**Workpaper SCGWP100303A**

**Revision 05**

**Southern California Gas Company**

**Customer Programs Department**

**Low-Flow Showerheads**

Revision History

|  |  |  |  |
| --- | --- | --- | --- |
| Revision No. | Date | **Description** | **Author** |
| a | Wednesday, March 03, 2010 | Workpaper modification from “showerhead + restriction valve” WP to exclude ShowerStart restriction valve measures and include only showerhead measures. MEASURES. 1.5 gpm, 1.6 gpm, & 1.7 gpm. Still two baselines, 2.5 gpm federal code & 2.25 gpm SEU average | Chan Paek |
| 0 | March 9. 2010 | For Release | Chan Paek |
| 1 | July 7, 2010 | For Release  Incorporates comments from ED dated 4/27/2010  Revision to water heater efficiency | Chan Paek |
| 2 | August 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. (See Section 2) | Chan Paek |
| 3 | ----- | Due to a confusion on the revision numbering convention, Revision 3 was omitted. | Carlos Pineda |
| 4 | October 29, 2013 | Weather Data Updates and Baseline Change from 2013 CPUC Water Fixtures Disposition | Joseph Pan |
| 5 | April 22, 2016 | Update due to change in flow rate baseline per CEC code, 1.0 and 1.25 LFSH measures added | Carlos Pineda |

# 

Measure Summary Table A

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Measure ID | Measure  Description | Pre-Existing  Description | Code/Standard  Description | Sector | App  Type(s) | Delivery  Method(s) | EUL ID/  RUL ID | NTG ID(s) | GSIA ID |
| ShwShh001 | Showerhead, 1.0 GPM, 2016 Code | N/A | 2.0 GPM flow rate Showerhead | RES | New, ROB, | Direct  Install | WtrHt-WH-Shrhd/10 | Res-sAll-mDHWshwr | Res-LowF-SH-All |
| ShwShh002 | Showerhead, 1.25 GPM, 2016 Code | N/A | 2.0 GPM flow rate Showerhead | RES | New, ROB, | Direct  Install | WtrHt-WH-Shrhd/10 | Res-sAll-mDHWshwr | Res-LowF-SH-All |
| ShwShh003 | Showerhead, 1.50 GPM, 2016 Code | N/A | 2.0 GPM flow rate Showerhead | RES | New, ROB, | Direct  Install | WtrHt-WH-Shrhd/10 | Res-sAll-mDHWshwr | Res-LowF-SH-All |
| ShwShh004 | Showerhead, 1.60 GPM, 2016 Code | N/A | 2.0 GPM flow rate Showerhead | RES | New, ROB | Direct  Install | WtrHt-WH-Shrhd/10 | Res-sAll-mDHWshwr | Res-LowF-SH-All |
| ShwShh005 | Showerhead, 1.70 GPM, 2016 Code | N/A | 2.0 GPM flow rate Showerhead | RES | New, ROB, | Direct  Install | WtrHt-WH-Shrhd/10 | Res-sAll-mDHWshwr | Res-LowF-SH-All |
| ShwShh006 | Showerhead, 1.0 GPM, 2018 Code | 2.25 GPM flow rate Showerhead | 1.8 GPM flow rate Showerhead | RES | ER | Direct  Install | WtrHt-WH-Shrhd/3.33 | Res-sAll-mDHWshwr | Res-LowF-SH-All |
| ShwShh007 | Showerhead, 1.25 GPM, 2018 Code | 2.25 GPM flow rate Showerhead | 1.8 GPM flow rate Showerhead | RES | ER | Direct  Install | WtrHt-WH-Shrhd/3.33 | Res-sAll-mDHWshwr | Res-LowF-SH-All |
| ShwShh008 | Showerhead, 1.50 GPM, 2018 Code | 2.25 GPM flow rate Showerhead | 1.8 GPM flow rate Showerhead | RES | ER | Direct  Install | WtrHt-WH-Shrhd/3.33 | Res-sAll-mDHWshwr | Res-LowF-SH-All |
| ShwShh009 | Showerhead, 1.60 GPM, 2018 Code | 2.25 GPM flow rate Showerhead | 1.8 GPM flow rate Showerhead | RES | ER | Direct  Install | WtrHt-WH-Shrhd/3.33 | Res-sAll-mDHWshwr | Res-LowF-SH-All |
| ShwShh010 | Showerhead, 1.70 GPM, 2018 Code | 2.25 GPM flow rate Showerhead | 1.8 GPM flow rate Showerhead | RES | ER | Direct  Install | WtrHt-WH-Shrhd/3.33 | Res-sAll-mDHWshwr | Res-LowF-SH-All |

