CLEAResult

Savings Calculations for Commercial Faucet Aerator

Baseline Water and Gas Consumption Estimates for Commercial Hot Water Applications

Prepared by, CLEAResult

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Measure Characteristic Summary

Characteristic	Description
Measure	Installation of low-flow faucet aerators in commercial facilities to reduce water use and save energy associated with water heating
Market Sector	Commercial
Base Case Description	Flow rate of 2.2 GPM
Efficient Case Description	0.5 GPM

Measure Description

This measure consists of installation of low-flow faucet aerators in commercial lavatories to reduce water use and save energy associated with water heating. To qualify for this measure, the flow rate of replacement low-flow faucet aerators must be rated at 0.5 gallons per minute or less.

EFFICIENCY IMPROVEMENT

The savings values are determined for the retrofit of existing operational faucet aerators with a flow rate of 2.2 gallons per minute with low-flow faucet aerators with a flow rate of 0.5 gallons per minute. Facilities that use gas water heaters are eligible for this measure.

Calculation Methodologies

In our review of studies related to the consumption of water from faucets in commercial buildings, we were not able to find direct information concerning hot water consumption. Multiple studies were reviewed to find data that was utilized to determine baseline consumption of water and natural gas in applications using hot water in lavatory faucets.

WATER CONSUMPTION CALCULATIONS

The water and gas consumption calculations for this measure were developed based on standard engineering methodologies. Data from water conservation programs, published studies and assumptions provided in statewide technical reference manuals were utilized to calculate the average consumption of water per faucet per year. Flow rates were found at existing fixtures up to 3.0 GPM[1].

HOSPITALITY CALCULATION:

Data were utilized to determine the average water consumption from faucets in individual hotel rooms. Water consumption in five hotels was metered over a short-term period at either a whole-building level or sub-metered by room and then disaggregated to determine consumption at multiple end uses. The data were extrapolated to show annual end use consumption. One faucet is assumed to be located in each room.

Data from the study are summarized for aerators below[2].

Table 1 – Hospitality Calculation Data

	Hotel 1	Hotel 2	Hotel 3	Hotel 4	Hotel 5	Total or Weighted Average
Total annual metered faucet water consumption from five hotels (gallons)	325000	932000	376000	409000	370000	2412000
Occupancy rate during testing ($\mathrm{OccRate_{wtd}}$)	0.9	0.7	0.8	0.9	0.9	0.82
Occupants Per Room ($\mathrm{OccPerRoom_{wtd}}$)	2	1.2	1.3	2	3	1.87
Total number of faucets	148	297	140	168	208	961

The average water consumption for individual faucets was calculated as

Equation 1

$$2510\frac{\text{Gallons}}{\text{Year}} = \frac{2{,}412{,}000\ \text{Gallons}}{961\ \text{Faucets}}$$

As occupancy rates and occupants per room vary, the data from the study were normalized using the weighted occupancy rate during testing and occupants per room to determine the annual consumption per occupant ($U_{HospOcc}$).

Equation 2

$$\text{Annual Water Consumption Per Occupant} = \frac{\text{Per Faucet Consumption}_{\text{avg}}}{\text{OccRate}_{\text{wtd}} \times \text{OccPerRoom}_{\text{wtd}}}$$

$$1632\ \frac{\text{Gallons}}{\text{Occupant}} = \frac{2510\ \text{Gallons}}{0.82 \times 1.87\frac{\text{Occupant}}{\text{Room}}}$$

Additional data were utilized to account for regional average of occupancy rate and national average of occupants per room to find the annual average consumption per faucet. The formula below is used to calculate the normalized annual consumption per faucet (U_{Hosp}), assuming the number of faucets identified in the study equal the number of rooms.

Table 2 – National and Southern California Regional Hospitality Occupancy Data

	Value	Units
Regional Hospitality Occupancy Rate[3] ($OccRate_{Regional}$)	77%	
National Hospitality Average Number of Guests per Room[4] ($OccPerRoom_{National}$)	1.4	guests per room

Equation 3

$$U_{Hosp} = \text{Annual Consumption Per Occupant} \times \text{OccRate}_{\text{Region}} \times \text{OccPerRoom}_{\text{National}}$$

$$1764\ \frac{\text{Gallons}}{\text{Faucet}} = 1632\ \frac{\text{Gallons}}{\text{Occupant}} \times 77\% \times 1.4\frac{\text{Occupant}}{\text{Room}}$$

SCHOOLS CALCULATION 1:

Data were utilized to determine the average water consumption from faucets in schools. Water consumption was logged and bills were reviewed for four schools. Two of those schools had sufficient data to disaggregate annual consumption into multiple end uses. Below is data from those schools related to the number of lavatory faucets and the total water consumption at faucets in the school. Additional faucets in the schools in classrooms and utility sinks exist in the schools. Because of the variation in purpose of use of faucets and the range in uses per day, it is difficult to determine how much water is consumed in

each faucet that would benefit from the reduction in flow rate. Ignoring the use of utility and classroom sinks, an estimate of consumption was calculated.

