a Wash Down Sprayer or Water Broom (gallons/year) = Flow Rate (gallons/minute) X Daily Use Time (minutes/day) X Days of Facility Operation (days/year)

Water Use After Retrofit

Use Equation 7.24 to estimate the water use after installing a nozzle on an existing wash-down sprayer without a nozzle, and substitute the flow rate of the new nozzle. Self-closing nozzles often flow at a rate of seven gpm.[83]

Water Savings

Determine the expected water savings by subtracting the water use ~~before~~ after nozzle retrofit or replacement from the current wash-down water use.

Payback

Use Equation 7.25 below to calculate the simple payback for the wash-down sprayer retrofit, identify the following information:

- Equipment and installation cost of the self-closing nozzle. Self-closing nozzles typically cost $100.
- Water savings as calculated using Equation 7.24.
- Facility-specific cost of water and wastewater.

Equation 7.25

Payback (years) = Equipment and Installation Cost ($) / [Water Savings (gallons/year) X Cost of Water and Wastewater ($/gallons)]

[82] East Bay Municipal Utility District. 2008. *Watersmart Guidebook—A Water-Use Efficiency Plan Review Guide for New Businesses.* Pages FOOD8-FOOD9. www.ebmud.com/for-customers/conservation-rebates-and-services/commercial/watersmart-guidebook

[83] Food Service Technology Center. Water Conservation Measures for Commercial Food Service. www.fishnick.com/savewater/bestpractices/Water_Conservation_in_CFS.pdf

Wash-Down Sprayer Replacement

Replacing a wash-down sprayer with a pressure washer or water broom can result in water savings between 100,000 and 400,000 gallons per year. Pressure washers and water brooms typically cost between $100 and $200; therefore, a facility saving 100,000 gallons per year could recoup the initial cost of the retrofit equipment in less than one year.[84] To estimate facility-specific savings and payback use the following information:

Current Water Use

Use Equation 7.25 to estimate the current water use of an existing wash-down sprayer.

Water Use After Replacement

Use Equation 7.25 to estimate the water use of a replacement pressure washer or water broom, and substitute the flow rate of the new device. Water brooms can use as little as two gpm.[85] Pressure washers have similar flow rates yet use higher water pressure.

Water Savings

Determine the expected water savings by subtracting the water use after replacement from the current wash-down water use.

Payback

Use Equation 7.XX to calculate the simple payback for the wash-down sprayer replacement, and substitute the cost of the pressure washer or water broom for the cost of the retrofit self-closing nozzle.

Additional Resources and References

American Water Works Association (Raftelis Financial Consulting). 2008. *Water and Wastewater Rate Survey*.

East Bay Municipal Utility District. 2008. *Watersmart Guidebook—A Water-Use Efficiency Plan Review Guide for New Businesses*. Pages FOOD8-FOOD9. www.ebmud.com/for-customers/conservation-rebates-and-services/commercial/watersmart-guidebook.

[84] Assumes a water and sewer rate of $7.16 per 1,000 gallons. Raftelis Financial Consulting. 2008. *Water and Wastewater Rate Survey*. American Water Works Association.
[85] Food Service Technology Center. Water Conservation Measures for Commercial Food Service. www.fishnick.com/savewater/bestpractices/Water_Conservation_in_CFS.pdf

Savings Potential

Water savings can be achieved through retrofitting existing laundry equipment to recirculate wash water or reduce the amount of water required for rinsing, or by replacing existing laundry equipment with more efficient equipment. To estimate facility-specific water savings and payback, use the following information:

Coin- or Card-Operated Washer or Multi-Load Washer Retrofit

Use the following information to estimate water savings and payback potential that may be achieved with recycling or ozone retrofits. Water savings can vary based upon the water use and use patterns of the existing laundry equipment and the type of retrofit selected.

Water Use

Use Equation 7.26 below to estimate the current water use from a commercial coin- or card-operated washer or multi-load washer, identify the following information:

- Washer's water factor (WF) in gallons per cycle per cubic foot of capacity. Coin- or card-operated washers installed since the early 1990's will have a WF of 9.5 or less.
- Capacity of the washer.
- Average number of cycles per load.
- Average number of loads per year.

