**Workpaper SCGWP100303B**

**Revision 6**

**Southern California Gas Company**

**Customer Programs Department**

**Temperature-Initiated Shower Flow Restriction Valve with and without an Integrated Low-Flow Showerhead**

Revision History

|  |  |  |  |
| --- | --- | --- | --- |
| Revision No. | Date | **Description** | **Author** |
| 0 | 03/03/2010 | PG&E authored Workpaper, reformatted to current WP template | PG&E |
| 1 | 03/09/2010 | Final Version Released for ED Review   * Revisions to Rev. 0 incorporate ASW M&V Study results alter baseline conditions. | Chan Paek |
| 2 | 07/07/2010 | Incorporates comments from ED dated 4/27/2010   * Revision to water heater efficiency * Revision to SF number of showerheads per household and its subsequent cascading affects. | Chan Paek |
| 3 | 08/16/2010 | Revised Terms and Conditions to exclude tub/shower combination systems as being a measure defined within the parameters of this Workpaper | Eric Kirchhoff |
| 4 | 8/31/2010 | For Release  Adjustment for baseline hot water consumption for shower as recommended by ED dated 4/27/2010.  Application of 7.4 min in place of old 11.2 minutes for shower duration was made to accommodate the suggested lower shower water consumption. Therm savings are adjusted accordingly | Chan Paek |
| 5 | 8/9/2011 | Incorporation of CPUC decision to reduce UES by 20% to account for reduced effect of the flow-restriction valve in tub/shower application.16 | Chan Paek |
| 6 | 12/16/2013 | Weather Data Updates and Baseline Change from 2013 CPUC Water Fixture Disposition | Joseph Pan |
|  |  |  |  |

# 

Measure Summary Table A

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Measure ID | Measure Name | Program Application Type (RE, NC, ROB, ER, etc) | EUR/RUL (yr) | CZ | Building Type | Building Vintage | Unit  Definition | NTG IMC | NTG Savings | Program Delivery Method (CustIncent, PreReb, Dirinstall, etc) | Gross Realization Rate (GRR) | % Eligible for TOU AC Adjustment |
| 1 | Temperature-Initiated Restriction Valve Only | NC, ROB | 10 | 1 | SF | EX | Valve | 0.55 | 0.55 | PreReb | 1 | N/A |
| 17 | Temperature-Initiated Restriction Valve Only | NC, ROB | 10 | 1 | MF | EX | Valve | 0.55 | 0.55 | PreReb | 1 | N/A |
| 33 | Temperature-Initiated Restriction Valve Only | RET | 6.7/3.3 | 1 | SF | EX | Valve | 0.7 | 0.7 | DirInstall | 1 | N/A |
| 49 | Temperature-Initiated Restriction Valve Only | RET | 6.7/3.3 | 1 | MF | EX | Valve | 0.7 | 0.7 | DirInstall | 1 | N/A |
| 65 | 1.6 gpm Showerhead + Restriction Valve | NC, ROB | 10 | 1 | SF | EX | Showerhead +Valve | 0.55 | 0.55 | PreReb | 1 | N/A |
| 81 | 1.6 gpm Showerhead + Restriction Valve | NC, ROB | 10 | 1 | MF | EX | Showerhead +Valve | 0.55 | 0.55 | PreReb | 1 | N/A |
| 97 | 1.6 gpm Showerhead + Restriction Valve | RET | 6.7/3.3 | 1 | SF | EX | Showerhead +Valve | 0.7 | 0.7 | DirInstall | 1 | N/A |
| 113 | 1.6 gpm Showerhead + Restriction Valve | RET | 6.7/3.3 | 1 | MF | EX | Showerhead +Valve | 0.7 | 0.7 | DirInstall | 1 | N/A |
| See Complete List in therm Saving Calculation File | | | | | | | | | | | | |

**SF = Single-Family**

**MF = Multi-Family**

**EX = Existing Vintage**

**NC = New Construction**

**RET = Early Retirement**

**ROB = Replacement On Burnout**

Measure Summary Table B

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Measure ID | Measure Name | 1st Baseline (EUL) | | | | 2nd Baseline (RUL) | | | |
| Gas Savings  (therms) | Base Total Cost ($/unit) | Measure Total Cost ($/unit) | Incremental Measure Cost ($/unit) | Gas Savings  (therms) | Base Total Cost ($/unit) | Measure Total Cost ($/unit) | Incremental Measure Cost ($/unit) |
|
| 1 | Temperature-Initiated Restriction Valve Only | 0 | 0 | 0 | 0 | 3.0 | 37.95 | 44.95 | 7 |
| 17 | Temperature-Initiated Restriction Valve Only | 0 | 0 | 0 | 0 | 3.2 | 37.95 | 44.95 | 7 |
| 33 | Temperature-Initiated Restriction Valve Only | 2.7 | 0 | 44.95 | 44.95 | 3.0 | 37.95 | 44.95 | 7 |
| 49 | Temperature-Initiated Restriction Valve Only | 2.9 | 0 | 44.95 | 44.95 | 3.2 | 37.95 | 44.95 | 7 |
| 65 | 1.6 gpm Showerhead + Restriction Valve | 0 | 0 | 0 | 0 | 11.9 | 37.95 | 54.95 | 17 |
| 81 | 1.6 gpm Showerhead + Restriction Valve | 0 | 0 | 0 | 0 | 13.3 | 37.95 | 54.95 | 17 |
| 97 | 1.6 gpm Showerhead + Restriction Valve | 9.9 | 0 | 54.95 | 54.95 | 11.9 | 37.95 | 54.95 | 17 |
| 113 | 1.6 gpm Showerhead + Restriction Valve | 8.6 | 0 | 54.95 | 54.95 | 13.3 | 37.95 | 54.95 | 17 |
| See Complete List in therm Saving Calculation File | | | | | | | | | |

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1. General Measure & Baseline Data
   1. Measure & Delivery Description

These measures create the opportunity for energy savings by installing temperature-initiated flow-restriction valves with or without an integrated low-flow showerhead in residential single-family or multifamily households.

These measures can be delivered to the Customer either as a New Construction program measure, an Early Retirement measure, or as a Replace On Burnout measure.

* + 1. Technical Description
       1. Low-Flow Showerhead

Low-flow showerheads are inexpensive and easy to install. Since about 73% of water used in a typical shower is hot water, this device will reduce the amount of water used. As a result, the water heater will consume less energy for water heating, thus creating an opportunity for savings[[1]](#endnote-1).

