Workpaper SWWH001v00

**Revision #0**

**Southern California Gas Company**

**Auto-Diverting Tub Spout with Thermostatic Shut-off Valve**

# At-a-Glance Summary

|  |  |  |
| --- | --- | --- |
| **Measure Codes** | ShwFLr005, ShwFLr006 | ShwFLr007, ShwFLr008 |
| **Measure Description** | The Auto-diverting tub spout (5.0 gpm) with thermostatic shut-off valve purges cold water through tub spout until the water raises to 95° F. The water is then diverted to the showerhead at a trickle until full flow (1.5 gpm) is activated via the pull cord. | The Auto-diverting tub spout (5.0 gpm) with thermostatic shut-off valve purges cold water through tub spout until the water raises to 95° F. The water is then diverted to the showerhead at a trickle until full flow (1.5 gpm) is activated via the pull cord. |
| **Base Case Description** | 5.0 gpm tub spout with a 2.0 gpm showerhead combo | 5.0 gpm tub spout with a 1.8 gpm showerhead combo |
| **Units** | Each | Each |
| **Energy Savings** | Refer to Excel Saving Calculation Attachment A | Refer to Excel Saving Calculation Attachment A |
| **Full Measure Cost ($/unit)** | $119.99 | $119.99 |
| **Incremental Measure Cost ($/unit)** | $94.00 | $91.38 |
| **Effective Useful Life** | 10 years (DEER EUL ID: WtrHt-WH-Shrhd) | 10 years (DEER EUL ID: WtrHt-WH-Shrhd) |
| **Measure Installation Type** | New Construction (NEW/NC), Replace on Burnout (ROB) | Early Retirement (ER) |
| **Net-to-Gross Ratio** | 0.7 (DEER NTGR ID: All-Default<=2yrs)  0.85 (DEER NTGR ID : Res-Default-HTR-di) | 0.7 (DEER NTGR ID: All-Default<=2yrs)  0.85 (DEER NTGR ID : Res-Default-HTR-di) |
| **Important Comments** | Calculated water savings for single family and multifamily are 1806.95 and 2017.62 gallons per year respectively.  This Workpaper has a complementary Ex Ante Database dataset that will be provided in a separate submission to the California Public Utilities Commission (CPUC). | Calculated water savings for single family and multifamily are 1806.95 and 2017.62 gallons per year respectively.  This Workpaper has a complementary Ex Ante Database dataset that will be provided in a separate submission to the California Public Utilities Commission (CPUC). |

# Revision History

|  |  |  |  |
| --- | --- | --- | --- |
| **Rev** | **Date** | **Author** | **Summary of Changes** |
| 0 | 04/25/16 | Miguel Urrea (SCG) | * Initial Release |
|  |  |  |  |

# Commission Staff and Cal TF Comments

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Rev** | **Party** | **Submittal Date** | **Comment Date** | **Comments** | **WP Developer Response** |
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# Section 1. General Measure & Baseline Data

## Measure Description & Background

For users intending to save energy and water during showers this measure offers a unique option, not until recently, available in the market. The Auto-diverting Tub Spout (ADTS) with thermostatic shut-off valve (TSV) replaces tub spouts and showerheads in the residential market with shower-bathtub combos (62% of all showers[[1]](#footnote-1)). With behavioral waste continuing to be a significant problem[[2]](#footnote-2) during shower warm-ups along with leaky tub spouts[[3]](#footnote-3) new technologies are needed. This measure saves energy and water by reducing shower warm-up waste, replaces leaky tub spouts, and lowering the showerhead flowrate. Mobile home savings are the same as single-family home savings and will not have a separate energy impact profile. NEW and ROB measures types will use code baseline from 2016 – 2.0 gpm showerhead. ER measure type will use code baseline from 2018 – 1.8 gpm due to the RUL of 3 years.

