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SERVICE & DOMESTIC HOT WATER

LOW-FLOW SHOWERHEAD, RESIDENTIAL

SWWH002-02

CONTENTS

MEASURE NAME

Low-Flow Showerhead or Flow Restriction Valves, Residential

STATEWIDE MEASURE ID

SWWH002-02

TECHNOLOGY SUMMARY

This measure is defined as a low-flow showerhead or a flow control valve (FCV) installed in a residential household. There are two types of low-flow showerheads:

> *Aerating showerheads* introduce air into the water flow, which produces an even, misty spray while maintaining sufficient water pressure.
> *Laminar- flow showerheads* split the flow of water into multiple parallel streams; no air is added. They produce less steam than aerating showerheads.

By reducing the flow rate, a low-flow showerhead will reduce the hot water use and result in both water and energy and savings.

Flow control valves act as a converging-diverging section with a throat in which the flow area is reduced to impede full flow while retaining pressure. The reduction in flow rate offsets the amount of hot water used, in effect the energy demand by the water heating source is reduced. A flow control valves operate and conserve energy in the same manner as a low-flow showerhead but is applied upstream from fixture point.

MEASURE CASE DESCRIPTION

The measure case technology is defined as reducing the pre-existing flow rate of a showerhead using a flow control valve or an efficient showerhead that replaces a base case showerhead head installed in a single family, multifamily, or mobile home household. Measure case flow rates for either the installation of an efficient showerhead or flow control valves are specified below. The measure offerings for the low-flow showerhead and flow-control valve (and therefore energy savings) vary by flow rate (gpm), as well as household type (single family, multifamily, or mobile home), climate zone, and installation type. Measure offerings are listed below.

Measure Offerings

Statewide Measure Offering ID	Measure Offering Description
SWWH002A	Efficient Showerhead, Gas, 1.0 gpm
SWWH002B	Efficient Showerhead, Gas, 1.25 gpm
SWWH002C	Efficient Showerhead, Gas, 1.5 gpm
SWWH002D	Efficient Showerhead, Gas, 1.6 gpm
SWWH002E	Efficient Showerhead, Gas, 1.7 gpm
SWWH002F	Efficient Showerhead, Gas, 1.0 gpm
SWWH002G	Efficient Showerhead, Gas, 1.25 gpm
SWWH002H	Efficient Showerhead, Gas, 1.5 gpm

Statewide Measure Offering ID	Measure Offering Description
SWWH002I	Efficient Showerhead, Gas, 1.6 gpm
SWWH002J	Efficient Showerhead, Gas, 1.7 gpm
SWWH002K	Efficient Showerhead, Electric, 1.0 gpm
SWWH002L	Efficient Showerhead, Electric, 1.25 gpm
SWWH002M	Efficient Showerhead, Electric, 1.5 gpm
SWWH002N	Efficient Showerhead, Electric, 1.6 gpm
SWWH002O	Efficient Showerhead, Electric, 1.7 gpm
SWWH002P	Efficient Showerhead, Electric, 1.0 gpm
SWWH002Q	Efficient Showerhead, Electric, 1.25 gpm
SWWH002R	Efficient Showerhead, Electric, 1.5 gpm
SWWH002S	Efficient Showerhead, Electric, 1.6 gpm
SWWH002T	Efficient Showerhead, Electric, 1.7 gpm
SWWH002U	Efficient Flow Control Valves, Gas, 1.0 gpm
SWWH002V	Efficient Flow Control Valves, Gas, 1.25 gpm
SWWH002W	Efficient Flow Control Valves, Gas, 1.5 gpm
SWWH002X	Efficient Flow Control Valves, Gas, 1.6 gpm
SWWH002Y	Efficient Flow Control Valves, Gas, 1.7 gpm
SWWH002Z	Efficient Flow Control Valves, Electric, 1.0 gpm
SWWH002AA	Efficient Flow Control Valves, Electric, 1.25 gpm
SWWH002AB	Efficient Flow Control Valves, Electric, 1.5 gpm
SWWH002AC	Efficient Flow Control Valves, Electric, 1.6 gpm
SWWH002AD	Efficient Flow Control Valves, Electric, 1.7 gpm

BASE CASE DESCRIPTION

The base case of a *normal replacement or new construction installation* is defined as a low-flow showerhead that meets the maximum flow rate requirements of the California Appliance Efficiency Regulations (Title 20), effective July 1, 2018.[1]

The base case of an *accelerated replacement installation* was derived from a residential field survey in Southern California that measured existing showerhead flow rates.