* + - 1. Temperature-Initiated Flow-Restriction Valve

Temperature-initiated flow-restriction valves are installed at the showerhead. The valve is initially open and allows cold water that has been sitting in the pipes to flow through the showerhead. When the water temperature reaches approximately 95 ºF, the valve restricts the water flow to a trickle until the user enters the shower and switches the valve open again to restore full flow. The intention of this device is to reduce the amount of hot water running down the drain during the ‘pre-useful shower’ warm-up period, i.e. the time the user lets the shower water run down the drain until the user enters the shower. This pre-useful shower period typically involves the user engaging in an activity outside of the shower stall, instead of standing at the showerhead, after which the user returns to the shower to find the hot water running (and the water has been hot for some period of time). By preventing hot water from unnecessarily running down the drain before the useful shower event, this device reduces water heater energy consumption because the hot water demand on the water heater has temporarily been restricted.

* + 1. Program Restrictions and Guidelines
       1. Terms and Conditions
          1. Make and model number must be included with a copy of customer’s receipt.
          2. Must have water heating source using natural gas distributed by the IOU sponsoring.
          3. The measure cannot be applied where recirculation pumps are used or where potential crossover between hot water and cod water may occur.
          4. The measure cannot be applied where tankless water heaters are used. Instantaneous tankless water heaters may have different effect on savings with temperature-initiated flow-restriction valves.
          5. Low-flow showerhead must pass test procedure ANSI/ASME A112.18.1-2000, Section 5.5.
          6. This measure cannot be applied where the showerhead is installed in tub/shower combination systems.
       2. Market Applicability

Measures presented in this paper apply to single-family and multi-family residential households.

* 1. DEER Differences Analysis
     1. Low-Flow Showerheads

There are no current DEER measures applicable for low-flow showerheads with flow of 1.7 gal-lons per minute (gpm) or less. However, there is a measure for showerheads with a flow of 2.0 gpm (Measure ID 2005-D03-937), though energy savings for 1.7 gpm showerheads may not be similar.

The 2004-05 DEER Methodology[[2]](#endnote-2) involved calculating the savings estimates as a percentage of the base water heat end-use Unit Energy Consumption (UEC). For Low-flow Showerheads, savings were 4% of the base water heat end-use. Multi-family base water heat end-use energy consumption was assumed to be between 76% and 82% of the single-family base water heat end-use. Water heating end-use was varied by utility service territory. The base case flow was assumed to be 2.5 gpm with the measure flow at 2.0 gpm.

The methodology employed in this work paper is similar to that found in a study done by the Ernest Orlando Lawrence Berkeley National Laboratory[[3]](#endnote-3). The study was headed by Peter J. Biermayer and was supported by the California Urban Water Conservation Council through the U.S. Department of Energy. This work paper method is more quantitative since resulting statistics from several studies were utilized for calculations. Also, the U.S. Census was used to find California population densities (people/household) and bath densities (baths/household) for multi-family residential units; therefore the resulting savings for this work paper are partially based on a state average rather than an investor owned utility service area average.

The ASW[[4]](#endnote-4) field study results within SEU service territory are applied in calculations for single-family units where applicable. The SEU “with an integrated low-flow showerhead” measure flow rate is 1.6 gpm rather than the DEER measure value of 2.0 gpm, and an alternate baseline flow rate different from the DEER assumption is used for Early Retirement program type. See Section 1.4 “Baseline Description” for more information.

The DEER measure also gave an overall energy savings for both electric and gas, while this work paper will provide an energy savings for gas only.

The DEER equipment and installation costs for low-flow showerheads was used, as it was assumed that equipment cost data will not vary significantly amongst different low-flow showerheads. Installation cost would be the same for all low-flow showerheads. The DEER effective useful life was also employed in the work paper, as low flow showerheads are subjected to very similar conditions, regardless of rated showerhead flow, and would be expected to have approximately the same EUL.

* + 1. Thermostatic Shower Restriction valves

There are currently no DEER measures that apply to this type of technology. However, DEER Measure 2005-D03-937 for Low-Flow Showerheads (2.0 gpm) was used to evaluate installation costs and EUL of the low flow showerhead portion of the combination showerhead-valve device of measures. It is assumed that installation cost for a thermostatic shower restriction valve would be the same for a low flow showerhead, as they are installed in the same general location (at the showerhead) and the valve does not require any specialized installation steps.

1. DEER Difference Summary

|  |  |
| --- | --- |
| DEER Difference Summary Table | |
| **Modified DEER Methodology** | **Yes** |
| **Scaled DEER Measure** | **No** |
| **DEER Building Prototypes Used** | **No** |
| **Deviation from DEER** | **DEER does not contain this type of measure** |
| **DEER Version** | **DEER2013, DEER2013 v1.0.3** |
| **DEER Run ID and Measure Name** | **DEER does not contain this type of measure** |

* 1. Code Analysis
     1. Title 20: These measures do not fall under Title 20 of the California Energy Regulations.
     2. Title 24: These measures do not fall under Title 24 of the California Energy Regulations. However, new weather data updates for ground water temperature should be applied.
     3. Federal Standards: Under this regulation, the following is required: The Federal Energy Policy Act of 1992 requires that “showerheads must use no more than 2.5 gpm”. This work paper does not address above code showerheads for the included measures.
     4. Water Fixtures Disposition:The Water Fixture Disposition[[5]](#endnote-5) changes the daily hot water consumptions to baselines of 28 gal/day for single family homes and 23.3 gal/day for multi-family dwellings according to the 2009 NREL and the Building America House Simulation Protocols[[6]](#endnote-6).

1. Code Summary

|  |  |  |
| --- | --- | --- |
| Code | Applicable Code Reference | Effective Dates |
| Title 24 (2013) | State Code Reference | 1/1/2014 |
| Title 20 (2013) | State Code Reference | 1/1/2014 |
| Federal Energy Policy Act (1992) | Federal Codes and Standards | 1992 |
| Water Fixtures Disposition | State Code Reference | 2/22/2013 |

* 1. Baseline Description

This measure involves two baseline showerhead flow rates for the calculations.

2.5 gpm is used as the Federal Energy Policy Act mandates for the New Constructions.

The other baseline flow rate is 2.25 gpm as discovered in the ASW field study with SEU customers by visiting residential households and measuring the existing showerheads flow rate. The 2.25 gpm baseline flow rate is the average of data obtained from this survey and used for Replacement on Burnout and Retrofit/Early Retirement programs.

The baseline shower water consumptions for single-family households are also derived from the ASW study. The derivation incorporated the number of showers taken, existing showerhead flow capacity, and water temperatures. Additional value references are shown in Table III.

Despite the baselines stated in the Federal Energy Policy Act and discovered in the ASW4 field study, California Public Utilities Commission (CPUC) adopts the DEER baseline values for hot water use that are developed from the NREL and America house Simulation Protocols6. It assumes a 28 gal/day hot water use for a single family home of 3 bedrooms and a 23.3 gal/day hot water use for a multi-family dwelling of 2 bedrooms.