Equation 7.26

Water Use of a Commercial Coin- or Card-Operated Washer or Multi-Load Washer (gallons/year) = Water Factor (gallons/cycle/ft^3 capacity) X Washer Capacity (ft^3) X Number of Cycles (cycles/load) X Number of Loads (loads/year)

Water Savings

Studies have documented water savings for retrofits with a simple recycling system, retrofits with a complex recycling system, and ozone system retrofits. To estimate water savings that may be achieved from retrofitting existing laundry equipment, multiply the water use of the existing laundry equipment (Equation 7.26) by the savings potential for the appropriate retrofit option indicated in the Table 7.14 (Equation 7.27).

Retrofit Option	Water Savings Potential[92]
Retrofit with simple recycling system	10–35%
Retrofit with complex recycling system	85–90%
Retrofit with ozone system	10–25%

Table 7.14 - Potential Water Savings From Commercial Laundry Retrofit Options

Equation 7.27

Water Savings from Commercial Laundry Retrofit (gallons/year) =
Current Water Use (gallons/year) X Water Savings Potential (%) from Retrofit in Table X

Washer Extractor or Tunnel Washer Retrofit

Existing washer extractors or tunnel washers can also be retrofitted to recirculate and reuse a portion of the wash or retrofitted with an ozone system.

Water Use

Use Equation 7.28 below to estimate the current water use from a washer extractor or tunnel washer, identify the following information:

- Washer's water efficiency in gallons per pound of fabric.
- Average number of pounds of fabric per load.
- Average number of loads per year.

Equation 7.28

Water Use of a Washer Extractor or Tunnel Washer (gallons/year) =
Water Efficiency (gallons/pound of fabric) X Pounds of Fabric per Load (pounds /load) X Number of Loads (loads/year)

Water Savings

Use Equation 7.XX to calculate water savings that can be achieved from retrofitting an existing washer extractor or tunnel washer, multiply the water use of the existing laundry equipment as calculated, by the savings potential for the appropriate retrofit option indicated in the Table 7.14 above.

[92] East Bay Municipal Utility District. 2008. *WaterSmart Guidebook: A Water-Use Efficiency Plan Review Guide for New Businesses.* www.ebmud.com/for-customers/conservation-rebates-and-services/commercial/watersmart-guidebook.

Coin- or Card-Operated Washer or Multi-Load Washer Replacement

Coin- or card-operated washer or multi-load washers can be replaced with more efficient laundry equipment. Look for washers with the Energy Star® designation.

Current Water Use

Use Equation ~~7.XX~~ 7.26 to estimate the current water use of a coin- or card-operated washer or multi-load washer.

Water Use After Replacement

Use Equation ~~7.XX~~ 7.26 to estimate the water use of a more-efficient, replacement commercial coin- or card-operated washer or multi-load washer, substitute the water factor and washer capacity of the replacement equipment. Energy Star® qualified coin- or card-operated washers will have a WF of 6.0 or less. An efficient multi-load washer will have a WF of 8.0 or less.

Water Savings

Calculate the expected water savings by subtracting the water use after replacement from the current water use.

Washer Extractor or Tunnel Washer Replacement

Existing washer extractors or tunnel washers can be replaced with more efficient laundry equipment.

Current Water Use

Use Equation ~~7.XX~~ 7.26 to estimate the current water use from a washer extractor or tunnel washer.

Water Use After Replacement

Use Equation ~~7.XX~~ 7.26 to estimate the water use of a more-efficient, replacement washer extractor or tunnel washer by substituting the new washer's water efficiency. Existing washer extractors can be replaced by machines with built-in water recycling capabilities that use less than 2.5 gallons of water per pound of fabric. Efficient tunnel washers typically use two gallons of water or less per pound of fabric.

Water Savings

Calculate the expected water savings by subtracting the water use after replacement from the current water use.

Additional Resources and References

Vacuum pumps, X-ray equipment, ice machines, and wok stoves use water for processes in addition to the water used for single-pass cooling. Such equipment and its associated water use, apart from single-pass cooling, are discussed in BMPs within this Guidebook.

Large industrial operations, including manufacturing facilities and power plants, sometimes use "once-through" cooling with water from a natural body of water. This type of cooling is discussed in the next two sections.