Base Case Specification

Installation Type	Max. Flow Rate (gpm)	Source
Normal replacement (code)	1.80	California Energy Commission (CEC). 2014. *2014 Appliance Efficiency Regulations.* CEC-400-2014-009-CMF.

[1] California Energy Commission (CEC). 2017. *2016 Appliance Efficiency Regulations.* CEC-400-2017-002. Section 1605.3, Table H-5.

Installation Type	Max. Flow Rate (gpm)	Source
Accelerated replacement – 1st baseline (existing condition)	2.25	Sempra Energy Utilities (SEU). 2012. "SEU 2009 ASW Data REDACTED.xlsx".
Accelerated replacement – 2nd baseline (code)	1.80	California Energy Commission (CEC). 2014. *2014 Appliance Efficiency Regulations.* CEC-400-2014-009-CMF.
Add-On Equipment (Existing Condition)	2.25	Sempra Energy Utilities (SEU). 2012. "SEU 2009 ASW Data REDACTED.xlsx".

CODE REQUIREMENTS

Applicable state and federal codes and standards for showerheads are specified below. The low-flow showerhead maximum flow rate was originally mandated by the Energy Policy Act of 1992.[2] The California Appliance Efficiency Regulations (Title 20)[3] effective in 1994 met the federal code and have exceeded it in subsequent updates.

Applicable State and Federal Codes and Standards

Code	Applicable Code Reference	Effective Date
CA Appliance Efficiency Regulations – Title 20 (2016)	Section 1605.3, Table H-5: The maximum flow rate of a showerhead shall not exceed 2.5 gpm at 80 psi.	Units manufactured on or after January 1, 1994 and prior to July 1, 2016.
	Section 1605.3, Table H-5: The maximum flow rate of a showerhead shall not exceed 2.0 gpm at 80 psi.	Units manufactured on or after July 1, 2016 and prior to July 1, 2018.
	Section 1605.3, Table H-5: The maximum flow rate of a showerhead shall not exceed 1.8 gpm at 80 psi.	Effective January 1, 2016 Units manufactured on or after July 1, 2018.
CA Building Energy Efficiency Standards – Title 24	None	n/a
Federal Standards - Energy Policy Act of 1992	Requires that showerheads must use no more than 2.5 gpm at 80 psi.	1992

A disposition issued by the Energy Division of the California Public Utilities Commission in 2013[4] mandated the revision of daily hot water consumption to a baseline of 28.0 gallons per day for a single-

[2] H.R.776 – 102nd Congress. Energy Policy Act of 1992. Pub. L. 102-486. Stat. 2776.

[3] California Energy Commission (CEC). 2014. *2014 Appliance Efficiency Regulations.* CEC-400-2014-009-CMF. Section 1605.3.

[4] California Public Utilities Commission (CPUC), Energy Division. 2013. "Workpaper Disposition for Water Fixtures." February 22.

family home and 23.3 gallons per day for a multifamily dwelling. These baselines are based upon the National Renewable Energy Laboratory (NREL) Building America House Simulation Protocols.[5]

NORMALIZING UNIT

Each.

PROGRAM REQUIREMENTS

Measure Implementation Eligibility

All combinations of measure application type, delivery type, and sector that are established for this measure are specified below. Measure application type is a categorization based on the circumstances and timing of the measure installation; each measure application type is distinguished by its baseline determination, cost basis, eligibility, and documentation requirements. Delivery type is the broad categorization of the delivery channel through which the market intervention strategy (financial incentives or other services) is targeted. This table also designates the broad market sector(s) that are applicable for this measure.

Note that some of the implementation combinations below may not be allowed for some measure offerings by all program administrators.

Implementation Eligibility

Measure Application Type	Delivery Type	Sector
Accelerated replacement	DnDeemDI	Res
Normal replacement	DnDeemDI	Res
Normal replacement	UpDeemed	Res
Normal replacement	DnDeemed	Res
New construction	DnDeemDI	Res
New construction	UpDeemed	Res
New construction	DnDeemed	Res
Add-on equipment	DnDeemDI	Res
Add-on equipment	DnDeemDI	Res
Add-on equipment	UpDeemed	Res

For *accelerated replacement* application types, this measure adopts the program-level "Preponderance of Evidence Assessment" described in Version 2.0 of the Accelerated Replacement Using Preponderance of Evidence report developed by the utilities and stakeholders to provide guidance for the California

[5] Henron, H. and C. Engebrecht. 2010. *Building America House Simulation Protocols.* Prepared for the U.S. Department of Energy Building Technologies Program. Golden, CO: National Renewable Energy Laboratory (NREL). NREL Report Number TP-550-49426.

programs ("POEV 2.0", see Section 7).[6]. "Continued viability" and "program influence" must be demonstrated as the evidence of accelerated replacement.