1. Base, Standard, and Measure Cases

|  |  |
| --- | --- |
| **Case** | **Description of Typical Scenario** |
| Measure | Auto-diverting Tub Spout (5.0 gpm) with thermostatic shut-off valve and 1.5 gpm showerhead |
| Existing Condition | 5.0 gpm tub spout with a 2.25 gpm showerhead |
| Code/Standard (2016) | 5.0 gpm tub spout with a 2.0 gpm showerhead |
| Code/Standard (2018) | 5.0 gpm tub spout with a 1.8 gpm showerhead |
| Industry Standard Practice | N/A |

1. Measures and Codes

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Measure Codes** | | | | **Measure Name** |
| SCG | SDG&E | SCE | PG&E |
| ShwFLr005 |  |  |  | Auto-diverting Tub Spout with thermostatic shut-off valve Showerhead (1.5 gpm) –Gas |
| ShwFLr006 |  |  |  | Auto-diverting Tub Spout with thermostatic shut-off valve Showerhead (1.5 gpm) –Electric |
| ShwFLr007 |  |  |  | Auto-diverting Tub Spout with thermostatic shut-off valve Showerhead (1.5 gpm) –Gas |
| ShwFLr008 |  |  |  | Auto-diverting Tub Spout with thermostatic shut-off valve Showerhead (1.5 gpm) –Electric |

Describe requirements for these measures, including:

* **Eligibility requirements**: Water heating source using natural gas or electricity distributed by IOU. The measure cannot be applied where tankless water heaters are used. Instantaneous tankless water heaters may have different effect on savings with thermostatic shut-off valves. Not compatible with showers containing a wall mounted diverter
* **Implementation and installation requirements**: Measures presented in this Workpaper apply to single-family, mobile, and multi-family residential households.
* **Other program restrictions and guidelines:** Make and model number must be included with a copy of the purchase receipt. Product must be certified by International Association of Plumbing and Mechanical Officials (IAPMO).

## 1.2 Technical Description

The ATDS with TSV helps to reduce structural waste, diminish behavioral waste to a trickle, stop tub spout leak and lowers the showerhead flow rate to 1.5 gpm. These benefits are realized through the use of a flow diverter and TSV within the tub spout that detects when water reaches 95° F. The technology purges the cold water in the shower piping through the spout causing faster hot water arrival water with less water (structural waste)2. Once the hot water arrives, the diverter changes the flow direction to the showerhead where the water flow is reduced to a trickle with no tub spout leak. Then the user simply pulls the lanyard on the showerhead to open the valve and allow normal water flow.

1. How the ADTS System Works





## 1.3 Installation Types and Delivery Mechanisms

The Tub Spout will be offered as a direct install and as a downstream rebate. These delivery channels were selected to deliver the Tub Spout since they are the same as current low flow showerhead program.

1. Installation Type Descriptions

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Installation Type** | **Savings** | | **Life** | |
| 1st Baseline (BL) | 2nd BL | 1st BL | 2nd BL |
| Replace on Burnout (ROB) | Above Code or Standard | N/A | EUL | N/A |
| New Construction (NEW/NC) | Above Code or Standard | N/A | EUL | N/A |
| Retrofit or Early Replacement (RET/ER) | Above Customer Existing | Above Code or Standard | RUL | EUL-RUL |

A delivery mechanism is a delivery method paired with an incentive method. Delivery mechanisms are used by programs to obtain program participation and energy savings.

1. Delivery Method Descriptions

|  |  |
| --- | --- |
| **Delivery Method** | **Description** |
| Financial Support | The program motivates customers, through financial incentives such as rebates or low interest loans, to implement energy efficient measures or projects. |
| New Construction | The program offers financial incentives and/or design assistance to customers involved with new building construction. This is intended is to motivate customer to exceed Title 24 building energy efficiency requirements (residential or nonresidential). |

1. Incentive Method Descriptions

|  |  |
| --- | --- |
| **Incentive Method** | **Description** |
| Direct Install | The program implements energy efficiency measures for qualifying customers, at no cost to the customer. |
| Down-Stream Incentive | The customer installs qualifying energy efficient equipment and submits an incentive application to the utility program. Upon application approval, the utility program pays an incentive to the customer. Such an incentive may be deemed or customized. |

## 1.4 Measure Parameters

### 1.4.1 DEER Data

There are currently no DEER measures that apply to this type of technology.

1. DEER Difference Summary

|  |  |
| --- | --- |
| **DEER Item** | **Used for Workpaper?** |
| Modified DEER methodology | No |
| Scaled DEER measure | No |
| DEER Base Case | No |
| DEER Measure Case | No |
| DEER Building Types | Yes |
| DEER Operating Hours | No |
| DEER eQUEST Prototypes | No |
| DEER Version | DEER 2016 |
| Reason for Deviation from DEER | DEER does not contain this type of measure. |
| DEER Measure IDs Used | N/A |

**Net-to-Gross Ratio**

The NTG values were obtained using the DEER READI tool[[4]](#footnote-4). The relevant NTG values for the measures in this Workpaper are in the table below. This is a new technology that varies from the standard low flow showerhead and thermostatic shut-off valve.