The flow rate needed to cool the equipment depends on the amount of heat rejected by the equipment. Manufacturer specifications generally provide a flow rate. If not, the measured energy rejected by the equipment can be used to calculate flow rates.

Example 1:

A piece of equipment has a recommended flow rate of 2.5 gallons per minute. How much water does it use in a day?

Equation 7.29

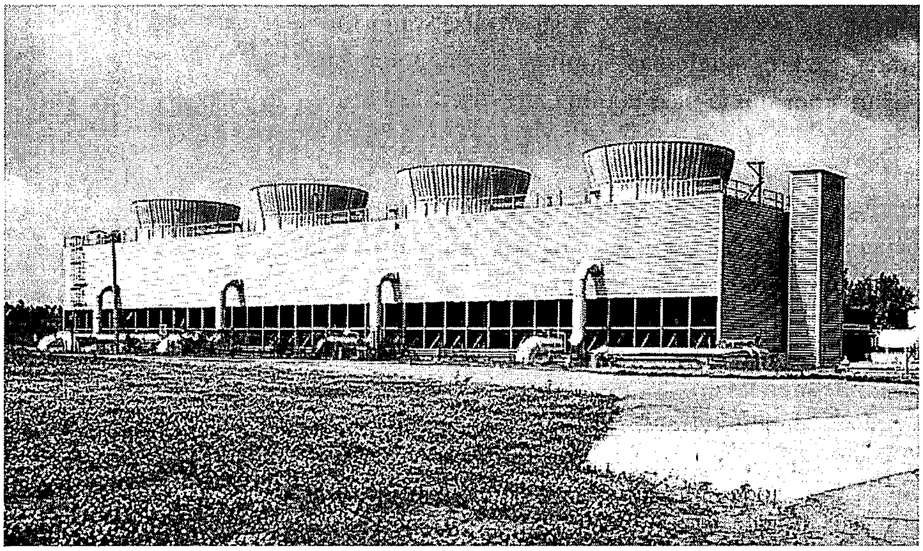
Water use = flow rate (gpm) X 1,440 = 2.5 X 1,440 = 3,600 gallons per day

Once-through Cooling on Natural Bodies of Water and Cooling Reservoirs

Once-through cooling on natural bodies of water refers to the use of a river, natural lake, or saltwater body as a source of cooling water. Water is directly returned to the natural body of water from which it was withdrawn. Since enormous volumes of water are typically involved, these withdrawals can impact aquatic wildlife by both entrapping them in the flow of water and by creating thermal barriers with the warm water that is discharged. To put this into perspective, one 750-megawatt power plant can withdraw as much as 1.5 billion gallons of water per day. For these reasons, the State of California no longer allows power plants to employ once-through cooling using sea water and freshwater sources that are not sufficient to support this type of flow rate. Smaller industrial facilities and some air conditioning systems can use this type of cooling, but permitting requires careful consideration. Because of its limitations, no further consideration is given in this document. Once-through cooling is not recommended as a best management practice.

Cooling reservoirs, sometimes called cooling ponds, are manmade reservoirs used by industries and power plants for process cooling. Water is pumped through heat exchangers and recirculated through the reservoir where it cools through natural processes. If water is pumped from a natural body of water such as a river, lake, or saltwater body, it is a form of once through cooling.

Figure 7.49 - Marley Counter-flow Towers



The amount of water used by a cooling tower (makeup water) depends on the amount of heat dissipated by evaporation, the amount that must be discharged to prevent the buildup of dissolved minerals and salts (blowdown), and the amounts lost through drift, leaks, overflows, and other losses. This can be expressed in a simple equation (Equation 7.30).

Equation 7.30

$$M = E + B + D + L$$

Where M = Makeup, E = Evaporation, B = Blowdown,
D = Drift and wind loss and L = Leaks, overflows, and other losses

Evaporation and Blowdown

When warm water from a process or an air conditioning compressor is returned to a cooling tower, its energy is dissipated to the atmosphere primarily by evaporation. The heat removed by evaporating one pound of water is approximately 973 BTUs and is known at the latent heat of evaporation. One gallon of water weighs 8.34 pounds so the evaporation of one gallon removes 8,114.8 BTUs. One ton-hour of cooling is equal to 12,000 BTU's by definition. Therefore, 1.48 gallons of water is evaporated for every ton-hour rejected to the cooling tower.