**Note: For the complete list of Measures, refer to the accompanying Measure Worksheet**

Measure Summary Table B

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Measure ID | Descriptors | | | | | Above Preexisting/  Customer-Average Savings | | | Above Code/  Standard Savings | | | Cost | | |
| Bldg Type | Bldg Vint | Bldg Loc | Bldg HVAC | Norm Unit | kWh/ unit | kW/unit | therm | kWh/ unit | kW/unit | therm | Code/ Standard ($/unit) | Measure ($/unit) | Incremental  Measure ($/unit) |
| ShwShh001 | SF | Any | 9 | N/A | Each | N/A | N/A | 0 | N/A | N/A | 10.35 | $0.00 | $45.96 | $14.90 |
| ShwShh002 | SF | Any | 9 | N/A | Each | N/A | N/A | 0 | N/A | N/A | 7.76 | $0.00 | $45.96 | $14.90 |
| ShwShh003 | SF | Any | 9 | N/A | Each | N/A | N/A | 0 | N/A | N/A | 5.2 | $0.00 | $45.96 | $14.90 |
| ShwShh004 | SF | Any | 9 | N/A | Each | N/A | N/A | 0 | N/A | N/A | 4.1 | $0.00 | $45.96 | $14.90 |
| ShwShh005 | SF | Any | 9 | N/A | Each | N/A | N/A | 0 | N/A | N/A | 3.1 | $0.00 | $45.96 | $14.90 |
| ShwShh006 | SF | Any | 9 | N/A | Each | N/A | N/A | 12.93 | N/A | N/A | 8.38 | $0.00 | $45.96 | $14.90 |
| ShwShh007 | SF | Any | 9 | N/A | Each | N/A | N/A | 10.35 | N/A | N/A | 5.69 | $0.00 | $45.96 | $14.90 |
| ShwShh008 | SF | Any | 9 | N/A | Each | N/A | N/A | 7.8 | N/A | N/A | 3.1 | $0.00 | $45.96 | $14.90 |
| ShwShh009 | SF | Any | 9 | N/A | Each | N/A | N/A | 6.7 | N/A | N/A | 2.1 | $0.00 | $45.96 | $14.90 |
| ShwShh010 | SF | Any | 9 | N/A | Each | N/A | N/A | 5.7 | N/A | N/A | 1.0 | $0.00 | $45.96 | $14.90 |
| ShwShh001 | MF | Any | 9 | N/A | Each | N/A | N/A | 0 | N/A | N/A | 11.55 | $0.00 | $45.96 | $14.90 |
| ShwShh002 | MF | Any | 9 | N/A | Each | N/A | N/A | 0 | N/A | N/A | 8.66 | $0.00 | $45.96 | $14.90 |
| ShwShh003 | MF | Any | 9 | N/A | Each | N/A | N/A | 0 | N/A | N/A | 5.78 | $0.00 | $45.96 | $14.90 |
| ShwShh004 | MF | Any | 9 | N/A | Each | N/A | N/A | 0 | N/A | N/A | 4.63 | $0.00 | $45.96 | $14.90 |
| ShwShh005 | MF | Any | 9 | N/A | Each | N/A | N/A | 0 | N/A | N/A | 3.47 | $0.00 | $45.96 | $14.90 |
| ShwShh006 | MF | Any | 9 | N/A | Each | N/A | N/A | 14.44 | N/A | N/A | 9.24 | $0.00 | $45.96 | $14.90 |
| ShwShh007 | MF | Any | 9 | N/A | Each | N/A | N/A | 11.55 | N/A | N/A | 6.35 | $0.00 | $45.96 | $14.90 |
| ShwShh008 | MF | Any | 9 | N/A | Each | N/A | N/A | 8.67 | N/A | N/A | 3.47 | $0.00 | $45.96 | $14.90 |
| ShwShh009 | MF | Any | 9 | N/A | Each | N/A | N/A | 7.52 | N/A | N/A | 2.31 | $0.00 | $45.96 | $14.90 |
| ShwShh010 | MF | Any | 9 | N/A | Each | N/A | N/A | 6.36 | N/A | N/A | 1.15 | $0.00 | $45.96 | $14.90 |

