* + 1. Low Flow Faucet Aerators

**Description**

This measure relates to the direct installation of a low flow faucet aerator in a commercial building. Expected applications include small business, office, restaurant, or motel. For multifamily or senior housing, the residential low flow faucet aerator should be used.

This measure was developed to be applicable to the following program types, DI.

If applied to other program types, the measure savings should be verified.

**Definition of Efficient Equipment**

To qualify for this measure the installed equipment must be an energy efficient faucet aerator, for bathrooms rated at 1.5 gallons per minute (GPM) or less, or for kitchens rated at 2.2 GPM or less. Savings are calculated on an average savings per faucet fixture basis.

**Definition of Baseline Equipment**

The baseline condition is assumed to be a standard bathroom faucet aerator rated at 2.25 GPM or more, or a standard kitchen faucet aerator rated at 2.75 GPM or more. Note if flow rates are measured, for example through a Direct Install program, then actual baseline flow rates should be used as opposed to the deemed values.

**Deemed Lifetime of Efficient Equipment**

The expected measure life is assumed to be 9 years.[[1]](#footnote-1)

**Deemed Measure Cost**

The incremental cost for this measure is $8[[2]](#footnote-2) or program actual.

**Loadshape**

Loadshape C02 - Commercial Electric DHW

**Coincidence Factor**

The coincidence factor for this measure is dependent on building type as presented below.

**Algorithm**

**Calculation of Savings**

**Electric Energy Savings**

**Note these savings are *per* faucet retrofitted[[3]](#footnote-3).**

ΔkWh = %ElectricDHW \* ((GPM\_base - GPM\_low)/GPM\_base) \* Usage \* EPG\_electric \* ISR

Where:

%ElectricDHW = proportion of water heating supplied by electric resistance heating

|  |  |
| --- | --- |
| DHW fuel | %Electric\_DHW |
| Electric | 100% |
| Fossil Fuel | 0% |

GPM\_base = Average flow rate, in gallons per minute, of the baseline faucet “as-used”

= 1.39[[4]](#footnote-4) or custom based on metering studies[[5]](#footnote-5) or if measured during DI:

= Measured full throttle flow \* 0.83 throttling factor[[6]](#footnote-6)

GPM\_low = Average flow rate, in gallons per minute, of the low-flow faucet aerator “as-used”

= 0.94[[7]](#footnote-7) or custom based on metering studies[[8]](#footnote-8) or if measured during DI:

= Rated full throttle flow \* 0.95 throttling factor[[9]](#footnote-9)

Usage = Estimated usage of mixed water (mixture of hot water from water heater line and cold water line) per faucet (gallons per year)

= If data is available to provide a reasonable custom estimate it should be used, if not use the following defaults (or substitute custom information in to the calculation):

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Building Type** | **Gallons hot water per unit per day[[10]](#footnote-10)**  **(A)** | **Unit** | **Estimated % hot water from Faucets [[11]](#footnote-11)**  **(B)** | **Multiplier [[12]](#footnote-12)**  **(C)** | **Unit** | **Days per year**  **(D)** | **Annual gallons mixed water per faucet**  **(A\*B\*C\*D)** |
| Small Office | 1 | person | 100% | 10 | employees per faucet | 250 | 2,500 |
| Large Office | 1 | person | 100% | 45 | employees per faucet | 250 | 11,250 |
| Fast Food Rest | 0.7 | meal/day | 50% | 75 | meals per faucet | 365 | 9,581 |
| Sit-Down Rest | 2.4 | meal/day | 50% | 36 | meals per faucet | 365 | 15,768 |
| Retail | 2 | employee | 100% | 5 | employees per faucet | 365 | 3,650 |
| Grocery | 2 | employee | 100% | 5 | employees per faucet | 365 | 3,650 |
| Warehouse | 2 | employee | 100% | 5 | employees per faucet | 250 | 2,500 |
| Elementary School | 0.6 | person | 50% | 50 | students per faucet | 200 | 3,000 |
| Jr High/High School | 1.8 | person | 50% | 50 | students per faucet | 200 | 9,000 |
| Health | 90 | patient | 25% | 2 | Patients per faucet | 365 | 16,425 |
| Motel | 20 | room | 25% | 1 | faucet per room | 365 | 1,825 |
| Hotel | 14 | room | 25% | 1 | faucet per room | 365 | 1,278 |
| Other | 1 | employee | 100% | 20 | employees per faucet | 250 | 5,000 |