As water evaporates, the dissolved minerals and salts in the makeup water remain. Additional water must be added (makeup) and some of the water in the basin periodically discharged (blowdown) to prevent minerals from building up and causing scaling and corrosion.

Drift and Wind Losses

Another type of water loss derives from drift and wind. It is caused by the entrainment of small droplets of water in the air stream as the fans force air through the tower or from wind blowing through the tower. If no drift eliminators are used, drift loss could be as high as 0.3 percent of circulation

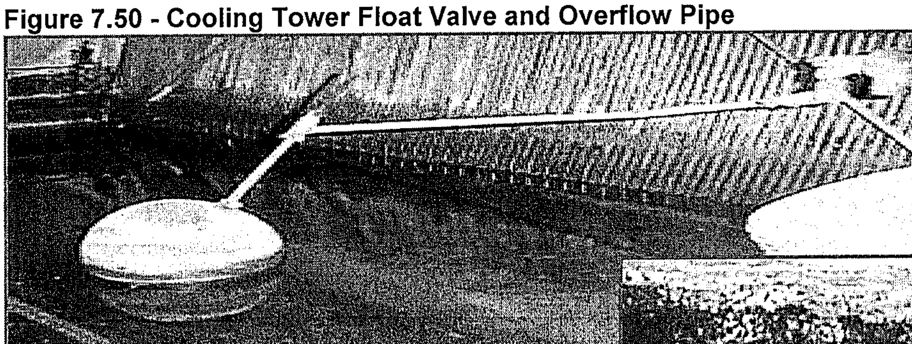
Modern towers are equipped with very effective drift eliminators. Drift losses can be reduced to under 0.003 percent of the mass flow of the tower, as reported by many manufactures. For a typical cooling tower, mass flow is in the range of 150 gallons per hour per ton-hour of cooling. With a modern drift elimination system, drift loss would be in the order of only 0.004 gallons per ton hour or under 0.3 percent of evaporation. This makes drift loss almost *negligible.* Drift eliminators also significantly reduce aerosols containing bacteria such as *Legionella (causes Legionnaire's Disease)*, as well as particulate deposition and salt deposits. *The implication of this is that drift term (D) in Equation 7.30 (M= E + B + D + L) can be dropped as part of the calculation.*

150 gal x 0.003% = 0.0045 gal

Leaks and Other Losses

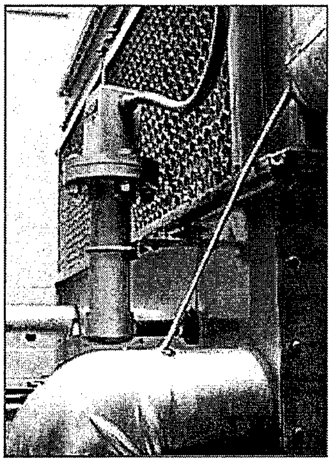
Leaks and other losses are primarily a maintenance issue. Well-maintained systems have little or no leak loss. One common source of loss is an improperly set water level in the basin of the cooling tower.

Figure 7.50 - Cooling Tower Float Valve and Overflow Pipe



An alternative to a float valve is an ultrasonic level detector such as the one shown in Figure 7.51.

Figure 7.51 - Ultrasonic Cooling Tower Level Control Valve



Regardless of the type of level controller used, one of the most common types of water loss is an improperly adjusted float, or level controller. Leaks can also be a problem. Properly maintaining the float or level controller, eliminating leaks, and installing modern drift eliminators, simplifies Equation 7.30 to Equation 7.31:

Equation 7.31

$$M = E + B$$

Cycles of Concentration

The concentration of the minerals (salinity) in the blowdown divided by the concentration of the minerals in the makeup water is called the cycle of concentration. This concentration of minerals is often called "total dissolved solids (TDS)" and is reported in milligrams per liter (mg/l) or parts per million (ppm).

Since the electrical conductivity of the water is related to the TDS, conductivity can be used to estimate TDS. Conductivity is measured in microSiemens. If the conductivity of the makeup water is 100 microSiemens and the conductivity of the blowdown is 500 microSiemens, the tower would be operating at five CCs (CC- cycle of concentration) {500/100=5}

Equations 7.32 and 7.33 show the calculation of cycles of concentrations.