**Note: For the complete list of Measures, refer to the accompanying Measure Worksheet**

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General Measure & Baseline Data

Measure & Delivery Description

This workpaper provides an opportunity for energy savings by installing low-flow showerheads in residential households. This Workpaper details the energy savings from the installation of low flow showerheads rated at (1.0, 1.25, 1.5, 1.6 and 1.7) GPM

* + 1. **Technical Description**

*Low-Flow Showerhead*

About 73% of the water used in a typical shower is hot. By reducing the flow rate this device will reduce the amount of water consumed. As a result, the water heater energy load will decrease, thus yielding energy and water savings[[1]](#endnote-1).

* + 1. **Program Restrictions and Guidelines**

*Terms and Conditions*

* Make and model number must be included with a copy of the purchase receipt
* Water heating source must combust natural gas distributed by SEU.
* Low-flow showerhead shall meet the requirements of test procedure ANSI/ASME A112.18.1-2000, Section 5.5
  + 1. **Market Applicability**

Measures presented in this workpaper apply to single-family and multi-family residential households in the SCG service territory.

DEER Differences Analysis

*Low-flow Showerheads*

There are currently no DEER measures applicable for low-flow showerheads having a lower operating (GPM) than the current Tittle 20 code . Energy savings will vary with each flowrate.

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 performance of water heaters was assumed to have an EF = 0.60. Also, the base case flow was assumed to be 2.5 GPM with a measure flow rate of 2.0 GPM.

The methodology employed in this Workpaper is different from DEER’s, but similar to the 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 Workpaper method is quantitative since the resulting statistics from several studies were applied in the calculations. In addition, the U.S. Census was used to find population densities in California (people/household) as well as bath densities (baths/household) for multi-family residential units; therefore the resulting savings for this Workpaper are partially based on a state average rather than an investor owned utility service area average.

The results from ASW[[4]](#endnote-4) field study within SEU service territory are applied in the calculations for single-family units where applicable. The SEU low-flow showerhead measure flow rates are 1.0, 1.25, 1.5, 1.6, and 1.7 GPM. The baseline applied to this measure conforms to the Tittle 20 flow rate code change taking place in 2016.

The DEER measure presents energy savings for both electric and gas, this Workpaper will only provide energy savings for gas.

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 (EUL) was also employed in this Workpaper, as showerheads are subjected to very similar conditions, regardless of showerhead flow rate, thus it is expected that all low flow showerheads have approximately the same EUL.

Table : 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** | **DEER2016** |
| **DEER Run ID and Measure Name** | **DEER does not contain this type of measure** |

Codes Analysis

***Title 20:*** Title 20 of the California Energy Regulations states that the flow rate of a showerhead shall not be greater than 2.5 GPM at 80 psi if they are sold or manufactured for sale in California prior to July 1, 2016. Early Retirement (ER) measures have dual baselines. A 2.25 GPM is used as the first baseline flow rate and 1.8 GPM at 80 PSI for the second baseline. NEW and ROB measures will have a single baseline with a 2.0 GPM at 80 PSI flow rate.

***Title 24:*** Same limitation of a 2.5 GPM maximum flow rate at 80 psi is stated in Title 24 for showerheads as is in Title 20. However, new regulations from the CEC set limitations to this flowrates. New weather data for all 16 climate zones are also updated according to the ground water temperatures.

***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”1. This Workpaper addresses above code showerheads with a flow rate of (1.0, 1.25, 1.5, 1.6 and 1.7) GPM.

***Water Fixtures Disposition:*** The Water Fixture Disposition[[5]](#endnote-5) changes the daily hot water consumptions to a baseline of 28.01 gal per day for single family homes and 23.3 gal per day for multi-family dwellings according to the 2009 NREL and the Building America House Simulation Protocols[[6]](#endnote-6).

