### Low Flow Faucet Aerators

This measure relates to the installation of a low flow faucet aerator in a household kitchen or bath faucet fixture.

This measure may be used for units provided through Efficiency Kit’s however the in service rate for such measures should be derived through evaluation results specifically for this implementation methodology.

This measure was developed to be applicable to the following program types:  TOS, NC, RF, DI, KITS.

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 a low flow 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 greater, or a standard kitchen faucet aerator rated at 2.75 GPM or greater. Average measured flow rates are used in the algorithm and are lower, reflecting the penetration of previously installed low flow fixtures (and therefore the freerider rate for this measure should be 0), use of the faucet at less than full flow, debris buildup, and lower water system pressure than fixtures are rated at.

###### 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.

For faucet aerators provided in Efficiency Kits, the actual program delivery costs should be utilized.

###### Loadshape

Loadshape R03 - Residential Electric DHW

###### Coincidence Factor

The coincidence factor for this measure is assumed to be 2.2%.[[3]](#footnote-3)

**Algorithm**

###### Calculation of Savings

###### Electric Energy Savings

Note these savings are *per* faucet retrofitted[[4]](#footnote-4) (unless faucet type is unknown, then it is per household).

ΔkWh = %ElectricDHW \* ((GPM\_base \* L\_base - GPM\_low \* L\_low) \* Household \* 365.25 \*DF / FPH) \* EPG\_electric \* ISR

Where:

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

|  |  |
| --- | --- |
| **DHW fuel** | **%ElectricDHW** |
| Electric | 100% |
| Natural Gas | 0% |
| Unknown | 16%[[5]](#footnote-5) |

GPM\_base = Average flow rate, in gallons per minute, of the baseline faucet “as-used.” This includes the effect of existing low flow fixtures and therefore the freerider rate for this measure should be 0.

= 1.39[[6]](#footnote-6) or custom based on metering studies[[7]](#footnote-7) or if measured during DI:

= Measured full throttle flow \* 0.83 throttling factor[[8]](#footnote-8)

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

= 0.94[[9]](#footnote-9) or custom based on metering studies[[10]](#footnote-10) or if measured during DI:

= Rated full throttle flow \* 0.95 throttling factor[[11]](#footnote-11)

L\_base = Average baseline daily length faucet use per capita for faucet of interest in minutes

= if available custom based on metering studies, if not use:

|  |  |
| --- | --- |
| **Faucet Type** | **L\_base (min/person/day)** |
| Kitchen | 4.5[[12]](#footnote-12) |
| Bathroom | 1.6[[13]](#footnote-13) |
| If location unknown (total for household): Single-Family | 9.0[[14]](#footnote-14) |
| If location unknown (total for household): Multi-Family | 6.9[[15]](#footnote-15) |

L\_low = Average retrofit daily length faucet use per capita for faucet of interest in minutes

= if available custom based on metering studies, if not use:

| **Faucet Type** | **L\_low (min/person/day)** |
| --- | --- |
| Kitchen | 4.5[[16]](#footnote-16) |
| Bathroom | 1.6[[17]](#footnote-17) |
| If location unknown (total for household): Single-Family | 9.0[[18]](#footnote-18) |
| If location unknown (total for household): Multi-Family | 6.9[[19]](#footnote-19) |

Household = Average number of people per household

|  |  |
| --- | --- |
| **Household Unit Type** | **Household** |
| Single-Family - Deemed | 2.56[[20]](#footnote-20) |
| Multi-Family - Deemed | 2.1[[21]](#footnote-21) |
| Custom | Actual Occupancy or Number of Bedrooms[[22]](#footnote-22) |

365.25 = Days in a year, on average.

DF = Drain Factor

|  |  |
| --- | --- |
| **Faucet Type** | **Drain Factor[[23]](#footnote-23)** |
| Kitchen | 75% |
| Bath | 90% |
| Unknown | 79.5% |

FPH = Faucets Per Household

| **Faucet Type** | **FPH** |
| --- | --- |
| Kitchen Faucets Per Home (KFPH) | 1 |
| Bathroom Faucets Per Home (BFPH): Single-Family | 2.83[[24]](#footnote-24) |
| Bathroom Faucets Per Home (BFPH): Multi-Family | 1.5[[25]](#footnote-25) |
| If location unknown (total for household): Single-Family | 3.83 |
| If location unknown (total for household): Multi-Family | 2.5 |

EPG\_electric = Energy per gallon of water used by faucet supplied by electric water heater

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

= (8.33 \* 1.0 \* (86 – 54.1)) / (0.98 \* 3412)