EPG\_electric = Energy per gallon of mixed water used by faucet (electric water heater)

= (8.33 \* 1.0 \* (WaterTemp - SupplyTemp)) / (RE\_electric \* 3412)

= 0.0795 kWh/gal for Bath, 0.0969 kWh/gal for Kitchen, 0.0919 kWh/gal for unknown

8.33 = Specific weight of water (lbs/gallon)

1.0 = Heat Capacity of water (btu/lb-°F)

WaterTemp = Assumed temperature of mixed water

= 86F for Bath, 93F for Kitchen 91F for Unknown[[13]](#footnote-13)

SupplyTemp = Assumed temperature of water entering building

= 54.1°F [[14]](#footnote-14)

RE\_electric = Recovery efficiency of electric water heater

= 98% [[15]](#footnote-15)

3412 = Converts Btu to kWh (Btu/kWh)

ISR = In service rate of faucet aerators dependant on install method as listed in table below[[16]](#footnote-16)

|  |  |
| --- | --- |
| **Selection** | **ISR** |
| Direct Install - Deemed | 0.95 |

EXAMPLE

For example, a direct installed kitchen faucet in a large office with electric DHW:

ΔkWh = 1 \* ((1.39 – 0.94)/1.39) \* 11,250 \* 0.0969 \* 0.95

= 335.3 kWh

For example, a direct installed bathroom faucet in an Elementary School with electric DHW:

ΔkWh = 1 \* ((1.39 – 0.94)/1.39) \* 3,000 \* 0.0795 \* 0.95

= 73.4 kWh

**Summer Coincident Peak Demand Savings**

ΔkW = (ΔkWh / Hours) \* CF

Where:

ΔkWh = calculated value above on a per faucet basis

Hours = Annual electric DHW recovery hours for faucet use

= (Usage \* 0.545[[17]](#footnote-17) )/GPH

= Calculate if usage is custom, if using default usage use:

| **Building Type** | **Annual Recovery Hours** |
| --- | --- |
| Small Office | 24 |
| Large Office | 109 |
| Fast Food Rest | 93 |
| Sit-Down Rest | 153 |
| Retail | 36 |
| Grocery | 36 |
| Warehouse | 24 |
| Elementary School | 29 |
| Jr High/High School | 88 |
| Health | 160 |
| Motel | 18 |
| Hotel | 12 |
| Other | 49 |

Where:

GPH = Gallons per hour recovery of electric water heater calculated for 85.9F temp rise (140-54.1), 98% recovery efficiency, and typical 12kW electric resistance storage tank.

= 56

CF = Coincidence Factor for electric load reduction

= Dependent on building type[[18]](#footnote-18)

| **Building Type** | **Coincidence Factor** |
| --- | --- |
| Small Office | 0.0064 |
| Large Office | 0.0288 |
| Fast Food Rest | 0.0084 |
| Sit-Down Rest | 0.0184 |
| Retail | 0.0043 |
| Grocery | 0.0043 |
| Warehouse | 0.0064 |
| Elementary School | 0.0096 |
| Jr High/High School | 0.0288 |
| Health | 0.0144 |
| Motel | 0.0006 |
| Hotel | 0.0004 |
| Other | 0.0128 |

EXAMPLE

For example, a direct installed kitchen faucet in a large office with electric DHW:

ΔkW = 335.3/109 \* 0.0288

= 0.0816 kW

For example, a direct installed bathroom faucet in an Elementary School with electric DHW:

ΔkW = 73.4/29 \* 0.0096

= 0.0243 kW

**Fossil Fuel Impact Descriptions and Calculation**

ΔTherms = %FossilDHW \* ((GPM\_base - GPM\_low)/GPM\_base) \* Usage \* EPG\_gas \* ISR

Where:

%FossilDHW = proportion of water heating supplied by fossil fuel heating

| **DHW fuel** | **%Fossil\_DHW** |
| --- | --- |
| Electric | 0% |
| Fossil Fuel | 100% |

EPG\_gas = Energy per gallon of mixed water used by faucet (gas water heater)

= (8.33 \* 1.0 \* (WaterTemp - SupplyTemp)) / (RE\_gas \* 100,000)

= 0.00397 Therm/gal for Bath, 0.00484 Therm/gal for Kitchen, 0.00459 Therm/gal for unknown

Where:

RE\_gas = Recovery efficiency of gas water heater

` = 67% [[19]](#footnote-19)

100,000 = Converts Btus to Therms (Btu/Therm)

Other variables as defined above.