Table : Code Summary

|  |  |  |
| --- | --- | --- |
| Code | Applicable Code Reference | Effective Dates |
| Federal Energy Policy Act (1992) | Federal Codes and Standards | 1992 |
| Water Fixtures Disposition | State Code Reference | 2/22/2013 |
| Title 20 (2014) | Section 1605.1 | 7/1/2016 , 7/1/2018 |

Baseline Description

The first baseline flow rate is 2.25 GPM for Early Retirement(ER) measures as discovered in the ASW4 field study with SEU customers by visiting residential households and measuring the existing showerheads flow rate. The 2.25 GPM flow rate is the customer’s average from the data obtained through the survey and is used for Early Retirement (ER) program. The baseline mixed water consumptions for single-family households are also derived from the ASW4. The derivation incorporated the values of showers taken, existing showerhead flow capacity, and water temperatures. Additional value references are shown in Table III. The second baseline for Early Retirement measures is 1.8 GPM flow rate at 80 PSI. The second baseline complies with the new Tittle 20 flow regulations taking effect on July 1, 2018.

NEW and ROB measures will have a single baseline with a flow rate of 2.0 GPM. This flow rate satisfies the Tittle 20 code change taking effect on July 1, 2016.

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 daily use that were developed from the NREL and “America house Simulation Protocols”6. In which a consumption of 28.01 and 23.3 gallons per day, for a single-family home of 3 bedrooms and multi-family dwelling of 2 bedrooms respectively, of hot water were determined. These values originate from a 2.25 GPM flow rate. Adjustments were made for water consumption for different flow rates.

The adopted NREL baselines standardize the daily hot water shower consumption for New Construction, Replace-On-Burnout and Early Retirement programs to 28.01 and 23.3 gallons per day for single and multifamily respectively. These baselines are independent of previously mentioned flowrate baselines of 2.0 and 2.25 GPM. However, the mixed water consumption for each of the measure showerheads (1.0 ,1.25, 1.5, 1.6, and 1.7 )GPM 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 proceeding section of Water Saving Estimation Methodologies.

EM&V, market potential, and other studies

The June 2004 RASS study[[7]](#endnote-7) addressed low flow showerheads in 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. In the 2004 RASS study7, low flow showerheads were defined as having a flow rate less than 2.5 GPM. Due to Tittle 20 code change, this workpaper serves to update the baseline of 2.5 GPM previously used in NEW and ROB measures.

The RASS study7 also evaluated the “number of showers taken per household on a typical day” (mean of 2.52 showers for single-family households and 2.22 showers for multi-family households). However, only multi-family household value from the RASS study7 was used in the energy savings calculation, calculations are explained in section two of this workpaper. For single-family households, the survey data from SEU customers (2.79 showers per household) was used.

Measure Effective Useful Life

The Effective Useful Life (EUL) of a 2.5 GPM showerheads is 10 years. This was taken from a DEER publication “EUL\_Summary\_10-1-08”. 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. However, due to the CPUC Tittle 20 flow rate changes, Early Retirement (ER) measures is this workpaper have a dual baseline, in which the remaining life will be applied. The Remaining Useful Life (RUL) is 1/3 of the single baseline EUL. The RUL will be applied to the second baseline for ER measures in this workpaper. The RUL value is 3.33 years, (

Net-to-Gross Ratios for Different Program Strategies

This workpaper yields two different Net-to-Gross (NTG) ratios, depending on the delivery method. Direct Installation will have a 0.70 NTG ratio. Prescribed Rebate will have a 0.55 NTG ratio.

Gross Realization Rate

This program will have a Gross Realization Rate (GRR) of .737.