1. NTGR ID

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **NTGR ID** | **Description** | **Sector** | **BldgType** | **Measure Delivery** | **NTGR** |
| All-Default <=2yrs | All other EEM with no evaluated NTGR; new technology in program for 2 or fewer years | All | Any | Any | 0.7 |
| Res-Default-HTR-di | All other EEM with no evaluated NTGR; direct install hard-to-reach only. | Res | Any | DirInstall | 0.85 |

\*Direct install measures that are not hard-to-reach will use the default NTG value.

**Spillage Rate**

Spillage rates are not tracked in Workpapers; they are tracked in an external document which will be supplied to the Commission Staff.

**Installation Rate**

The GSIA ID for low flow showerheads with flow restrictor valve and without flow restrictor valve is the closest technology description to the ADTS with TSV. Neither of the GSIA IDs are applicable to this Workpaper because of the forced tub spout warm-up and the type of installation required for this technology. The default GSIA ID is used. The GSIA values were obtained using the DEER READI tool4. The relevant IR values for the measures in this Workpaper are in the table below.

1. GSIA ID

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **GSIA ID** | **Description** | **Sector** | **BldgType** | **ProgDelivID** | **GSIAValue** |
| Def-GSIA | Default GSIA values | Any | Any | Any | 1 |

**Effective and Remaining Useful Life**

The EUL and RUL values were obtained using the DEER READI tool4. DEER defines the RUL as 1/3 of the EUL value. The RUL value is only applicable to the first baseline period for an RET measure with an applicable code baseline. The DEER effective useful life for low-flow showerheads was employed as the technologies are subjected to very similar conditions and would be expected to have approximately the same EUL of 10 years[[5]](#footnote-5). The relevant EUL and RUL values for the measures in this Workpaper are in the table below.

1. EUL ID

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **EUL ID** | **Description** | **Sector** | **UseCategory** | **EUL (Years)** | **RUL (Years)** |
| WtrHt-WH-Shrhd | Low-Flow Showerhead | Res | SHW | 10 | 3.3 |

### 1.4.2 Codes and Standards Analysis

1. Code Summary

|  |  |  |
| --- | --- | --- |
| **Code** | **Reference** | **Effective Dates** |
| Title 20 (2014)[[6]](#footnote-6) | Section 1605.3 | July 1, 2016 |

1. Standards for Showerheads

|  |  |  |  |
| --- | --- | --- | --- |
| **Appliance** | **Maximum Flow Rate** | | |
| Manufactured on or after January 1, 1994 and prior to July 1, 2016 | Manufactured on or after July 1, 2016 and prior to July 1, 2018 | Manufactured on or after July 1, 2018 |
| Showerheads | 2.5 gpm at 80 psi | 2.0 gpm at 80 psi | 1.8 gpm at 80 psi |

\*Taken from Title 20 Section 1605.3 Table H-5

## 1.5 EM&V, Market Potential, and Other Studies – Base Case and Measure Case Information

In order to establish saving conservative values were chosen.

### 1.5.1 Disaggregating Residential Shower Warm‐Up Waste (Sherman 2014)

An Understanding and Quantification of Behavioral Waste Based On Data from Lawrence Berkeley National Lab

|  |  |
| --- | --- |
| Type | Analysis of shower water waste data |
| Author | Troy Sherman of Evolve Technologies LLC |
| Completion Date | August 2014 |
| Time Frame | 2013 to 2014 |
| Market Covered | Single Family |
| Techniques Used | 1,057 Survey respondents and 19 homes monitored throughout California |
| Relevance/Impacts | This study quantifies structural waste and behavioral waste time frames due to shower warm-ups in single family homes. The data and findings from this study help establish the base case consumption and water savings for this Workpaper. |
| Concerns (Survey Techniques, # of respondents, etc…) | The flow rate average of the dedicated showers and tub/shower combos participating in the study was 1.79 gpm. This average is significantly below the typical 2.2 gpm flow rates sited in multiple REUW studies. The lower average flow rates indicate the study’s participants are likely more conservation oriented than average and, as a result, could be producing less total warm-­‐up waste than typical. Data does not take multifamily residents into consideration, but is used in Workpaper as best available data. |