= 0.0795 kWh/gal (Bath), 0.0969 kWh/gal (Kitchen), 0.0919 kWh/gal (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[[26]](#footnote-26)

SupplyTemp = Assumed temperature of water entering house

= 54.1F [[27]](#footnote-27)

RE\_electric = Recovery efficiency of electric water heater

= 98% [[28]](#footnote-28)

3412 = Converts Btu to kWh (btu/kWh)

ISR = In service rate of faucet aerators dependant on install method as listed in table below

| **Selection** | **ISR** |
| --- | --- |
| Direct Install - Single Family | 0.95[[29]](#footnote-29) |
| Direct Install – Multi Family Kitchen | 0.91[[30]](#footnote-30) |
| Direct Install – Multi Family Bathroom | 0.95[[31]](#footnote-31) |
| Efficiency Kit Bathroom Aerator | 0.63[[32]](#footnote-32) |
| Efficiency Kit Kitchen Aerator | 0.60 |

For example, a direct installed kitchen low flow faucet aerator in a single-family electric DHW home:

ΔkWh = 1.0 \* (((1.39 \* 4.5 – 0.94 \* 4.5) \* 2.56 \* 365.25 \*0.75) / 1) \* 0.0969 \* 0.95

= 131 kWh

For example, a direct installed bath low flow faucet aerator in a multi-family electric DHW home:

ΔkWh = 1.0 \* (((1.39 \* 1.6 – 0.94 \* 1.6) \* 2.1 \* 365.25 \* 0.90) /1.5) \* 0.0795 \* 0.95

= 25.0 kWh

For example, a direct installed low flow faucet aerator in unknown faucet in a single-family electric DHW home:

ΔkWh = 1.0 \* (((1.39 \* 9.0 – 0.94 \* 9.0) \* 2.56 \* 365.25 \* 0.795) /3.83) \* 0.0919 \* 0.95

= 68.6 kWh

###### Summer Coincident Peak Demand Savings

ΔkW = ΔkWh / Hours \* CF

Where:

ΔkWh = calculated value above

Hours = Annual electric DHW recovery hours for faucet use per faucet

= ((GPM\_base \* L\_base) \* Household/FPH \* 365.25 \* DF ) \* 0.545[[33]](#footnote-33) / GPH

| **Building Type** | **Faucet location** | **Calculation** | **Hours per faucet** |
| --- | --- | --- | --- |
| Single Family | Kitchen | ((1.39 \* 4.5) \* 2.56/1 \* 365.25 \* 0.75) \* 0.545 / 25.5 | 94 |
| Bathroom | ((1. 39 \* 1.6) \* 2.56/2.83 \* 365.25 \* 0.9) \* 0.545 / 25.5 | 14 |
| Unknown | ((1. 39 \* 9.0) \* 2.56/3.83 \* 365.25 \* 0.795) \* 0.545 / 25.5 | 52 |
| Multi Family | Kitchen | ((1. 39 \* 4.5) \* 2.1/1 \* 365.25 \* 0.75) \* 0.545 / 25.5 | 77 |
| Bathroom | ((1. 39 \* 1.6) \* 2.1/1.5 \* 365.25 \* 0.9) \* 0.545 / 25.5 | 22 |
| Unknown | ((1. 39 \* 6.9) \* 2.1/2.5 \* 365.25 \* 0.795) \* 0.545 / 25.5 | 50 |

GPH = Gallons per hour recovery of electric water heater calculated for 70.9F temp rise (125-54.1), 98% recovery efficiency, and typical 4.5kW electric resistance storage tank.

= 25.5

CF = Coincidence Factor for electric load reduction

= 0.022[[34]](#footnote-34)

For example, a direct installed kitchen low flow faucet aerator in a single family electric DHW home:

ΔkW = 131/94 \* 0.022

= 0.0306 kW

###### Natural Gas Savings

ΔTherms = %FossilDHW \* ((GPM\_base \* L\_base - GPM\_low \* L\_low) \* Household \* 365.25 \*DF / FPH) \* EPG\_gas \* ISR

Where:

%FossilDHW = proportion of water heating supplied by Natural Gas heating

|  |  |
| --- | --- |
| **DHW fuel** | **%Fossil\_DHW** |
| Electric | 0% |
| Natural Gas | 100% |
| Unknown | 84%[[35]](#footnote-35) |

EPG\_gas = Energy per gallon of Hot water supplied by gas

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

= 0.00341 Therm/gal for SF homes (Bath), 0.00415 Therm/gal for SF homes (Kitchen), 0.00394 Therm/gal for SF homes (Unknown)

= 0.00397 Therm/gal for MF homes (Bath), 0.00484 Therm/gal for MF homes (Kitchen), 0.00459 Therm/gal for MF homes (Unknown)

RE\_gas = Recovery efficiency of gas water heater

= 78% For SF homes[[36]](#footnote-36)

= 67% For MF homes[[37]](#footnote-37)

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

Other variables as defined above.