Table 3 – Schools Calculation 1 Data[2]

	Combined	School 1	School 2
Total annual water consumption at faucets (gallons)	735000	230000	505000
Total number of faucets	187	65	122

The average water consumption for individual faucets was calculated

Equation 4

$$\frac{735{,}000\ \text{Gallons}}{187\ \text{Faucets}} = 3{,}930\,\frac{\text{Gallons}}{\text{Year}}$$

This estimate is likely high, due to the exclusion of classroom and utility sink faucets in the count of total number. Additionally, the use of this value to determine water and energy savings would ignore times when faucets are used to fill containers, in which instances, installing low flow aerators would not affect consumption.

SCHOOLS CALCULATION 2:

In this calculation, water end use consumption data were used to estimate annual consumption at lavatory faucets based on the number of flushes occurring per student or employee per day. Estimates are provided for the number of flushes per person per day and the amount of water consumed at the faucet per flush.

Table 4 – Schools Calculation 2 Data

	Value	Units
Faucet Water Consumption Per Flush (U_{Flush})[5]	0.11	Gallons
Flushes Per Person Per Day ($N_{FlushSchool}$)[5]	3.12	Flushes/Day
Total Count Students & Staff [2]	5705	
Total Count Lavatory Faucets [2]	187	
Operating Days Per Year [2]	180	Days/Year

Lavatory faucet water consumption per year ($U_{FaucetSchool2}$) is calculated as:

Equation 5

$$U_{FaucetSchool2} = U_{Flush} \times N_{FlushSchool} \times \frac{People}{Faucet} \times \frac{Days}{Year}$$

$$1885\ \frac{Gallon}{Faucet \times Year} = 0.11\,\frac{Gallon}{Flush} \times 3.12\,\frac{Flush}{Person \times Day} \times 30.5\,\frac{People}{Faucet} \times 180\,\frac{Days}{Year}$$

To check the value of 0.11 gallons of lavatory faucet water use per flush, data were found relating to the time and likelihood of school students washing hands. Studies suggest 58% of high school girls and 48% of high school boys wash hands after using the restroom. Another study suggests an average hand washing time of 6 seconds for men and women[67]. Assuming an

average baseline flow rate of 2.2 GPM, this suggests 0.13 gallons of water at lavatory faucets are used after each use of the bathroom. This value is in close alignment with the 0.11 gallons used in the calculation above.

RESTAURANT CALCULATION:

A calculation methodology similar to that used in Schools Calculation 2 was used to estimate baseline water consumption per lavatory faucet in restaurants. Estimates are provided for the number of flushes restaurant per day and the amount of water consumed at the faucet per flush.

Table 5 – Restaurant Calculation Data

	Value	Units
Faucet Water Consumption Per Flush (U_{Flush})[5]	0.11	Gallons
Customer and Employee Flushes Per Day ($N_{FlushRest}$)[5]	240	Flushes/Day
Average Number Lavatory Faucets Per Restaurant[8] ($Faucets_{AvgRest}$)	2.08	Lavatory Faucets Per Restaurant
Operating days per year	365.25	Days/Year

Lavatory faucet water consumption per year ($U_{FaucetRest}$) is calculated as:

Equation 6

$$U_{FaucetRest} = \frac{U_{Flush} \times N_{FlushRest} \times \frac{Days}{Year}}{Faucets_{AvgRest}}$$

$$4637 \frac{Gallon}{Faucet \times Year} = \frac{0.11 \frac{Gallon}{Flush} \times 240 \frac{Flush}{Day} \times 365.25 \frac{Days}{Year}}{2.08 \frac{Lavatory\ Faucets}{Restaurant}}$$

WATER SAVINGS CALCULATIONS

The consumption of replacing a 2.2 GPM faucet aerator (F_B) with a 0.5 GPM aerator (F_P) is calculated as:

Equation 7

$$U_P = \frac{U_B \times 0.5\ GPM}{2.2\ GPM}$$

Where,

U_P = Annual post-installation consumption in gallons

U_B = Annual baseline consumption in gallons

Water Savings (U_S) is calculated as:

Equation 8

$$U_S = U_B - U_P$$

Table 6 – Calculated Water Savings

	Baseline Water Consumption, U_B (Gallons/Year)	Post-Installation Water Consumption, U_P (Gallons/Year)	Water Savings (Gallons/Year)
Hospitality	1764	401	1363
Schools	1885	428	1456
Restaurant	4637	1054	3583

ENERGY CONSUMPTION CALCULATIONS

Annual gas consumption is calculated as:

Equation 9

$$\text{Therms} = \frac{\rho \times C_P \times U \times \left(T_H - T_{Supply}\right) \times \frac{1}{E_T}}{100{,}000\ \text{BTU/Therm}}$$

Table 7 – Energy Calculation Constants

	Value	Units
Base Flow Rate (F_B)	2.2	Gallons per Minute
Post Flow Rate (F_P)	0.5	Gallons per Minute
Mixed Water Temperature (T_H)[9]	104	^oF
Hospitality Supply Water Temperature (T_{supply})[10]	63.3	^oF
School Supply Water Temperature (T_{supply})	63.9	^oF
Restaurant Supply Water Temperature (T_{supply})	63.5	^oF
Water Density (ρ)	8.33	lb/gallon
Specific Heat of Water (C_p)	1	BTU/lb^oF
Recovery Efficiency (E_T)	0.78	

Table 8 – Calculated Energy Savings

	Baseline Natural Gas Consumption (Therms/Year)	Post-Installation Natural Gas Consumption (Therms/Year)	Natural Gas Savings (Therms/Year)

Hospitality	7.68	1.74	5.93
Schools	8.07	1.83	6.24
Restaurant	20.07	4.56	15.51

MEASURE COST

The cost for installing this measure includes material and labor costs. Material cost per showerhead is found at $5 from internet retailers. Six aerator installs per hour are assumed in the labor cost calculations. A value of $58.80 per hour is found in READI v2.3.0 under Domestic Hot Water – Storage Water Heater. The tables below provide location-specific and weighted labor costs based on DEER material and labor multipliers.

Table 9 – Material and Labor Costs by Building Location

Building Location	Material Multiplier	Labor Multiplier	Aerator Material Cost	Aerator Labor Cost
CZ05	0.96	1.067	$ 4.80	$ 6.27
CZ06	1.002	1.076	$ 5.01	$ 6.33
CZ08	0.959	1.067	$ 4.80	$ 6.27
CZ09	1.001	1.075	$ 5.01	$ 6.32
CZ10	1.001	1.076	$ 5.01	$ 6.33
CZ13	1.003	1.158	$ 5.02	$ 6.81
CZ14	0.96	1.04	$ 4.80	$ 6.12
CZ15	0.959	1.067	$ 4.80	$ 6.27
CZ16	0.96	1.083	$ 4.80	$ 6.37

Table 10 – Location-Weighted Costs

	Hospitality	School	Restaurant
Material	$ 4.93	$ 4.93	$ 4.94
Labor	$ 6.32	$ 6.31	$ 6.31
Total	$ 11.25	$ 11.24	$ 11.25

[1] Seattle Public Utilities. (2002), *Hotel Water Conservation A Seattle Demonstration*

[2] Dziegielewski, B., Kiefer, J., Opitz, E., Porter, G., Lantz, G. (2000) *Commercial and Institutional End Uses of Water*
[3] Southern California Lodging Forecast, PKF Consulting USA
https://www.cpp.edu/~collins/partners/outlook.../PKFConsulting.pdf
[4] 2013 Lodging Industry Profile. American Hotel and Lodging Association
[5] Gleick, P., Haasz, D., Henges-Jeck, C. (2003), *Waste Not, Want Not:The Potential for Urban Water Conservation in California*
[6] Borchgrevink, C., Cha, J., Kim, S., *Hand Washing Practices in a College Town Environment*
[7] Guinan, M.E., McGuckin-Guinan, M., & Sevareid, A. (1997). Who washes hands after using the bathroom? *American Journal of Infection Control*
[8] Water Resources Engineering, Inc. (2002), *Water Conservation Market Penetration Study – Final Report*
[9] California Public Utilities Commission, Energy Division, WORKPAPER DISPOSITION FOR Water Fixtures (2013)
[10] Southern California Gas Company, Workpaper SCGWP100303A, Revision 3 (2013)