The adopted NREL baselines standardize the daily hot water consumption for shower for New Construction, Replace-On-Burnout, and Early Retirement programs to 28 gal/day for single family and 23.3 gal/day for multi-family independent of baseline flow rates of 2.5 gpm and 2.25 gpm. However, the mixed water consumption for 1.6 gpm showerheads used in the water saving calculation is normalized by a ratio of NREL6 hot water consumption to mixed water consumptions of 2.5 gpm and 2.25 gpm baselines. The method of calculation will be shown in the later section of Water Saving Estimation Methodologies.

* 1. EM&v, market potential, and other studies

The June 2004 RASS study5 addressed low flow showerheads in the home for the PG&E service territory. The study addressed the question, “Do you have low flow showerheads installed in the shower(s)?” The majority of respondents had low flow for some or all showerheads in their homes. For this 2004 RASS study, low flow showerheads were defined as having a flow rate of 2.5 gpm or less; 2.5 gpm is the base case for the measure New Construction program and Replace on Burnout Program covered in this work paper, and the responses did not specify which showerheads were actually less than 2.5 gpm. Because the survey showed that over 30% of showerheads actually exceed the base case flow rate, it is reasonable to assume that the average base case is 2.5 gpm.

The RASS study also evaluated the “number of showers taken per household on a typical day” (mean of 2.52 showers taken in single-family households and 2.22 showers taken in multi-family households). However, only multi-family household values from the RASS study were applied in the calculation of water and energy savings for all measures in Section 2 of this work paper. For single-family households, the survey data from the SEU ASW study (2.79 showers taken per household) was used.

* 1. Measure Effective Useful Life

The Effective Useful Life (EUL) of 2.5 gpm showerheads is 10 years. This was taken from EUL Summary 06-20-08a with IOU 06-08. Although the DEER source refers only to 2.5 gpm showerheads, it is assumed that 1.7 or lower gpm showerheads degrade similarly and will have the same EUL of 10 years. Therefore the EUL used for these measures is 10 years. Dual baseline approach also applies to early retirement of showerhead. The Remaining Useful Life (RUL) is 1/3 of the single baseline EUL.

There is no DEER data for Temperature Initiated Shower Restriction Valves. However, the only known product of this type of device, manufactured by ShowerStart™, passed a required IAPMO life-cycle test of a minimum of 10,000 cycles[[7]](#endnote-7). Assuming that one cycle corresponds with one shower event, and from the ASW study data which found that there are 2.01 showerheads per household and 2.79 showers per household per day, 10,000 cycles translates to a minimum of 19 years.

However, the life-cycle testing does not account for prolonged exposure to hot water. The thermostatic valve and the low-flow showerhead are subjected to the same environmental conditions of the shower, with the main difference between the thermostatic valve and the showerhead being the thermostatic component of the valve. The DEER EUL of 10 years for low flow showerheads was also used in place of EUL for thermostatic restriction valve in this paper.

Dual baseline approach also applies to early retirement of showerheads and valves. The remaining Useful Life (RUL) is 1/3 of EUL.

* 1. net-to-gross ratios for different program strategies

This program yields 2 different Net-to-Gross (NTG) ratios according to delivery methods. Direct Installation will have a 0.70 NTG ratio. Prescribed Rebate will have a 0.55 NTG ratio.

* 1. Gross Realization Rate

This program will have a Gross Realization Rate (GRR) of 1.

1. Energy Savings & Demand Reduction Calculations
   1. data and assumptions, conversion factors

Table III below lists the data, assumptions and conversion factors used in the calculations for this work paper. Table IV below defines the water and energy variables stated in the calculation formulas. The sources for these assumptions are listed in Table XIX of the Appendix. The calculations will be similar to the method used in the Lawrence Berkeley National Laboratory (LBNL) study3. Factors that are not intuitive are explained. The variables used in the water and energy savings analysis are listed in table form below as well.

The following Low Flow Showerhead analysis can be further validated by using the U.S. Department of Energy’s (DOE) “Energy Cost Calculator for Faucets and Showerheads” with inputs from Table III[[8]](#endnote-8).

1. Data and Assumptions, & Conversion Factors

|  |  |  |  |
| --- | --- | --- | --- |
| **Constant** | **Description** | **Value** | **Units** |
| VdotNREL, SF | NREL baseline daily hot water consumption for SF | 28 | gal/day |
| VdotNREL, MF | NREL baseline daily hot water consumption for MF | 23.3 | gal/day |
| Vdotbase Fed | baseline showerhead water flow, Federal requirement (volumetric flow rate) | 2.5 | gpm |
| Vdotbase SEU | baseline showerhead water flow, SGC/SDG&E Survey (volumetric flow rate) | 2.25 | gpm |
| GNormalized, SF | normalization factor for water saving calculation for Single Family | See Table VI | unitless |
| GNormalized, MF | normalization factor for water saving calculation for Mulit-Family | See Table VI | unitless |
| Vdotlow1.5 | low flow showerhead water flow (volumetric flow rates) | 1.5 | gpm |
| Vdotlow 1.6 | low flow showerhead water flow (volumetric flow rates) | 1.6 | gpm |
| Vdotlow 1.7 | low flow showerhead water flow (volumetric flow rates) | 1.7 | gpm |
| Tin | water temperature entering water heater | See Table | ºF |
| Tout,tempered | water temperature exiting showerhead (SEU survey data) | 106 | ºF |
| Tout, hot | water temperature exiting water heater | 123 | ºF |
| Δtshower | mean shower duration, Aquacraft, Inc., 2000[[9]](#endnote-9). | 7.4 | minutes / shower |
| Δtvalve | average hot water waste time before user gets in shower (pre-useful shower hot water waste time) | 0.56 | minutes / shower |
| Cvolume | volumetric conversion constant for cubic feet to gallons | 7.481 | gal / ft3 |
| Cdays/year | time conversion constant from days to years | 365 | days / year |
| Ctherm | energy conversion constant from Btu's to therms | 100,000 | Btu / therm |
| ρ | density of water at 60 ºF | 62.37 | lbm / ft3 |
| Fthrott | throttling factor to account for the effects of pipe clogging and/or pressure less than 80 psig on flow rate | 0.9 | unitless |
| Fts | adjustment factor for tub/shower application of the flow restriction valve | 0.8 | unitless |
| Nshowers, SF | average number of showers per single-family household per day | 2.79 | showers / household / day |
| Nshowers, MF | average number of showers per multi-family household per day | 2.22 | showers / household / day |
| Nshowerheads, SF | average number of showerheads per single-family household | 2.01 | showerheads / household |
| Nshowerheads, MF | average number of showerheads per multi-family household | 1.50 | showerheads / household |
| REres,gas | Recovery Efficiency (Title 20 gas-fired residential water heaters) | 0.778 | unitless (heat out / heat in) |