For example, a direct-installed kitchen low flow faucet aerator in a fuel DHW single-family home:

ΔTherms = 1.0 \* (((1.39 \* 4.5 – 0.94 \* 4.5) \* 2.56 \* 365.25 \*0.75) / 1) \* 0.00415 \* 0.95

= 5.60 Therms

For example, a direct installed bath low flow faucet aerator in a fuel DHW multi-family home:

ΔTherms = 1.0 \* (((1.39 \* 1.6 – 0.94 \* 1.6) \* 2.1 \* 365.25 \* 0.90) /1.5) \* 0.003974 \* 0.95

= 1.25 Therms

For example, a direct installed low flow faucet aerator in unknown faucet in a fuel DHW single-family home:

ΔTherms = 1.0 \* (((1.39 \* 9.0 – 0.94 \* 9.0) \* 2.56 \* 365.25 \* 0.795) /3.83) \* 0.00394 \* 0.95

= 2.94 Therms

###### Water Impact Descriptions and Calculation

Δgallons = ((GPM\_base \* L\_base - GPM\_low \* L\_low) \* Household \* 365.25 \*DF / FPH) \* ISR

Variables as defined above

For example, a direct-installed kitchen low flow aerator in a single family home

Δgallons = (((1.39 \* 4.5 – 0.94 \* 4.5) \* 2.56 \* 365.25 \*0.75) / 1) \* 0.95

= 1350 gallons

For example, a direct installed bath low flow faucet aerator in a multi-family home:

Δgallons = (((1.39 \* 1.6 – 0.94 \* 1.6) \* 2.1 \* 365.25 \* 0.90) /1.5) \* 0.95

= 314 gallons

For example, a direct installed low flow faucet aerator in unknown faucet in a single-family home:

Δgallons = (((1.39 \* 9.0 – 0.94 \* 9.0) \* 2.56 \* 365.25 \* 0.795) /3.83) \* 0.95

= 747 gallons

###### Deemed O&M Cost Adjustment Calculation

N/A

###### Sources

|  |  |
| --- | --- |
| **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: RS-HWE-LFFA-V05-160601**