Table : GSIA

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Measure ID | GSIA ID | GSIA Type | GSIA Value | Description |
| ShwShh001 | Res-LowF-SH-All | Annual Installation Rate | .737 | Residential low-flow Showerhead |
| ShwShh002 | Res-LowF-SH-All | Annual Installation Rate | .737 | Residential low-flow Showerhead |
| ShwShh003 | Res-LowF-SH-All | Annual Installation Rate | .737 | Residential low-flow Showerhead |
| ShwShh004 | Res-LowF-SH-All | Annual Installation Rate | .737 | Residential low-flow Showerhead |
| ShwShh005 | Res-LowF-SH-All | Annual Installation Rate | .737 | Residential low-flow Showerhead |

Energy Savings & Demand Reduction Calculations

Data and Assumptions, Conversion factors

Table IV, below, lists the data, assumptions and conversion factors used in the calculations for this workpaper. Table V below defines the water and energy variables stated in the calculation formulas. The sources for these assumptions are listed in Table XI of the Appendix. The calculations will be similar to the method used in the Lawrence Berkeley National Laboratory (LBNL) study3. Statistical result from ASW4 survey was applied wherever possible. 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” [[8]](#endnote-8) with inputs from Table III.

Table : Data and Assumptions, & Conversion Factors

|  |  |  |  |
| --- | --- | --- | --- |
| **Constant** | **Description** | **Value** | **Units** |
| V̇base Code | baseline showerhead water flow, code requirement (volumetric flow rate) | 2.0 | GPM |
| V̇base Avg | baseline showerhead water flow, customer average obtained from SGC/SDG&E Survey (volumetric flow rate) | 2.25 | GPM |
| GNormalized, SF | normalization factor for water saving calculation for Single Family | See Table VII | unitless |
| GNormalized, MF | normalization factor for water saving calculation for Mulit-Family | See Table VII | unitless |
| Tout,tempered | water temperature exiting showerhead.  ASW survey data | 106 | ºF |
| Tout, hot | water temperature exiting water heater | 130 | ºF |
| tshower | mean shower duration, Aquacraft, Inc., 2000[[9]](#endnote-9). | 7.4 | minutes / shower |
| Cvolume | volumetric conversion constant for cubic feet to gallons | 7.481 | gal / 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 |
| Nshowers, SF | average number of showers taken per single-family household per day, from ASW study data | 2.79 | showers / household / day |
| Nshowers, MF | average number of showers taken per multi-family household per day, from RASS data | 2.22 | showers / household / day |
| Nshowerheads, SF | average number of showerheads per single-family household, from ASW study data | 2.01 | showerheads / household |
| Nshowerheads, MF | average number of showerheads per multi-family household, from RASS data | 1.50 | showerheads / household |
| REres,gas | Recovery Efficiency (Title 20 gas-fired residential water heaters) | 0.77 | unitless (heat out / heat in) |

Table : Water and Energy Variables

|  |  |  |  |
| --- | --- | --- | --- |
| **Variable** | **Description** | **Value** | **Units** |
| WSF baseline NREL | annual water consumption for 28.01 gal/day baseline case | See Table VI | gal / showerhead - yr |
| WMF baseline NREL | annual water consumption for 23.3 gal/day baseline case | See Table VI | gal / showerhead - yr |
| Wbaseline Code | annual water consumption for 2.5 gpm baseline case | See Table VI | gal / showerhead - yr |
| Wbaseline Avg | annual water consumption for 2.25 gpm baseline case | See Table VI | 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 28.01 gal per day and 23.3 gal per day, respectively.

**Normalization Factor:** This factor is for the adjustments of savings on the measure showerheads (1.0, 1.25, 1.5, 1.6, 1.7 GPM) 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.

**Showerheads per Household:** The survey data from SEU territories was averaged to be 2.01 showerheads per single-family household. For multi-family households, data from the U.S. Census Bureau[[10]](#endnote-10) 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.

**Water Temperature Entering Heater:** The ground water temperatures entering the heater were updated per the new DEER 2013 Title 24 Weather Data Update. This update categorized ground water temperatures by the 16 different climate zones of California. The ground water temperature will be a key factor in determining the amount of hot water needed for a mixed water of 106 degree F, which is a typical mixed water temperature comes out of the showerheads. Thus, from the monthly hot water consumption in each climate zone, a weighted average of the ground water temperature can be deduced. The ground water temperature is tabulated in Table X below. Detailed calculation is in the attachment.