1. Water and Energy Variables

|  |  |  |  |
| --- | --- | --- | --- |
| **Variable** | **Description** | **Value** | **Units** |
| WSF baseline NREL | annual water consumption for 28 gal/day baseline case | See Table V | gal / showerhead - yr |
| WMF baseline NREL | annual water consumption for 23.3 gal/day baseline case | See Table V | gal / showerhead - yr |
| Wbaseline Fed | annual water consumption for 2.5 gpm baseline case | See Tables III | gal / showerhead - yr |
| Wbaseline SEU | annual water consumption for 2.35 gpm baseline case | See Table III | gal / showerhead - yr |
| W1.5 | annual water consumption for measures of low flow 1.5 gpm showerhead alone | See Table IV | gal / showerhead - yr |
| W1.6 | annual water consumption for measures of low flow 1.6 gpm showerhead alone | See Table IV | gal / showerhead - yr |
| W1.7 | annual water consumption for measures of low flow 1.7 gpm showerhead alone | See Table IV | gal / showerhead - yr |
| W valve Fed | annual avoided hot water waste attributable to thermostatic restriction valve for 2.5 gpm baseline case | See Table V | gal / showerhead - yr |
| W valve SEU | annual avoided hot water waste attributable to thermostatic restriction valve for 2.25 gpm baseline case | See Table V | gal / showerhead - yr |
| W valve 1.6 | annual avoided hot water waste attributable to thermostatic restriction valve with 1.6 gpm low flow showerhead | See Table V | gal / showerhead - yr |

**NREL Baseline Hot Water Consumptions:** California Public Utilities Commission published Water Fixture Disposition in 2013 pertaining energy saving values for showerheads. In the disposition, C.P.U.C. adopted baselines of daily hot water consumptions for single family homes and multi-family dwellings to be 28 gal/day and 23.3 gal/day, respectively.

**Normalization Factor:** This factor is for the adjustments of savings on the 1.6 gpm showerheads with respect to the baseline change in the disposition. The factor is a ratio of NREL hot water consumptions to federal code or SCG survey mixed water consumptions.

**Pre-Useful Shower Hot Water Waste Time:** There are no scientific studies that have been done that document how much *hot* water is wasted before a user gets into the shower, and consequently how long this wasted hot water is running. This pre-useful shower *hot* water waste time was approximated as 34 seconds by estimating the *total* pre-useful shower water waste time and then subtracting the *cold* water waste time from it.

The *total* pre-useful shower water waste time was based on the assumption that most people either brush their teeth while waiting for the shower to warm up, or do an activity or series of activities comparable in time length (e.g., undressing or using the toilet). A shower behavior survey of approximately 162 people conducted by Hotwire Development, LLC[[10]](#endnote-10) supported this assumption and was the only survey of this nature that could be found. An average teeth-brushing time of 78.15 seconds was estimated from a study done by the University of Zurich, Switzerland[[11]](#endnote-11). This time is likely conservative, as it is based on the time the toothbrush is actually in the mouth, and not the time it takes to prepare the brush and then rinse and clean it. The time also does not account for other activities done in addition to teeth brushing before getting in the shower, which was indicated by many respondents to the Hotwire survey.

The *cold* water waste time was then approximated as 44.6 seconds using a study done by Oakridge National Lab[[12]](#endnote-12). This study evaluated the length of time it took for hot water to get to the farthest fixture in the house through a variety of hot water distribution systems in California. Various piping, insulation, and run lengths were evaluated based on typical old and new construction houses, and a flow rate of 2.25 gpm. For House Models 1 through 5 (new construction) and 6 and 7 (old construction), the “Typical Hot Water Wait Times” for both clustered events and cold water draw were averaged. The averaged typical wait times excluded those times associated with centrally located water heaters, parallel PEX and demand recirculation systems.

An average hot water wait time, adjusted for 1.6 gpm was derived from the different run cases. The time was then weighted based on the percentage of new and old construction (10% and 90% respectively) homes the study indicated were in California. The times were not weighted according to the distribution of the different types of piping and insulation configurations are actually found in homes, as this weighted distribution is unknown. This study also assumed the water was turned to full hot, soliciting maximum hot water flow from the water heater.

**Persons per household:** Using data acquired from the 2000 Census for California[[13]](#endnote-13), it was assumed that renter-occupied units corresponded to multi-family units, respectively. The ASW study data was used for single-family units.

**Shower duration:** Water trace data from ten single family homes in Seattle (Aquacraft, Inc., 2000) 9 showed that the mean shower duration is 7.4 minutes. Another measurement study of residential end use of water by AWWA Research Foundation[[14]](#endnote-14) shows the similar data, a median of 7.2 minutes and a mean of 8.2 minutes, for shower duration. Shower duration of 7.4 minutes, along with other assumptions used in this workpaper, results in more realistic baseline shower water consumption that is equivalent to about 33% of the total domestic hot water consumption.

**Weighted Average Showerheads per Household:** The survey data from SEU territories was averaged to be 2.01 showerheads per single-family household. Acquired data from the U.S. Census Bureau13 was used to calculate the weighted average showerheads per household for the multi-family residences. The data for number of bathrooms per household for new construction of multi-family units between the years 1978-2006 was used. After the weighted average was calculated, the result was rounded up to the nearest tenth. Savings are conservative since rounding this number up results in lower savings. The calculations are shown in the appendix.

**Throttling factor:** This factor adjusts rated flow to account for pressures less than 80 psig and for limiting flow by throttling back (closing) the control valve to the shower. In addition, partial clogging due to debris in the pipe or from calcium deposits in areas with hard water contributes to this factor3.

**Tub+Shower adjustment factor:** It is assumed that, in a bathtub where both a showerhead and a tub spout are present, the use of hot water flow restriction valve attached on the showerhead may not be effective because the water may be dispensed through the spout instead of the showerhead while waiting for the water temperature to reach a desired level. A 0.80 adjustment factor was applied to reduce the UES (Unit Energy Savings) by 20% as ordered by CPUC[[15]](#endnote-15).

**Showerhead Temperature:** For low flow showerheads, the outlet water heater temperature is assumed to be 106ºF to account for tempering of the hot water with cold water to establish full shower flow, as obtained from the ASW survey study in SEU territories. Hot water does not comprise the entire shower flow, so evaluating a smaller water heater temperature rise limits the water heater energy attributable to entire shower flow. The water temperature entering the heater varies with climate zones according to the new Title 24 weather data.

**Gas Water Heater Efficiencies:** To convert the water heating load to energy use at the water heater, the recovery efficiency (RE) is used. A weighted value of 0.778 is derived from the current CEC maintained Title 20 Appliance Database (downloaded on December 6, 2013) of natural-gas fired, storage-type water heaters without limit to the listed EF.