EXAMPLE

For example, a direct installed kitchen faucet in a large office with gas DHW:

ΔTherms = 1 \* ((1.39 – 0.94)/1.39) \* 11,250 \* 0.00484 \* 0.95

= 16.7 Therms

For example, a direct installed bathroom faucet in an Elementary School with gas DHW:

ΔTherms = 1 \* ((1.39 – 0.94)/1.39) \* 3,000 \* 0.00397 \* 0.95

= 3.66 Therms

**Water Impact Descriptions and Calculation**

Δgallons = ((GPM\_base - GPM\_low)/GPM\_base) \* Usage \* ISR

Variables as defined above

EXAMPLE

For example, a direct installed faucet in a large office:

Δgallons = ((1.39 – 0.94)/1.39) \* 11,250 \* 0.95

= 3,640 gallons

For example, a direct installed faucet in a Elementary School:

Δgallons = ((1.39 – 0.94)/1.39) \* 3,000 \* 0.95

= 971 gallons

**Deemed O&M Cost Adjustment Calculation**

N/A

**Sources used for GPM assumptions**

|  |  |
| --- | --- |
| **Source ID** | **Reference** |
| 1 | 2011, DeOreo, William. California Single Family Water Use Efficiency Study. April 20, 2011. |
| 2 | 2000, Mayer, Peter, William DeOreo, and David Lewis. Seattle Home Water Conservation Study. December 2000. |
| 3 | 1999, Mayer, Peter, William DeOreo. Residential End Uses of Water. Published by AWWA Research Foundation and American Water Works Association. 1999. |
| 4 | 2003, Mayer, Peter, William DeOreo. Residential Indoor Water Conservation Study. Aquacraft, Inc. Water Engineering and Management. Prepared for East Bay Municipal Utility District and the US EPA. July 2003. |
| 5 | 2011, DeOreo, William. Analysis of Water Use in New Single Family Homes. By Aquacraft. For Salt Lake City Corporation and US EPA. July 20, 2011. |
| 6 | 2011, Aquacraft. Albuquerque Single Family Water Use Efficiency and Retrofit Study. For Albuquerque Bernalillo County Water Utility Authority. December 1, 2011. |
| 7 | 2008, Schultdt, Marc, and Debra Tachibana. Energy related Water Fixture Measurements: Securing the Baseline for Northwest Single Family Homes. 2008 ACEEE Summer Study on Energy Efficiency in Buildings. |