**Shower Duration:** Water trace data from ten single family homes in Seattle (Aquacraft, Inc., 2000) 7 showed that the mean shower duration is 7.4 minutes. Another measurement study of residential end use of water by AWWA Research Foundation[[11]](#endnote-11) 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.

**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 factor.

**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 0.77 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.

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. In addition, water savings are an essential benefit during the current California drought crisis.

***Low Flow Showerhead (1.0/1.25/1.5 / 1.6 / 1.7 GPM)***

Table : Water Consumption

**\*For detailed water savings see attached calculation sheet\***

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Measure Name: | Single-Family  (2.0 GPM) | Multi-Family  (2.0 GPM | Single-Family  (2.25 GPM) | Multi-Family  (2.25 GPM) |
| CPUC Baseline Annual Hot Water Use | 4521 | 5048 | 5086 | 5679 |
| Code Baseline Annual Water Use | 6748 | 7195 | 6748 | 7195 |
| SEU Average Baseline Annual  water Use | 7592 | 8095 | 7592 | 8095 |
| Unit in [gallons / showerhead / year] | | | | |

Calculations:

The following defined variables will be referred throughout in the expressions used.

* *= 1.0, 1.25, 1.5, 1.6, 1.7 GPM*
* *j=2.25, 2.5,2.0 GPM*
* *U= daily water Consumption*
* *K=24.90 SF, 20.75MF Gallons per Day at 2.0 Baseline*
* *V̇= volume flow rate*
* *N = number of shower taken in single and multi-family*
* *F=throttling factor*
* *C = days per year*
* *G= Normalization factor*
* *M = Number of shower heads in a single and multi-family*

CPUC Baseline Hot Water consumption for single and multi-family units was found through the following expression.

Code and SEU Average Baseline Water consumption for multi and single family were found through the following expressions.

Table : Normalization Factors

|  |  |
| --- | --- |
| Single-Family | Multi-Family |
| 0.6700 | 0.7016 |

Calculations:

NEW and ROB Normalization Factor:

Single and Multi-Family:

ER Normalization Factor:

45

Single and Multi-Family:

Table : Annual Water Consumption Per Shower: (NEW, ROB, ER)

|  |  |  |
| --- | --- | --- |
| Showerhead | Single-Family | Multi-Family |
| 1.0 GPM Showerhead | 2261 | 2524 |
| 1.25 GPM Showerhead | 2826 | 3155 |
| 1.5 GPM Showerhead | 3391 | 3786 |
| 1.6 GPM Showerhead | 3617 | 4039 |
| 1.7 GPM Showerhead | 3843 | 4291 |
| 1.8 GPM Showerhead | 4069 | 4543 |
| Unit in [gallons / showerhead / year] | | |

Calculations:

Measure Water consumption

Single and Multi-Family: The varying value is M, for number of shower heads in each type of dwelling.

This same calculation method was applied for multi-family water consumption, but using the appropriate number of showers and number of shower heads for a multi-family unit.

Table : Annual Water Savings by Using Low Flow Showerheads (2.0 GPM Baseline)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Single-Family Savings | | Multi-Family Savings | |
| **Showerheads** | **NEW and ROB** | **ER** | **NEW and ROB** | **ER** |
| 1.0 GPM Showerhead | 2261 | 2826 | 2524 | 3155 |
| 1.25 GPM Showerhead | 1695 | 2261 | 1893 | 2524 |
| 1.5 GPM Showerhead | 1130 | 1695 | 1262 | 1893 |
| 1.6 GPM Showerhead | 904 | 1469 | 1010 | 1641 |
| 1.7 GPM Showerhead | 678 | 1243 | 757 | 1388 |
| 1.8 GPM Showerhead | 452 | 1017 | 505 | 1136 |
| Unit in [gallons / showerhead / year] | | | | |

**\*For detailed water savings see attached calculation sheet\***

Calculations:

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

ER Annual Low Flow Showerhead Savings = CPUC Baseline annual water use (Table VI) – Measure annual water use (Table IX)

Gas Energy Savings Estimation Methodologies

The gas energy savings can be easily estimated by taking total hot water savings (Table IX) 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.