* 1. wATER Savings ESTIMATION METHODOLOGIES

## Although water savings will not be a part of this program, the hot water savings are the basis for calculating the gas energy savings at gas water heaters.

***Low Flow Showerhead (1.6 gpm)***

1. Annual Baseline Water Consumption Per Showerhead

|  |  |  |
| --- | --- | --- |
| Measure Name: | Single-Family | Multi-Family |
| CPUC Baseline Annual Hot Water Use | 5086 | 5679 |
| Code Baseline Annual Water Use | 8436 | 8994 |
| SEU Average Baseline Annual Water Use | 7592 | 8095 |
| Unit in [gallons / showerhead / year] | | |

Calculations:

CPUC Baseline Hot Water consumption

Single-Family: WSF baseline NREL = [VdotNREL, SF \* Cdays/year] / ( Nshowerheads,SF )

Multi-Family: WMF baseline NREL = [VdotNREL, MF \* Cdays/year] / ( Nshowerheads,MF )

Code and SEU Average Baseline Water consumption

Single-Family: Wbaseline Code = [ Vdotbase Code \* Δtshower \* Nshowers,SF \* Cdays/year \* Fthrott ] / ( Nshowerheads,SF )

Wbaseline Avg = [ Vdotbase Avg \* Δtshower \* Nshowers,SF \* Cdays/year \* Fthrott ] / ( Nshowerheads,SF )

Multi-Family: Wbaseline Code = [ Vdotbase Code \* Δtshower \* Nshowers,MF \* Cdays/year \* Fthrott ] / ( Nshowerheads,MF )

Wbaseline Avg = [ Vdotbase Avg \* Δtshower \* Nshowers,MF \* Cdays/year \* Fthrott ] / ( Nshowerheads,MF )

1. Normalization Factors

|  |  |  |
| --- | --- | --- |
| Program Types | Single-Family | Multi-Family |
| NEW and ROB | 0.6030 | 0.6314 |
| RET | 0.6700 | 0.7016 |

Calculations:

NEW and ROB Normalization Factor:

Single-Family: GNormalized, SF = WSF baseline NREL / Wbaseline Code

Multi-Family: GNormalized, MF = WMF baseline NREL / Wbaseline Code

RET Normalization Factor:

Single-Family: GNormalized, SF = WSF baseline NREL / Wbaseline Avg

Multi-Family: GNormalized, MF = WMF baseline NREL / Wbaseline Avg

1. Annual Water Consumption Per Showerhead – NEW and ROB Programs

|  |  |  |
| --- | --- | --- |
| **Showerhead** | **Single-Family** | **Multi-Family** |
| 1.6 gpm Showerhead | 3255 | 3635 |
| Unit in [gallons / showerhead / year] | | |

1. Annual Water Consumption Per Showerhead – RET Program

|  |  |  |
| --- | --- | --- |
| **Showerhead** | **Single-Family** | **Multi-Family** |
| 1.6 gpm Showerhead | 3617 | 4039 |
| Unit in [gallons / showerhead / year] | | |

Calculations:

Measure Water consumption

Single-Family:

W1.6 = [Vdotlow 1.6 \* Δtshower \* Nshowers,SF \* Cdays/year \* Fthrott \* GNormalized, SF] / ( Nshowerheads,SF )

Multi-Family:

W1.6 = [Vdotlow 1.6 \* Δtshower \* Nshowers,MF \* Cdays/year \* Fthrott \* GNormalized, MF] / ( Nshowerheads,MF )

1. Annual Water Savings by Using Low Flow Showerheads

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Single-Family Savings | | Multi-Family Savings | |
| **Showerheads** | **NEW and ROB** | **RET** | **NEW and ROB** | **RET** |
| 1.6 gpm Showerhead | 1831 | 1469 | 2045 | 1641 |
| Unit in [gallons / showerhead / year] | | | | |

Calculations:

NEW and ROB Annual Low Flow Showerhead Savings = CPUC Baseline annual water use (Table VII) – Measure annual water use (Table VIII)

RET Annual Low Flow Showerhead Savings = CPUC Baseline annual water use (Table VII) – Measure annual water use (Table VIII)

***Thermostatic Shower Restriction Valve***

1. Avoided Total Water (106°F) Waste with Thermostatic Shower Restriction Valve – NEW and ROB Programs

|  |  |  |
| --- | --- | --- |
| **Showerheads** | **Single-Family** | **Multi-Family** |
| Restriction Valve Only  ( w/ Fed baseline) | 511 | 545 |
| Restriction Valve Only  ( w/ SEU baseline) | 460 | 490 |
| 1.6 gpm Showerhead and Restriction Valve | 197 | 220 |
| Unit in [gallons / showerhead / year] | | |

1. Avoided Total Water (106°F) Waste with Thermostatic Shower Restriction Valve – RET Program

|  |  |  |
| --- | --- | --- |
| **Showerheads** | **Single-Family** | **Multi-Family** |
| 1.6 gpm Showerhead and Restriction Valve | 219 | 245 |
| Unit in [gallons / showerhead / year] | | |

Calculations:

Avoided hot water use due to the thermostatic restriction valve only

Single-Family: Wvalve Fed = [ Vdotbase,Fed \* Δtvalve \* Nshowers,SF \* Cdays/year \* Fthrott \* Fts] / ( Nshowerheads,SF )

Wvalve SEU = [ Vdotbase,SEU \* Δtvalve \* Nshowers,SF \* Cdays/year \* Fthrott \* Fts] / ( Nshowerheads,SF )

Wvalve 1.6 = [ Vdotlow1.6 \* Δtvalve \* Nshowers,SF \* Cdays/year \* Fthrott \* Fts\* GNormalized, SF] / ( Nshowerheads,SF )

Multi-Family: Wvalve Fed = [ Vdotbase,Fed \* Δtvalve \* Nshowers,MF \* Cdays/year \* Fthrott \* Fts] / ( Nshowerheads, MF )

Wvalve SEU = [ Vdotbase,SEU \* Δtvalve \* Nshowers,MF \* Cdays/year \* Fthrott \* Fts] / ( Nshowerheads, MF )

Wvalve 1.6 = [ Vdotlow1.6 \* Δtvalve \* Nshowers,MF \* Cdays/year \* Fthrott \* Fts\* GNormalized, MF] / ( Nshowerheads, MF )

1. Summary of Annual Shower Water Savings: Low Flow Showerheads and Thermostatic Shower Restriction Valve

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Single-Family Savings** | | **Multi-Family Savings** | |
| **Showerheads** | **Fed Baseline** | **SEU Baseline** | **Fed Baseline** | **SEU Baseline** |
| Restriction Valve Only | 511 | 460 | 545 | 490 |
| 1.6 gpm Showerhead + Valve | 2028 | 1688 | 2265 | 1885 |
| Unit in [gallons / showerhead / year] | | | | |

Calculations:

Annual Hot Water Savings numbers above are taken from Table X for 1.6 gpm showerheads only and from Table XI for the restriction valve only. The savings for “1.6 gpm showerhead + restriction valve” unit is calculated by adding 1.6 gpm water savings from Table X and the avoided hot water waste from Table XI.