### 1.5.2 Evaluation of Potential Best Management Practices – Residential Hot Water Distribution (Koeller 2007)

An analysis of the waste of water that occurs in a typical household between the times the tap/fixture is turned on and desired useful hot water arrives.

|  |  |
| --- | --- |
| Type | Research on structural water waste |
| Author | John Koeller of Koeller and Company |
| Completion Date | October 2006 |
| Time Frame | 2005 |
| Market Covered | Single Family and multifamily |
| Techniques Used | Laboratory tests |
| Relevance/Impacts | This study quantifies structural waste in terms of water in pipe (100 ft. of pipe). The study focuses on how various flow rates affect structural waste. |
| Concerns (Survey Techniques, # of respondents, etc…) | No concerns |

### 1.5.3 Taitem Tech Tip – Leaking Shower Diverters (Taitem 2011)

Diverter valves with leaks in shower mode waste both water and energy.

|  |  |
| --- | --- |
| Type | Research on leaking shower diverters |
| Author | Taitem Engineering |
| Completion Date | 2011 |
| Time Frame | 2011 |
| Market Covered | Single Family and multifamily |
| Techniques Used | Survey of 130 apartment and houses with 120 bath/shower units w/ diverters |
| Relevance/Impacts | Study found that 34% of the diverters leaked more than 0.1 gallons per minute (gpm) with the average at 0.8 gpm. |
| Concerns (Survey Techniques, # of respondents, etc…) | No concerns |

### 1.5.4 Residential End Uses of Water (REUW 1999)

Study designed to provide specific data on the end uses of water in single-family residential settings across the country.

|  |  |
| --- | --- |
| Type | Study on single family end use of water |
| Author | Peter W. Mayer and William B. DeOreo of Aquacraft, Inc. |
| Completion Date | 1999 |
| Time Frame | 1996 to 1997 |
| Market Covered | Single Family |
| Techniques Used | Survey of 5,000 households and detailed end use study of 1,200 households. |
| Relevance/Impacts | Mean shower volume is 17.2 gallons |
| Concerns (Survey Techniques, # of respondents, etc…) | No concerns |

### 1.5.5 SEU Survey conducted by ASW (ASW 2009)

Data from various residential water measurements and household questionnaire responses from Feb to May 2009

|  |  |
| --- | --- |
| Type | Survey on residential water use |
| Author | ASW |
| Completion Date | 2009 |
| Time Frame | February to May 2009 |
| Market Covered | Single Family |
| Techniques Used | Survey of 249 households. |
| Relevance/Impacts | Mean number of showerheads in single family household is 2.01. Pre-existing showerheads flow rate is 2.25 gpm. |
| Concerns (Survey Techniques, # of respondents, etc…) | No concerns |

### 1.5.6 The End Use of Hot Water in Single Family Homes from Flow Trace Analysis (Aquacraft 2000)

Single family hot water use study.

|  |  |
| --- | --- |
| Type | Study on single family end use of hot water |
| Author | Peter W. Mayer and William B. DeOreo of Aquacraft, Inc. |
| Completion Date | 2000 |
| Time Frame | October 1999 – 14 days |
| Market Covered | Single Family |
| Techniques Used | Survey and measurements of 10 Seattle homes. |
| Relevance/Impacts | Water trace data from ten single family homes in Seattle (Aquacraft, Inc., 2000) showed that the mean shower duration is 7.4 minutes. Another measurement study of residential end use of water by AWWA Research Foundation (REUW 1999) 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 |
| Concerns (Survey Techniques, # of respondents, etc…) | Low sample size. |

## 1.6 Data Quality and Future Data Needs

There is currently no single study which is recognized as a statewide acceptable report on the use of hot water in tub/shower combos for single family and multifamily units. The studies listed above are the best available data. Further research is needed both in the area of hot water usage in tub/shower combos (including warm-up practices) and current pre-existing conditions for both tub spout and showerhead. Due to the recent and upcoming code changes for showerhead flow rates in combination with the current drought in California the pre-existing showerhead flow rates should be revisited.