Table : Annual Natural Gas Savings (2.0 GPM Baseline)

|  |  |  |
| --- | --- | --- |
| LFSH | Savings  (Therm/Year) | CZ |
| 1.0 GPM, SF,EUL - 2016 Code | 10.35 | 9 |
| 1.25 GPM, SF,EUL 2016 Code | 7.76 | 9 |
| 1.5 GPM, SF,EUL-2016 Code | 5.2 | 9 |
| 1.6 GPM, SF,EUL – 2016 Code | 4.1 | 9 |
| 1.7 GPM, SF,EUL – 2016 Code | 3.1 | 9 |
| 1.0 GPM, MF,EUL – 2016 Code | 11.55 | 9 |
| 1.25 GPM, MF,EUL –2016 Code | 8.66 | 9 |
| 1.5 GPM, MF,EUL -2016 Code | 5.78 | 9 |
| 1.6 GPM, MF,EUL -2016 Code | 4.63 | 9 |
| 1.7 GPM, MF,EUL -2016 Code | 3.47 | 9 |

**\*For complete measures and details see Measure Worksheet attached\***

Calculations:

The energy saved for natural gas heaters is given by the following expression.

\*, where,

* *ρ = Water Density at 60 °F*
* *T = Temperature °F*
* *η =Thermal Efficiency, Res Gas Water Heater = .77*

The saving for Early Retirement (ER) measures will have dual baselines, denoted as first and second baselines. The first baseline savings utilize a 2.25 GPM flow rate while the second baseline will utilize a flow rate of 1.8 GPM which is the Tittle 20 code change taking place on July 1, 2018 and an RUL value of 3.33 years NEW and ROB measures will have a single baseline which will use a 2.0 GPM flow rate, NEW and ROB will utilize the EUL of the shower head.

Base Case & Measure Costs

Base Case Cost

Revised DEER cost[[12]](#endnote-12) data for 2.5 GPM showerhead measure was used for installed base cost. The equipment/material cost per unit ($/unit) is $14.32, while the installation cost is $16.74 per unit. The total installed base cost per unit is $31.06.

The base material cost and base labor cost for Early Retirement is $0.00.

Gross Measure Cost

Low flow showerheads will have the same cost as a 2.0 GPM showerhead cost in DEER200812. The DEER 2008 measure cost is $45.96, to replace greater than 2.5 GPM (~4-6 GPM) showerheads with 2.0 GPM showerheads. The components of low flow showerhead fixtures are fundamentally the same, thus low flow showerheads will not incur any additional. In addition, installation costs will be the same for low flow showerheads.

The DEER equipment cost per unit ($/unit) is $29.22 for low flow showerheads, and the installation labor cost is $16.74. The total installed measure cost per unit is $45.96, same as the base cost.

For ER measures, a dual baseline is adopted. RUL will equal to . In the remaining useful life (RUL) of the measure, there will be no base total cost in upgrading from 2.25 GPM showerheads to less than 2.0 GPM showerheads. However, the base total cost will be $31.06 after the remaining useful life.

Incremental Measure Cost

The incremental measure cost is the difference between the measure total cost and the base total cost. In ER program, the base total cost is $0 in the first baseline and $31.06 in the second baseline; however, the measure total cost is $0 in the second baseline.

For NEW and ROB programs, the first baseline total cost is $31.06 and $0.00 in the second, this programs have a measure total cost of $45.96 in the first baseline and $0.00 in the second.

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***[[13]](#endnote-13)***. Below is a summary of their conclusions.

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.

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.

Appendix and Attachments

1. Therm Savings Calculation Sheet:

2. Weighted Average Ground Water Temperature Calculations

3. Title 20 Appliance Database Natural-Gas Fired Storage-Type Water Heater Subset (downloaded July 7, 2010):

4. Measure Worksheet:

Table : Sources for Data and Assumptions, Conversion Factors

|  |  |
| --- | --- |
| **Data and Assumptions** | **Source** |
| Showerheads per Household | ASW4 survey data for SF, and U.S Census Bureau (Weighted average of new units completed in the West region from 1978-2006) 12 for MF |
|
| Showers taken per Household per Day | RASS5, p. 100 of PG&E Banner Data for MF, ASW4 survey data for SF |
| 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 Workpaper. |
| Average Shower Flow | ASW4 survey data, simple average of pre-installation flow rate of all surveyed sites.  PG&E Calculations, derived from *Potential Water and Energy Savings from Showerheads*3, p. 4 and RASS4, p.121 |
| Cold water heater inlet temperature (ºF) | 2013 Title 24 Weather Data |
| Hot water heater outlet temperature (ºF) | ASW4 survey data |
| Shower temperature (ºF) | *ASW*4 survey data |
| Gas Water Heater Efficiency | *California Title 20 Appliance Regulations*12 |
| **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* |