* 1. Gas Energy Savings Estimation Methodologies

The gas energy savings can be easily estimated by taking total hot water savings (Table XI) and calculating heat applied to raise the temperature from ground water temperature to 106°F of mixed water temperature. The ground water temperature varies with climate zone, and the weighted average of the ground water temperature is calculated from the annual hot water consumptions that vary throughout the year.

1. Weighted Average Ground Water Temperatures

|  |  |  |
| --- | --- | --- |
| Climate Zone | Single-Family | Multi-Family |
| 1 | 51.4 | 51.4 |
| 2 | 57.2 | 57.2 |
| 3 | 57.0 | 57.0 |
| 4 | 59.4 | 59.4 |
| 5 | 55.8 | 55.8 |
| 6 | 61.7 | 61.7 |
| 7 | 62.5 | 62.5 |
| 8 | 63.7 | 63.7 |
| 9 | 63.7 | 63.7 |
| 10 | 64.0 | 64.0 |
| 11 | 62.8 | 62.7 |
| 12 | 60.7 | 60.6 |
| 13 | 63.8 | 63.6 |
| 14 | 62.3 | 62.1 |
| 15 | 74.9 | 74.6 |
| 16 | 51.6 | 51.5 |
| Unit in [°F] | | |

1. Annual Natural Gas Savings – NEW and ROB Program

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Single-Family Savings | | Multi-Family Savings | |
| **Climate Zone** | **Valve Only** | **1.6 gpm Showerhead + Valve** | **Valve Only** | **1.6 gpm Showerhead + Valve** |
| 1 | 3.0 | 11.9 | 3.2 | 13.3 |
| 2 | 2.7 | 10.6 | 2.8 | 11.8 |
| 3 | 2.7 | 10.6 | 2.9 | 11.9 |
| 4 | 2.5 | 10.1 | 2.7 | 11.3 |
| 5 | 2.7 | 10.9 | 2.9 | 12.2 |
| 6 | 2.4 | 9.6 | 2.6 | 10.8 |
| 7 | 2.4 | 9.5 | 2.5 | 10.6 |
| 8 | 2.3 | 9.2 | 2.5 | 10.3 |
| 9 | 2.3 | 9.2 | 2.5 | 10.3 |
| 10 | 2.3 | 9.1 | 2.5 | 10.2 |
| 11 | 2.4 | 9.4 | 2.5 | 10.5 |
| 12 | 2.5 | 9.8 | 2.6 | 11.0 |
| 13 | 2.3 | 9.2 | 2.5 | 10.3 |
| 14 | 2.4 | 9.5 | 2.6 | 10.6 |
| 15 | 1.7 | 6.8 | 1.8 | 7.6 |
| 16 | 3.0 | 11.8 | 3.2 | 13.2 |
| Unit in [therms / showerhead / year] | | | | |

1. Annual Natural Gas Savings – RET Program (1st Period)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Single-Family Savings | | Multi-Family Savings | |
| **Climate Zone** | **Valve Only** | **1.6 gpm Showerhead + Valve** | **Valve Only** | **1.6 gpm Showerhead + Valve** |
| 1 | 2.7 | 9.9 | 2.9 | 8.6 |
| 2 | 2.4 | 8.8 | 2.6 | 7.7 |
| 3 | 2.4 | 8.9 | 2.6 | 7.7 |
| 4 | 2.3 | 8.4 | 2.4 | 7.3 |
| 5 | 2.5 | 9.1 | 2.6 | 7.9 |
| 6 | 2.2 | 8.0 | 2.3 | 7.0 |
| 7 | 2.1 | 7.9 | 2.3 | 6.8 |
| 8 | 2.1 | 7.7 | 2.2 | 6.7 |
| 9 | 2.1 | 7.6 | 2.2 | 6.7 |
| 10 | 2.1 | 7.6 | 2.2 | 6.6 |
| 11 | 2.1 | 7.8 | 2.3 | 6.8 |
| 12 | 2.2 | 8.2 | 2.4 | 7.1 |
| 13 | 2.1 | 7.6 | 2.2 | 6.7 |
| 14 | 2.2 | 7.9 | 2.3 | 6.9 |
| 15 | 1.5 | 5.6 | 1.7 | 4.9 |
| 16 | 2.7 | 9.8 | 2.9 | 8.6 |
| Unit in [therms / showerhead / year] | | | | |

1. Annual Natural Gas Savings – RET Program (2nd Period)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Single-Family Savings | | Multi-Family Savings | |
| **Climate Zone** | **Valve Only** | **1.6 gpm Showerhead + Valve** | **Valve Only** | **1.6 gpm Showerhead + Valve** |
| 1 | 3.0 | 11.9 | 3.2 | 13.3 |
| 2 | 2.7 | 10.6 | 2.8 | 11.8 |
| 3 | 2.7 | 10.6 | 2.9 | 11.9 |
| 4 | 2.5 | 10.1 | 2.7 | 11.3 |
| 5 | 2.7 | 10.9 | 2.9 | 12.2 |
| 6 | 2.4 | 9.6 | 2.6 | 10.8 |
| 7 | 2.4 | 9.5 | 2.5 | 10.6 |
| 8 | 2.3 | 9.2 | 2.5 | 10.3 |
| 9 | 2.3 | 9.2 | 2.5 | 10.3 |
| 10 | 2.3 | 9.1 | 2.5 | 10.2 |
| 11 | 2.4 | 9.4 | 2.5 | 10.5 |
| 12 | 2.5 | 9.8 | 2.6 | 11.0 |
| 13 | 2.3 | 9.2 | 2.5 | 10.3 |
| 14 | 2.4 | 9.5 | 2.6 | 10.6 |
| 15 | 1.7 | 6.8 | 1.8 | 7.6 |
| 16 | 3.0 | 11.8 | 3.2 | 13.2 |
| Unit in [therms / showerhead / year] | | | | |

Calculations:

Energy Savings for Natural Gas Water Heater in therms is given as followes.

qgas saved = [ W (Table XII) \* ρ \* cp,H20 \* (Tout,tempered - Tin)] / ( REres,gas \* Cvolume \* Ctherm ) ]

The saving in RET program is calculated from 2 different baselines for the 1st period and 2nd period. In the remaining useful life, savings in measures are calculated using the baseline of 2.25 gpm normalizing with appropriate single-family and multi-family normalization factors. In the effective useful life, savings in the measure showerheads are also calculated using the baseline of 2.5 gpm normalizing with appropriate single-family and multi-family normalization factors. The EUL saving for RET programs are the same as the savings in NEW and ROB programs.