# Section 2. Calculation Methodology

## 2.1 Methodology

SoCal Gas completed three steps to estimate ex ante energy savings:

1. Establish Base Case Water Usage:
   * Structural waste (time hot water takes to reach the water fixture)
     + percentages of showerhead warm up versus tub spout warm up
   * Behavioral waste (time user takes to enter shower minus structural waste time)
     + Percentages of tub spout warm up while multitasking
   * Tub spout leak percentage and rate
   * Shower time and water usage
     + Showerhead and tub spout flow rate
     + Showers mixed daily water usage - single family and multifamily
     + Showers per day - single families and multifamily
2. Calculate Water Savings due to:
   * Forced tub spout warm-up
   * Removal of behavioral waste
   * Removal of tub spout leak
   * Reduction in Showerhead flow rate
3. Convert Water Savings to Energy Savings.
   * Convert water savings to therm savings
   * Convert therm savings to kWh savings
   * Calculate kW savings from kWh savings

## 2.2 Calculations

The energy saved comes from four different pieces. First part from structural waste, second from behavioral waste, third from leaky tub spout, and the fourth from reduced water flow during shower. Calculations resulted in similar findings as found in “Auto-Diverting Tub Spout System with ShowerStart TSV”.[[7]](#footnote-7)

### 2.2.1 Data, Assumptions, and Conversion Factors

The table below summarizes the base case assumptions and data derived from studies.

1. Base Case Parameters and Assumptions



**Showerhead Flow Rate**

With previous established 2.25 gpm in preexisting condition[[8]](#footnote-8) and the recent code update to 2.0 gpm6 it was decided to use code as the current code baseline and 1.8 gpm for early retirement code baseline due to the 3 year RUL period.

**Tub Spout Flow Rates**

With limited studies on tub spout flow rates a market assessment shows significant spouts available above 5 gpm. Since 5 gpm is the flow rate of the ADTS, it was chosen as the baseline flowrate so no savings would be derived from the tub spout flow rate alone.

**Mixed Daily Water for Showers**

The 2013-2014 domestic hot water fixture disposition[[9]](#footnote-9) set the mixed daily water for shower usage with a 2.25 gpm showerhead. The ratio of the values 2.25 gpm over 2.0 gpm showerhead were used to calculate the baseline mixed daily water usage. Mixed daily water usage is used to calculate the number of showers take per day.

**Structural Waste**

In tub/shower combos the user has the option to purge the cold water via the showerhead or the tub spout. Tub spout warm-ups are found to save both time and energy when compared to showerhead warm-ups due to the faster gpm[[10]](#footnote-10). Tub spout warm-ups are found to occur during 40% of the time in tub/shower combos2. Structural waste time is calculated by subtracting out the behavioral waste time from the total warm-up waste time.

**Behavioral Waste**

From the time when the water reaches desired temperature till the user gets in the shower. Because of the faster warm-up with a tub spout it is more likely that the user will sit near the tub to wait for hot water before entering the shower. This does not always occur and 58% of users initiating a tub spout warm-ups were found to multitask during warm-up2. Behavioral waste time varies and as such a conservative value was taken2.

**Weighted Average Showerheads per Household**

The survey data from SEU territories7 was averaged to be 2.01 showerheads per single-family household. Acquired data from the U.S. Census Bureau[[11]](#footnote-11) 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 1978-2014 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.

**Shower duration**

Water trace data from ten single family homes in Seattle (Aquacraft, Inc., 2000)[[12]](#footnote-12) showed that the mean shower duration is 7.4 minutes. Another measurement study of residential end use of water by AWWA Research Foundation (REUW 1999)1 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.

**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 2013 Title 24[[13]](#footnote-13) 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 0.813 is derived from the current CEC maintained Title 20 Appliance Database[[14]](#footnote-14) (downloaded on March 25, 2016) of natural-gas fired, storage-type water heaters without limit to the listed EF. A RE of 0.98 is used for Electric Water heaters, taken from 2013-2014 Water Fixture Disposition8.

### 2.2.2 Establish Base Case Water Usage

Base case water usage is broken into three parts: structural, behavioral, and shower usage.