**Measure Code: CI-HWE-LFFA-V06-160601**

1. Table C-6, Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007. "http://neep.org/Assets/uploads/files/emv/emv-library/measure\_life\_GDS%5B1%5D.pdf" [↑](#footnote-ref-1)
2. Direct-install price per faucet assumes cost of aerator and install time. (2011, Market research average of $3 and assess and install time of $5 (20min @ $15/hr) [↑](#footnote-ref-2)
3. This algorithm calculates the amount of energy saved per aerator by determining the fraction of water consumption savings for the upgraded fixture. Due to the distribution of water consumption by fixture type, as well as the different number of fixtures in a building, several variables must be incorporated. [↑](#footnote-ref-3)
4. DeOreo, B., and P. Mayer. Residential End Uses of Water Study Update. Forthcoming. ©2015 Water Research Foundation. Reprinted With Permission. [↑](#footnote-ref-4)
5. Measurement should be based on actual average flow consumed over a period of time rather than a onetime spot measurement for maximum flow. Studies have shown maximum flow rates do not correspond well to average flow rate due to occupant behavior which does not always use maximum flow. [↑](#footnote-ref-5)
6. 2008, Schultdt, Marc, and Debra Tachibana. Energy related Water Fixture Measurements: Securing the Baseline for Northwest Single Family Homes. 2008 ACEEE Summer Study on Energy Efficiency in Buildings. Page 1-265. www.seattle.gov/light/Conserve/Reports/paper\_10.pdf [↑](#footnote-ref-6)
7. Average retrofit flow rate for kitchen and bathroom faucet aerators from sources 2, 4, 5, and 7. This accounts for all throttling and differences from rated flow rates. Assumes all kitchen aerators at 2.2 gpm or less and all bathroom aerators at 1.5 gpm or less. The most comprehensive available studies did not disaggregate kitchen use from bathroom use, but instead looked at total flow and length of use for all faucets. This makes it difficult to reliably separate kitchen water use from bathroom water use. It is possible that programs installing low flow aerators lower than the 2.2 gpm for kitchens and 1.5 gpm for bathrooms will see a lower overall average retrofit flow rate. [↑](#footnote-ref-7)
8. Measurement should be based on actual average flow consumed over a period of time rather than a onetime spot measurement for maximum flow. Studies have shown maximum flow rates do not correspond well to average flow rate due to occupant behavior which does not always use maximum flow. [↑](#footnote-ref-8)
9. 2008, Schultdt, Marc, and Debra Tachibana. Energy related Water Fixture Measurements: Securing the Baseline for Northwest Single Family Homes. 2008 ACEEE Summer Study on Energy Efficiency in Buildings. Page 1-265. www.seattle.gov/light/Conserve/Reports/paper\_10.pdf [↑](#footnote-ref-9)
10. Table 2-45 Chapter 49, Service Water Heating, 2007 ASHRAE Handbook, HVAC Applications. [↑](#footnote-ref-10)
11. Estimated based on data provided in Appendix E; “Waste Not, Want Not: The Potential for Urban Water Conservation in California”; http://www.pacinst.org/reports/urban\_usage/appendix\_e.pdf [↑](#footnote-ref-11)
12. Based on review of the Illinois plumbing code (Employees and students per faucet). Retail, grocery, warehouse and health are estimates. Meals per faucet estimated as 4 bathroom and 3 kitchen faucets and average meals per day of 250 (based on California study above) – 250/7 = 36. Fast food assumption estimated. [↑](#footnote-ref-12)
13. Cadmus and Opinion Dynamics Showerhead and Faucet Aerator Meter Study Memorandum dated June 2013, directed to Michigan Evaluation Working Group. If the aerator location is unknown an average of 91% should be used which is based on the assumption that 70% of household water runs through the kitchen faucet and 30% through the bathroom (0.7\*93)+(0.3\*86)=0.91. [↑](#footnote-ref-13)
14. US DOE Building America Program. Building America Analysis Spreadsheet. For Chicago, IL <http://www1.eere.energy.gov/buildings/building_america/analysis_spreadsheets.html>. [↑](#footnote-ref-14)
15. Electric water heaters have recovery efficiency of 98%: <http://www.ahridirectory.org/ahridirectory/pages/home.aspx> [↑](#footnote-ref-15)
16. ComEd Energy Efficiency/ Demand Response Plan: Plan Year 2 (6/1/2009-5/31/2010) Evaluation Report: All Electric Single Family Home Energy Performance Tune-Up Program Table 3-8 <http://ilsagfiles.org/SAG_files/Evaluation_Documents/ComEd/ComEd%20EPY2%20Evaluation%20Reports/ComEd_All_Electric_Single_Family_HEP_PY2_Evaluation_Report_Final.pdf> [↑](#footnote-ref-16)
17. 54.5% is the proportion of hot 120F water mixed with 54.1F supply water to give 90°F mixed faucet water. [↑](#footnote-ref-17)
18. Calculated as follows: Assumptions for percentage of usage during peak period (1-5pm) were made and then multiplied by 65/365 (65 being the number of days in peak period) and by the number of total annual recovery hours to give an estimate of the number of hours of recovery during peak periods. There are 260 hours in the peak period so the probability you will see savings during the peak period is calculated as the number of hours of recovery during peak divided by 260. See ‘C&I Faucet Aerator.xls’ for details. [↑](#footnote-ref-18)
19. Review of AHRI Directory suggests range of recovery efficiency ratings for new Gas DHW units of 70-87%. Average of existing units is estimated at 75%. Commercial properties are more similar to MF homes than SF homes. MF hot water is often provided by a larger commercial boiler. This suggests that the average recovery efficiency is somewhere between a typical central boiler efficiency of .59 and the .75 for single family home. An average is used for this analysis by default. [↑](#footnote-ref-19)