1. Base Case & Measure Costs
   1. Base Case Cost

DEER Measure ID 2005-D03-937 for 2.5 gpm showerheads was used for installed costs for measures for “showerhead only” units and “showerhead + valve” units. The equipment cost per unit ($/unit) is $22.95, while the installation cost is $15.00 per unit. The DEER total installed cost per unit is $37.95.

* 1. Gross Measure Cost

Therefore, DEER Measure ID 2005-D03-937 for 2.5 gpm showerheads was used for installed costs for this measure.

Single-family customers will have the option of installing the low flow showerheads in their homes themselves, which will not incur an installation cost. There is no installation cost associated with the upstream program for single-family residences. The Direct Install program for multi-family customers will incur minimal costs because the showerhead and/or showerhead fixture installation will be quick and peripheral to the vendor’s primary purpose of water heater installation at the customer site. If installation cost estimates are required, the DEER low flow showerhead measure data provides this reference.

The DEER equipment cost per unit ($/unit) is $22.95 for low flow showerheads, and was applied. The DEER total installed cost per unit is $37.95 and was used for the showerhead measures.

The DEER measure assumed a measure cost of $37.95 for replacing >2.5gpm (~4-6 gpm) showerheads with 2.5 gpm Showerheads. Because the components of the low flow showerhead fixtures are fundamentally the same, is assumed that low flow showerheads will not incur anymore additional costs beyond the 2.5 gpm showerheads. It is also assumed that the installation costs will be the same for low flow showerheads and thermostatic shower restriction valves, which are installed at the showerhead location.

The equipment costs for combination Low Flow Showerhead and Thermostatic Shower Restriction Valves were obtained from the manufacturer ShowerStart™’s website[[16]](#endnote-16) , as this is currently the only available manufacturer of the thermostatic valve device addressed in this work paper. The website lists a retail price of $39.95 for the showerhead and valve combination. The Thermostatic Shower Restriction Valve alone is priced at $29.95.

Including the low flow showerhead installation costs from DEER, the measure cost is $54.95 for the showerhead + valve unit and $44.95 for the valve-only unit.

For RET measures, dual baseline is adopted. 1/3 of EUL is credited as RUL. In the remaining useful life of the measures, there will be no base total cost upgrading from 2.25 gpm showerheads to <2.0 gpm showerheads. However, the base total cost will be $37.95 after the remaining useful life.

* 1. Incremental Measure Cost

Using the DEER base cost case of 2.5 gpm showerheads, the incremental cost for presented measures are shown below in Table XVII & XVIII:

1. First Period Measure Cost Summary – RUL

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Measure Name:** | **Program Type** | **Target Sector** | **Base Material Cost** | **Base Labor Cost** | **Base Total Cost** | **Measure Material Cost** | **Measure Labor Cost** | **Measure**  **Total Cost** | **Incremental Measure Cost** |
| Restriction Valve Only | NEW | SF | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MF | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| RET | SF | 0 | 0 | 0 | 29.95 | 15.00 | 44.95 | 44.95 |
| MF | 0 | 0 | 0 | 29.95 | 15.00 | 44.95 | 44.95 |
| ROB | SF | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MF | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1.6 gpm Showerhead  +  Restriction Valve | NEW | SF | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MF | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| RET | SF | 0 | 0 | 0 | 39.95 | 15.00 | 54.95 | 54.95 |
| MF | 0 | 0 | 0 | 39.95 | 15.00 | 54.95 | 54.95 |
| ROB | SF | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MF | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

1. Second Period Measure Cost Summary – EUL

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Measure Name:** | **Program Type** | **Target Sector** | **Base Material Cost** | **Base Labor Cost** | **Base Total Cost** | **Measure Material Cost** | **Measure Labor Cost** | **Measure**  **Total Cost** | **Incremental Measure Cost** |
| Restriction Valve Only | NEW | SF | 22.95 | 15.00 | 37.95 | 29.95 | 15.00 | 44.95 | 7.00 |
| MF | 22.95 | 15.00 | 37.95 | 29.95 | 15.00 | 44.95 | 7.00 |
| RET | SF | 22.95 | 15.00 | 37.95 | 29.95 | 15.00 | 44.95 | 7.00 |
| MF | 22.95 | 15.00 | 37.95 | 29.95 | 15.00 | 44.95 | 7.00 |
| ROB | SF | 22.95 | 15.00 | 37.95 | 29.95 | 15.00 | 44.95 | 7.00 |
| MF | 22.95 | 15.00 | 37.95 | 29.95 | 15.00 | 44.95 | 7.00 |
| 1.6 gpm Showerhead  +  Restriction Valve | NEW | SF | 22.95 | 15.00 | 37.95 | 39.95 | 15.00 | 54.95 | 17.00 |
| MF | 22.95 | 15.00 | 37.95 | 39.95 | 15.00 | 54.95 | 17.00 |
| RET | SF | 22.95 | 15.00 | 37.95 | 39.95 | 15.00 | 54.95 | 17.00 |
| MF | 22.95 | 15.00 | 37.95 | 39.95 | 15.00 | 54.95 | 17.00 |
| ROB | SF | 22.95 | 15.00 | 37.95 | 39.95 | 15.00 | 54.95 | 17.00 |
| MF | 22.95 | 15.00 | 37.95 | 39.95 | 15.00 | 54.95 | 17.00 |

1. Other Concerns

Factors unrelated to energy savings were also investigated further for program effectiveness: reliability and scalding issues. Applied Technology Services (ATS), a division of Pacific Gas and Electric Company, was contracted to test these issues and develop a report on their findings[[17]](#endnote-17) . Below is a summary of their conclusions.

* 1. Reliability

Due to a lack of government enforcement, the advertised versus actual flow rate of low flow showerheads is a concern. ATS tested two samples of ten different showerhead models (for a total of twenty) with various flow rates, most of which are less than 2 gpm. Their findings concluded nine out of ten showerhead models demonstrated flow rates consistent to the manufacturers’ advertised flow rates.

* 1. Scalding

Safety issues over scalding were also a concern with low flow showerheads. Scalding, or thermal shock, is the result of a rapid change in water temperature, causing sudden physical reactions in which a person may slip or fall. Scalding may also cause epidermal damage, depending on the length of exposure to hot water temperatures. After testing, ATS has concluded that showerhead design, mixing, and pressure did not greatly affect the potential for scalding. However, plumbing systems with inadequate piping may increase the risk for scalding with installation of low flow showerheads. Testing under plumbing systems with adequate piping showed minimal to no effects. Due to uncertainty of the design of a customer’s plumbing system, there is a certain degree of risk for scalding when installing low flow showerheads. Therefore, due to legal reasons, a disclaimer will be provided for participants of this program.