**Structural Usage**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| (StWt) | Structural Waste (Time) = | | |  |  |  |
|  | BWt / BWp - BWt = | |  |  | 33 | sec/Warm-up |
|  |  |  |  |  |  |  |
| (TslStw) | Tub Spout Leak during Structual Waste Time | | | |  |  |
|  | StWt / C1 \* TslR = | |  |  | 0.440 | gal/Warm-up |
|  |  |  |  |  |  |  |
| (ShStw) | Shower Structure Waste = | | |  |  |  |
|  | StWt / C1 \* ShFr = | |  |  | 1.10 | gal/Warm-up |
|  |  |  |  |  |  |  |
| (WtP) | Amount of Water in Pipe = | | |  |  |  |
|  | ShStw / SP = | |  |  | 0.85 | gal |
|  |  |  |  |  |  |  |
| (TsStw) | Tub Structure Waste = | |  |  |  |  |
|  | WtP \* TsWuPWt = | |  |  | 0.89 | gal/Warm-up |
|  |  |  |  |  |  |  |
| (WStwTslW) | Weighted Structural Waste w/ Tub Spout Leak Weighted= | | | | |  |
|  | (ShStw + TslStw \* TslP) \* ShWu + TsStw \* TsWu = | | | | 1.11 | gal/Warm-up |

**Behavioral Usage**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| (TsBwP) | Tub Spout Behavioral Waste (Percentage) = | | | |  |  |
|  | TMWu \* TsWu = | |  |  | 23% | % |
|  |  |  |  |  |  |  |
| (TslBw) | Tub Spout Leak during Behavioral Waste | | | |  |  |
|  | BWt / C1 \* TslR = | |  |  | 0.627 | gal/Warm-up |
|  |  |  |  |  |  |  |
| (ShBw) | Shower Behavioral Waste = | | |  |  |  |
|  | BWt / C1 \* ShFr = | |  |  | 1.57 | gal/Warm-up |
|  |  |  |  |  |  |  |
| (TsBw) | Tub Behavioral Waste = | | |  |  |  |
|  | BWt / C1 \* TSFr = | |  |  | 3.92 | gal/Warm-up |
|  |  |  |  |  |  |  |
| (WBwTslW) | Weighted Behavioral Waste w/ Tub Spout Leak Weighted= | | | | | |
|  | (ShBw + TslBw \* TslP) \* ShWu + TsBw \* Bwp = | | | | 1.98 | gal/Warm-up |

**Shower Usage**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| (ASht) | Actual Shower Time = | | |  |  |  |
|  | Sht - (StWt + BWt) / C1 = | | |  | 6.07 | min |
|  |  |  |  |  |  |  |
| (AShtWuTslW) | Actual Shower Time Water Usage W/ Tub Spout Leak Weighted= | | | | | |
|  | Asht \* (ShFr + TslR \* TslP) = | | |  | 13.78 | gal/shower |

### 2.2.3 Calculating Water Savings

Water savings come from the forced tub spout warm-up, removal of behavioral waste, removal of tub spout leak, and reduction in showerhead flow rate.

**Forced Tub Spout Warm-up**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| (TsStw) | Tub Structure Waste = | |  |  |  |  |
|  | WtP \* TsWuPWt = | |  |  | 0.89 | gal/Warm-up |
|  |  |  |  |  |  |  |
| (WStwTslW) | Weighted Structural Waste w/ Tub Spout Leak Weighted= | | | | |  |
|  | (ShStw + TslStw \* TslP) \* ShWu + TsStw \* TsWu = | | | | 1.11 | gal/Warm-up |
|  |  |  |  |  |  |  |
| (StWtrS) | Structural Water Savings = | | | |  |  |
|  | WStwTslW - TsStw= | | |  | 0.21 | gal/Warm-up |

**Removal of Behavioral Waste**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| (WBwTslW) | Weighted Behavioral Waste w/ Tub Spout Leak Weighted= | | | | | |
|  | (ShBw + TslBw \* TslP) \* ShWu + TsBw \* Bwp = | | | | 1.98 | gal/Warm-up |
|  |  |  |  |  |  |  |
| (BWtrS) | Behavioral Water Savings = | | | |  |  |
|  | WBwTslW – 0 = | | | | 1.98 | gal/Warm-up |