Table : 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.*

List References and include all savings calculations and all relevant project information as deemed necessary. This section is project specific documents only. Do not include any confidential information!

Choose the appropriate Excel spreadsheet below as needed. Be sure to delete those that are not used.

References:

1. U.S.Department of Energy (June 15, 2012). *Reduce Hot Water Use for Energy Savings*. Retrieve from <http://energy.gov/energysaver/articles/reduce-hot-water-use-energy-savings>. [↑](#endnote-ref-1)
2. Itron, In. (December 2005). *2004-2005 Database for Energy Efficient Resources (DEER) Update Study: Final Report*, Pages 2-20 to 2-23. Retrieved December 19, 2007. [↑](#endnote-ref-2)
3. Biermayer, P. J. (2006). *Potential Water and Energy Savings from Showerheads,* Pages 4 to 7. Contract No. DE-AC02-05CH11231. Ernest Orlando Lawrence Berkeley National Laboratory. Environmental Energy Technologies Division. [↑](#endnote-ref-3)
4. SEU Survey conducted by ASW (2009) while servicing SEU customers (February ~ May, 2009), including data from various residential water measurements and household questionnaire response. [↑](#endnote-ref-4)
5. California Public Utilities Commission, Energy Division (2013). Workpaper Disposition for Water Fixtures. [↑](#endnote-ref-5)
6. Hendron, Robert and Engebrecht, Cheryn. *Building America Research Benchmark Definition*, Updated December 2009, National Renewable Energy Laboratory. Retrieved from <http://www.nrel.gov/docs/fy10osti/47246.pdf>. [↑](#endnote-ref-6)
7. *California Statewide Residential Appliance Saturation Study* (RASS - 2004). Contract No. 400-04-009. Prepared for the California Energy Commission by KEMA-XENERGY, Itron, Roper, and ASW. PG&E Banner Subset, Pages 100 and 102. Retrieved from http://www.energy.ca.gov/reports/400-04-009/2004-08-17\_400-04-009\_PG+E.PDF [↑](#endnote-ref-7)
8. Retrieve from http://www1.eere.energy.gov/femp/technologies/eep\_faucets\_showerheads\_calc.html [↑](#endnote-ref-8)
9. Aquacraft, Inc, Water Engineering and Management.

   *The End Use of Hot Water In Single Family Homes From Flow Trace Analysis,* Table 1: Hot Water End Use Statistics in Ten Seattle Homes over 14 Days [↑](#endnote-ref-9)
10. U.S. Census Bureau, 2000 Census. *Bathrooms per household* CA. [↑](#endnote-ref-10)
11. American Water Works Association Research Foundation (1999). *Residential End Uses of Water,* Page 99, Showers. [↑](#endnote-ref-11)
12. Revised DEER Measure Cost Summary )05\_30\_2008) Revised (06\_02\_2008).xls [↑](#endnote-ref-12)
13. Leni-Konig, K. (2008). *Low Flow Showerhead Test Report: Scalding, Flow Rates, and the Evolve Ladybug Showerhead Adapter*, Pages ii, 11 and 12. Applied Technology Services. Pacific Gas and Electric Company

    14California Energy Commission (2013), Appliance Efficiency Database. Retrieve from <http://www.appliances.energy.ca.gov/QuickSearch.aspx>.

    Briefly describe the cost of the new technology including: measure equipment material costs, installation labor, and maintenance.

    List References Add workpaper references here using the format shown below and also insert the appropriate letter in brackets (e.g. [A] )in the body of the work paper for each citation.

    See sample text. Insert, AutoText, Normal, References [↑](#endnote-ref-13)