Equation 7.32

Cycles of Concentration (CC) = Total Dissolved Solids (TDS) in Blowdown ÷ TDS in Makeup Water

CC=TDS (*blowdown water* ÷ TDS (*makeup water)*

Where conductivity is used in place of TDS, as it is for all cooling tower controllers, the following equivalent equation should provide the same results.

pounds per hour (lb/hr) of 150-pounds per-square-inch-gauge (psig) steam. It operates for 8,000 hours per year. The blowdown ratio is:

Equation 7.41

Blowdown Ratio = 3,200 = 6.0% 3,200 + 50,000

From the table, the heat recoverable corresponding to a six percent blowdown ratio with a 150-psig boiler operating pressure is 1.7 MMBtu/hr. Since the table is based on a steam production rate of 100,000 lb/hr, the annual savings for this plant are:

Equation 7.42

Annual Energy Savings = [1.7 MMBtu/hr X (50,000 lb/hr/100,000 lb/hr) X 8,000 hr/yr]/0.80 = 8,500 MMBtu/yr ;

8,500 MMBtu Annual Cost Savings = 8,500 MMBtu/yr x $8.00/MMBtu = $68,000

They are two separate equations. Therefore, I added semicolon (;) inbetween.

Blowdown Rate % Boiler Feed Water	Steam Pressure, PSIG				
	50	100	150	250	300
2	0.45	0.5	0.55	0.65	0.65
4	0.90	1.0	1.1	1.3	1.3
6	1.3	1.5	1.7	1.9	2.0
8	1.7	2.0	2.2	2.6	2.7
10	2.2	2.5	2.8	3.2	3.3
20	4.4	5.0	5.6	6.4	6.6

Based on a steam production rate of 100,000 pounds per hour 60oF makeup water & 90% heat recovery.
Source: Recovery Heat from Boiler Blowdown - www.eere.energy.gov

60°F Note the superscript.

Table 7.42 - Recoverable Heat from Boiler Blowdown

Additional Resources and References

American Society of Mechanical Engineers. 1994. *Consensus Operating Practices for Control of Feedwater/Boiler Water Chemistry in Modern Industrial Boilers.*

due to minimal costs. Retrofitting private use lavatory faucets used in dorms, barracks, hotels or hospital patient rooms with WaterSense-labeled faucet accessories (such as an aerator) may save a facility between 160 and 220 gallons of water per user per year. Since WaterSense-labeled faucet accessories typically cost less than $10, these devices normally pay for themselves in less than one year. At the same time, retrofitting public use faucets to reduce the flow rate to the CalGreen maximum of 0.4 gpm could save a facility between 150 and 600 gallons of water per user per year.

To estimate facility-specific water savings and payback, use the following:

Current Water Use

To estimate the current water use of an existing lavatory faucet, identify the following information and use Equation 7.46 below:

- Flow rate of the existing lavatory faucet. Faucets installed in 1996 or later generally have flow rates of 2.2 gpm or less (commercial applications may be as low as 0.5 gpm). Faucets installed between 1994 and 1996 generally have flow rates of 2.5 gpm or less. A simple measurement with a calibrated device can be used to determine the existing flow.
- Average daily use time. The average residential lavatory faucet use is approximately eight minutes per person per day.[178] For commercial and industrial applications, usage is approximately one-fourth of that amount.
- Number of building occupants.
- Days of facility operation per year.

Equation 7.46

person

Water Use of a Faucet (gallons/year) = Flow Rate (gallons/minute) X Daily Use Time (minutes/day) X Number of Building Occupants X Days of Facility Operation (days/year)

*

Daily use time per person (minutes/day/person)

Water Use After Retrofit or Replacement

To estimate the water use after retrofitting or replacing an existing faucet with a water-efficient model or aerator, use Equation 7.46, substituting the flow rate of the retrofit or replacement. WaterSense labeled aerators use no more than 1.5 gpm. Manually operated public use lavatory faucets can be retrofitted with 0.5 gpm aerators.

178 Mayer, Peter W., and DeOreo William B. 1998. *Residential End Uses of Water.* Aquacraft, Inc. Water Engineering and Management. American Water Works Association.