1. Table C-6, Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007. "http://neep.org/uploads/EMV%20Forum/EMV%20Studies/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. Calculated as follows: Assume 18% aerator use takes place during peak hours (based on: <http://www.aquacraft.com/sites/default/files/pub/DeOreo-%282001%29-Disaggregated-Hot-Water-Use-in-Single-Family-Homes-Using-Flow-Trace-Analysis.pdf>) There are 65 days in the summer peak period, so the percentage of total annual aerator use in peak period is 0.18\*65/365 = 3.21%. The number of hours of recovery during peak periods is therefore assumed to be 3.21% \*180 = 5.8 hours of recovery during peak period where 180 equals the average annual electric DHW recovery hours for faucet use including SF and MF homes. There are 260 hours in the peak period so the probability you will see savings during the peak period is 5.8/260 = 0.022 [↑](#footnote-ref-3)
4. This algorithm calculates the amount of energy saved per aerator by determining the fraction of water consumption savings for the upgraded fixture. [↑](#footnote-ref-4)
5. Default assumption for unknown fuel is based on EIA Residential Energy Consumption Survey (RECS) 2009 for Midwest Region, data for the state of IL. If utilities have specific evaluation results providing a more appropriate assumption for homes in a particular market or geographical area then that should be used [↑](#footnote-ref-5)
6. Deoreo, B., and P. Mayer. Residential End Uses of Water Study Update. Forthcoming. ©2015 Water Research Foundation. Reprinted With Permission. [↑](#footnote-ref-6)
7. 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-7)
8. 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-8)
9. Average retrofit flow rate for kitchen and bathroom faucet aerators from sources 2, 4, 5, and 7(see source table at end of characterization). 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-9)
10. 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-10)
11. 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-11)
12. Cadmus and Opinion Dynamics Showerhead and Faucet Aerator Meter Study Memorandum dated June 2013, directed to Michigan Evaluation Working Group. This study of 135 single and multi-family homes in Michigan metered energy parameters for efficient showerhead and faucet aerators. [↑](#footnote-ref-12)
13. Ibid. [↑](#footnote-ref-13)
14. One kitchen faucet plus 2.83 bathroom faucets. Based on findings from a 2009 ComEd residential survey of 140 sites, provided by Cadmus. [↑](#footnote-ref-14)
15. One kitchen faucet plus 1.5 bathroom faucets. Based on findings from a 2009 ComEd residential survey of 140 sites, provided by Cadmus. [↑](#footnote-ref-15)
16. Cadmus and Opinion Dynamics Showerhead and Faucet Aerator Meter Study Memorandum dated June 2013, directed to Michigan Evaluation Working Group. [↑](#footnote-ref-16)
17. Ibid. [↑](#footnote-ref-17)
18. One kitchen faucet plus 2.83 bathroom faucets. Based on findings from a 2009 ComEd residential survey of 140 sites, provided by Cadmus. [↑](#footnote-ref-18)
19. One kitchen faucet plus 1.5 bathroom faucets. Based on findings from a 2009 ComEd residential survey of 140 sites, provided by Cadmus. [↑](#footnote-ref-19)
20. 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 citing 2006-2008 American Community Survey data from the US Census Bureau for Illinois cited on p. 17 of the PY2 Evaluation report. 2.75 \* 93% evaluation adjustment [↑](#footnote-ref-20)
21. Navigant, ComEd PY3 Multi-Family Home Energy Savings Program Evaluation Report Final, May 16, 2012. [↑](#footnote-ref-21)
22. Bedrooms are suitable proxies for household occupancy, and may be preferable to actual occupancy due to turnover rates in residency and non-adult population impacts. [↑](#footnote-ref-22)
23. Because faucet usages are at times dictated by volume, only usage of the sort that would go straight down the drain will provide savings. VEIC is unaware of any metering study that has determined this specific factor and so through consensus with the Illinois Technical Advisory Group have deemed these values to be 75% for the kitchen and 90% for the bathroom. If the aerator location is unknown an average of 79.5% 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\*0.75)+(0.3\*0.9)=0.795. [↑](#footnote-ref-23)
24. Based on findings from a 2009 ComEd residential survey of 140 sites, provided by Cadmus. [↑](#footnote-ref-24)
25. Ibid. [↑](#footnote-ref-25)
26. 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-26)
27. 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-27)
28. Electric water heaters have recovery efficiency of 98%: <http://www.ahridirectory.org/ahridirectory/pages/home.aspx> [↑](#footnote-ref-28)
29. 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 [↑](#footnote-ref-29)
30. Navigant, ComEd-Nicor Gas EPY4/GPY1 Multi-Family Home Energy Savings Program Evaluation Report DRAFT 2013-01-28 [↑](#footnote-ref-30)
31. Ibid. [↑](#footnote-ref-31)
32. From Navigant memo, “Nicor Gas energySMART Energy Saving Kits Program In Service Rate and Process  
    Analysis”, August 28, 2015. [↑](#footnote-ref-32)
33. 54.5% is the proportion of hot 120F water mixed with 54.1F supply water to give 90F mixed faucet water. [↑](#footnote-ref-33)
34. Calculated as follows: Assume 18% aerator use takes place during peak hours (based on: <http://www.aquacraft.com/sites/default/files/pub/DeOreo-%282001%29-Disaggregated-Hot-Water-Use-in-Single-Family-Homes-Using-Flow-Trace-Analysis.pdf>) There are 65 days in the summer peak period, so the percentage of total annual aerator use in peak period is 0.18\*65/365 = 3.21%. The number of hours of recovery during peak periods is therefore assumed to be 3.21% \*180 = 5.8 hours of recovery during peak period where 180 equals the average annual electric DHW recovery hours for faucet use including SF and MF homes. There are 260 hours in the peak period so the probability you will see savings during the peak period is 5.8/260 = 0.022 [↑](#footnote-ref-34)
35. Default assumption for unknown fuel is based on EIA Residential Energy Consumption Survey (RECS) 2009 for Midwest Region, data for the state of IL. If utilities have specific evaluation results providing a more appropriate assumption for homes in a particular market or geographical area then that should be used [↑](#footnote-ref-35)
36. DOE Final Rule discusses Recovery Efficiency with an average around 0.76 for Gas Fired Storage Water heaters and 0.78 for standard efficiency gas fired tankless water heaters up to 0.95 for the highest efficiency gas fired condensing tankless water heaters. These numbers represent the range of new units however, not the range of existing units in stock. 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 78%. [↑](#footnote-ref-36)
37. Water heating in multi-family buildings is often provided by a larger central boiler. This suggests that the average recovery efficiency is somewhere between a typical central boiler efficiency of 0.59 and the 0.75 for single family homes. An average efficiency of 0.67 is used for this analysis as a default for multi-family buildings. [↑](#footnote-ref-37)