**Removal of Tub Spout Leak and Reduction in Showerhead Flow Rate**

A 2.0 gpm Showerhead flowrate is used in the base case (AShtWuTslW) formula and 1.5 in the proposed case (AShtWuP) formula.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| (AShtWuTslW) | Actual Shower Time Water Usage W/ Tub Spout Leak Weighted= | | | | | | |
|  | Asht \* (ShFr + TslR \* TslP) = | | | |  | 13.78 | gal/shower |
|  |  |  |  | |  |  |  |
| (AShtWuP) | Actual Shower Time Water Usage W/out Tub Spout Leak = | | | | | | |
|  | Asht \* ShFr = | | | |  | 9.10 | gal/shower |
|  |  |  |  | |  |  |  |
| (ShtWtrS) | Shower Time Water Savings = | | | | |  |  |
|  | AShtWuTslW - AShtWuP = | | |  |  | 4.68 | gal/shower |

**Total Shower Water Savings**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| (TShWtrS) | Total Shower Water Savings w/ Tub Spout Leak Weighted= | | | |  |
|  | StWtrS + BWtrS + ShtWtrS |  |  | 6.87 | gal/shower |

**Annual Single Family Water Savings**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| (SFMDW – 2.0 gpm) | Single Family Mixed Daily Water = | | | |  |  |
|  |  | | | | 24.90 | gal/day |
|  |  |  | |  |  |  |
| (SFSpD) | SF Showers per Day - Showerhead = | | | |  |  |
|  | SFMDW / (TShWuPr \* SFSh) = | | | | 0.72 | showers/day |
|  |  | |  |  |  |  |
| (SFWtrS) | SF Water Savings = | | | |  |  |
|  | TShWtrS \* SFSpD \* 365 days/year = | | | | 1806.95 | gal/year |

**Annual Multifamily Water Savings**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| (MFMDW – 2.0 gpm) | Multifamily Mixed Daily Water = | | |  |  |
|  |  | | | 20.75 | gal/day |
|  |  |  |  |  |  |
| (MFSpD) | MF Showers per Day - Showerhead = | | |  |  |
|  | MFMDW / (TShWuPr \* MFSh) = | | | 0.80 | showers/day |
|  |
| (MFWtrS) | MF Water Savings = | | |  |  |
|  | TShWtrS \* MFSpD \* 365 days/year = | | | 2017.62 | gal/year |

### 2.3.4 Convert Water to Energy Savings

**Water to Gas Savings**

The natural gas savings is equal to the energy required to raise the volume of water saved from ground water temperature to the water temperature at the showerhead. The values and equation used to make the conversion is shown below.

where,

* *Tout = 106 °F; Water Temp at Showerhead*
* *Tin = Climate Zone Specific; Cold Water Temperature*
* *REGas = 0.813; Recovery Efficiency*

**Water to Electric Savings**

The Electric savings (kWh) is equal to the energy required to raise the volume of water saved from ground water temperature to the water temperature at the showerhead. The power consumption (kW) is defined by the percentage of the daily hot water consumed during peak period.

where,

* *REElec = 0.98; Recovery Efficiency*

where,

* *Epp = 0.11; Percentage of daily DHW energy consumption during peak period*

# Section 3. Load Shapes

Load shapes are used for portfolio lifecycle cost analysis. A load shape indicates the distribution of a measure’s energy savings over one year. A load shape is a set of fractions summing to unity, with one fraction per hour (or other time period). Multiplying a savings value by the load shape value for any particular hour yields the energy savings for that particular hour.

The ideal load shape for net benefits estimates would represent the difference between the base case and measure case. The closest load shapes that are applicable to the measures in this Workpaper are listed in the table below.

1. Building Types and Load Shapes

|  |  |  |
| --- | --- | --- |
| **Building Type** | **Load Shape** | **E3 Alternate Building Type** |
| Residential Mobile Home - Double-Wide | Residential | HeatPump\_WtrHt-RC |
| Residential Multi-family | Residential | HeatPump\_WtrHt-RC |
| Residential Single Family | Residential | HeatPump\_WtrHt-RC |

# Section 4. Costs

## 4.1 Base Case Cost

Available DEER cost data for low flow showerheads comes from DEER 2008 and the 2010-2012 Measure Cost Study (MCS). MCS was used for labor/installation cost data, but since no GPM was listed for the showerhead a vendor cost study was performed for showerhead and tub spout cost. Cost data can be found in Attachment B.