Attachments

therm Saving Calculation Sheet:



Title 20 Appliance Database Natural-Gas Fired Storage-Type Water Heater Subset (Downloaded January 10, 2014)



1. Sources for Data and Assumptions, Conversion Factors

|  |  |
| --- | --- |
| **Data and Assumptions** | **Source** |
| Showerheads per Household | U.S Census Bureau (Weighted average of new units completed in the West region from 1978-2006) 12 for MF, and ASW4 survey data for SF. |
|
| Showers per Household per Day | RASS5, p. 100 of PG&E Banner Data for MF, ASW4 survey data for SF |
| Average Pre-Useful Shower Hot Water Wait Time | *Shower Behavior: Attitudes, Awareness, and Usage Survey*8, question #8; *New Studies on Estimated and Actual Tooth-brushing Times and Dentifrice Use*9; *Evaluation of Residential Hot Water Distribution Systems by Numeric Simulation*10, Appendix A |
| Throttling Factor | *Potential Water and Energy Savings from Showerheads*3, p. 6 |
| Baseline Flow (gpm rated @ standard 80 psi) | Maximum allowable flow used as baseline1. |
| Measure Flow (gpm) | Assumed for this work paper. |
| Average Shower Flow | ASW4 survey data |
| Cold water heater inlet temperature (ºF) | ASW4 survey data |
| Hot water heater outlet temperature (ºF) | ASW4 survey data |
| Shower temperature (ºF) | *ASW*4 survey data |
| Electric Water Heater Efficiency | *California Title 20 Appliance Regulations*12, p. 89 |
| Gas Water Heater Efficiency | *California Title 20 Appliance Regulations*12, p. 89 |
|  |  |
| **Conversion Factors** |  |
| lbs/(1 Gallon H2O) | *Marks’ Handbook for Mechanical Engineers* |
| Btu/(lb H2O F) | *Marks’ Handbook for Mechanical Engineers* |
| therms/Btu | *Marks’ Handbook for Mechanical Engineers* |

1. Weighted Average Number of Bathrooms (Showerheads) in the West Region

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Multi-family** | | |  |  |  | **Single-Family** | | | |  |
| **# Baths** | **1** | **1.5** | **2+** |  |  | **# Baths** | **1.5** | **2** | **2.5** | **3+** |  |
| **Year** |  |  |  |  |  | **Year** |  |  |  |  |  |
| 1978 | 102 | 18 | 40 |  |  | 1978 | 62 | 200 | 95 | N/A |  |
| 1979 | 104 | 16 | 49 |  |  | 1979 | 64 | 189 | 85 | N/A |  |
| 1980 | 84 | 16 | 53 |  |  | 1980 | 47 | 129 | 57 | N/A |  |
| 1981 | 55 | 10 | 46 |  |  | 1981 | 40 | 98 | 45 | N/A |  |
| 1982 | 41 | 7 | 34 |  |  | 1982 | 28 | 66 | 27 | N/A |  |
| 1983 | 59 | 10 | 35 |  |  | 1983 | 41 | 113 | 46 | N/A |  |
| 1984 | 92 | 10 | 62 |  |  | 1984 | 33 | 132 | 68 | N/A |  |
| 1985 | 117 | 15 | 76 |  |  | 1985 | 38 | 133 | 68 | N/A |  |
| 1986 | 112 | 17 | 87 |  |  | 1986 | 33 | 137 | 83 | N/A |  |
| 1987 | 91 | 13 | 87 |  |  | 1987 | 29 | 134 | 51 | 45 |  |
| 1988 | 71 | 10 | 74 |  |  | 1988 | 21 | 117 | 61 | 50 |  |
| 1989 | 56 | 8 | 67 |  |  | 1989 | 14 | 118 | 63 | 61 |  |
| 1990 | 53 | 7 | 62 |  |  | 1990 | 14 | 112 | 61 | 68 |  |
| 1991 | 32 | 7 | 48 |  |  | 1991 | 14 | 93 | 47 | 51 |  |
| 1992 | 22 | 5 | 31 |  |  | 1992 | 15 | 102 | 69 | 46 |  |
| 1993 | 19 | 2 | 23 |  |  | 1993 | 17 | 113 | 74 | 43 |  |
| 1994 | 20 | 3 | 28 |  |  | 1994 | 20 | 129 | 84 | 52 |  |
| 1995 | 26 | 2 | 36 |  |  | 1995 | 16 | 114 | 74 | 49 |  |
| 1996 | 28 | 4 | 45 |  |  | 1996 | 15 | 118 | 81 | 54 |  |
| 1997 | 33 | 3 | 41 |  |  | 1997 | 12 | 112 | 79 | 56 |  |
| 1998 | 33 | 3 | 42 |  |  | 1998 | 13 | 112 | 90 | 68 |  |
| 1999 | 34 | 4 | 47 |  |  | 1999 | 13 | 122 | 100 | 75 |  |
| 2000 | 33 | 3 | 41 |  |  | 2000 | 15 | 110 | 88 | 74 |  |
| 2001 | 32 | 2 | 46 |  |  | 2001 | 12 | 111 | 101 | 79 |  |
| 2002 | 38 | 4 | 47 |  |  | 2002 | 11 | 120 | 103 | 90 |  |
| 2003 | 29 | 3 | 41 |  |  | 2003 | 11 | 127 | 116 | 108 |  |
| 2004 | 31 | 5 | 39 |  |  | 2004 | 10 | 152 | 127 | 120 |  |
| 2005 | 24 | 4 | 41 |  |  | 2005 | 12 | 143 | 152 | 130 |  |
| 2006 | 28 | 4 | 42 |  |  | 2006 | 13 | 117 | 157 | 128 |  |
| **Total** | 1499 | 215 | 1410 |  |  | **Total** | 683 | 3573 | 2352 | 1447 |  |
| **%** | 0.48 | 0.07 | 0.45 |  |  | **%** | 0.08 | 0.44 | 0.29 | 0.18 |  |
| **Wt. Avg.** | 0.48 | 0.10 | 0.90 | 1.49 |  | **Wt. Avg.** | 0.13 | 0.89 | 0.73 | 0.54 | 2.28 |
|  |  |  | Rounded | 1.50 |  |  |  |  |  | Rounded | 2.50 |
| **\* Data from U.S. Census Bureau** | | | |  |  |  |  |  |  |  |  |

*It is assumed that 1 bathroom contains a shower or bath with a showerhead. Data from the Census Bureau for the West Region was used for the calculations.*

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