1. Base Case Cost

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Measure Code** | **Product Description** | **Equipment Cost** | **Labor/ Installation Cost** | **Maintenance/ Other Cost** | **Total Base Case Cost** |
| ShwFLr005, ShwFLr006 | 2.0 GPM Showerhead | $38.62 | $15.67 |  | $54.29 |
| ShwFLr007, ShwFLr008 | 1.8 GPM Showerhead | $41.23 | $15.67 |  | $56.91 |
| ShwFLr005, ShwFLr006,  ShwFLr007, ShwFLr008 | 5.0 GPM Tub Spout with Diverter | $28.03 | $15.67 |  | $43.70 |
| ShwFLr005, ShwFLr006 | Showerhead and Tub Spout with Diverter | $66.65 | $31.34 |  | $97.99 |
| ShwFLr007, ShwFLr008 | Showerhead and Tub Spout with Diverter | $69.27 | $31.34 |  | $100.61 |

## 4.2 Measure Case Cost

There is no available cost data for this measure. Labor/installation cost was taken from discussion with contractors and equipment cost came from manufacturer.

1. Measure Case Cost

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Measure Code** | **Product Description** | **Equipment Cost** | **Labor/ Installation Cost** | **Maintenance/ Other Cost** | **Total Base Case Cost** |
| ShwFLr005, ShwFLr006,  ShwFLr007, ShwFLr008 | ADTS w/single-function 1.5 gpm Showerhead & All Quick Connect Mounts | $119.99 | $72.00 |  | $191.99 |

## 4.3 Full and Incremental Measure Cost

1. Full and Incremental Measure Cost Equations

|  |  |  |  |
| --- | --- | --- | --- |
| **Installation Type** | **Incremental Measure Cost** | **Full Measure Cost** | |
| **1st Baseline** | **2nd Baseline** |
| ROB | (MEC + MLC) – (BEC + BLC) | (MEC + MLC) – (BEC + BLC) | N/A |
| NEW/NC |
| RET/ER | (MEC + MLC) – (BEC + BLC) | MEC + MLC | (MEC + MLC) – (BEC + BLC) |
| REF | (MEC + MLC) – (BEC + BLC) | MEC + MLC | N/A |
| REA | MEC + MLC | MEC + MLC | N/A |

MEC = Measure Equipment Cost; MLC = Measure Labor Cost

BEC = Base Case Equipment Cost; BLC = Base Case Labor Cost

1. Full and Incremental Costs

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Measure Code** | **Installation Type** | **Incremental Measure Cost** | **Full Measure Cost** | |
| **1st Baseline** | **2nd Baseline** |
| ShwFLr005, ShwFLr006, | ROB/NC | $94.00 | $94.00 | N/A |
| ShwFLr007, ShwFLr008 | ER | $91.38 | $191.99 | $91.38 |

# Attachments

Attachment A – Tub Spout Calculations



Attachment B – Tub Spout and Showerhead Cost Data



# References

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1. Residential End Uses of Water (Mayer, 1999) [↑](#footnote-ref-1)
2. Disaggregating Residential Shower Warm-Up Waste (Sherman, 2014) [↑](#footnote-ref-2)
3. Leaking Shower Diverters (Taitem Engineering, 2011) [↑](#footnote-ref-3)
4. (Remote Ex-Ante Database Interface, 2015) [↑](#footnote-ref-4)
5. Tub Spout Flow-Reduction Systems Test (Hsia, 2015) [↑](#footnote-ref-5)
6. Water Appliance Amendments (California Energy Commision, 2016) [↑](#footnote-ref-6)
7. (Sherman, Auto-Diverting Tub Spout System with ShowerStart TSV, 2015) [↑](#footnote-ref-7)
8. SEU Survey Conducted by ASW (ASW, 2009) [↑](#footnote-ref-8)
9. Water Fixture Disposition (CPUC, 2013) [↑](#footnote-ref-9)
10. Residential Hot Water Distribution (Koeller & Klein, 2007) [↑](#footnote-ref-10)
11. Bathrooms (US Census, 2014) [↑](#footnote-ref-11)
12. The End Use of Hot Water in Single Family Homes from Flow Trace Analysis (Mayer & DeOreo, 2000) [↑](#footnote-ref-12)
13. (2013 Building Energy Efficiency Standards, 2013) [↑](#footnote-ref-13)
14. (California Energy Commission Appliance Efficiency Database, 2016) [↑](#footnote-ref-14)