To demonstrate the *viability* of the pre-existing system or to show that the program is replacing equipment that is "installed and operating," the customer must be approached by a direct install implementer. Additionally, the program must obtain and provide additional documentation, including (but not limited to) the following:

- Targeted segment of the market or customers
- Customer/site information
- Make/model of pre-existing equipment and/or
- Performance/flowrate measurements of pre-existing equipment, and/or
- Photograph of pre-existing equipment in place and operating

Specific documentation requirements will be determined by the program administrator and will be specified in the program implementation plan.

Program influence evidence can be demonstrated through one of the three alternatives listed in Section 7.3 of POEV 2.0. This measure establishes the program-level evidence of program influence by adopting the net-to-gross (NTG) ratio from prior program evaluation results.

Eligible Products

The low-flow showerhead or flow control valve must meet the specification in the Measure Case Description.

Eligible Building Types

This measure is applicable in all existing California residential households of any vintage, including single-family, multifamily, and mobile homes.

Eligible Climate Zones

The measure is applicable in all California climate zones.

PROGRAM EXCLUSIONS

None.

[6] Track 1 Working Group. 2016. *Accelerated Replacement Using Preponderance of Evidence. Version 2.0.* December 7.

DATA COLLECTION REQUIREMENTS

Data collection requirements are to be determined.

USE CATEGORY

Service & Domestic Hot Water

ELECTRIC SAVINGS (kWh)

The electric unit energy savings (UES) from the installation of a low-flow showerhead or a flow-control valve is determined by the reduction of hot water usage and the reduction in energy consumption required to heat water for showers.

The electric UES is derived from the gas UES, the ratio of the recovery efficiency of a gas water heater to that an electric water heater, and a therm-to-kWh conversion factor. Refer to the Gas Savings section for the derivation of the gas UES. All other inputs used for this calculation are presented in the following table.

$$UES_{kWh} = UES_{therms} \times \frac{EFF_{gas}}{EFF_{elec}} \times \frac{100{,}000\ BTU}{therm} \times \frac{kWh}{3{,}413\ BTU}$$

$UES_{kWh} =$ *Annual electric unit energy savings (kWh/yr)*
$UES_{therms} =$ *Annual gas unit energy savings (therms/yr)*
$EFF_{gas} =$ *Min. water heater efficiency (recovery efficiency), gas*
$EFF_{elec} =$ *Min. water heater efficiency (recovery efficiency), electric*

Electric UES Inputs

Energy Savings Inputs / Constants	Value	Source
Gas Unit Energy Savings (therms/yr)	Varies by CZ	See Gas Savings section.
Gas Water Heater Min. Efficiency (recovery efficiency)	0.77	Southern California Gas Company (SCG). 2010. “Gas Fired Storage Water Heater Extract from CEC Appliance Data 07.07.2010.xlsx.” California Public Utilities Commission (CPUC), Energy Division. 2010. *Non-DEER Measure Review Template: PGECODHW113 – Low Flow Showerhead and Thermostatic Shower Restriction Valve.* April 27.
Electric Water Heater Min. Efficiency (recovery efficiency, RE)	0.98	California Energy Commission (CEC). 2014. *2014 Appliance Efficiency Regulations.* CEC-400-2014-009-CMF. Section 1604.

Recovery Efficiency: To convert the water heating load to electric energy use at the water heater, the recovery efficiency (RE) is used. Recovery efficiency is a measure of how efficiently the heat from the energy source is transferred to the water (the ratio of energy output used to heat the water divided by energy input).

PEAK ELECTRIC DEMAND REDUCTION (kW)

Peak electrical demand reduction calculation is a function of the electric unit energy savings (UES), a peak period usage factor, and the operating hours per year. The peak period usage factor (PPUF) – similar in concept to a coincident demand factor (CDF) – reflects the percent of hot water usage during the designated peak demand period.

$$kW_{reduction} = \frac{UES_{kWh} \times PPUF}{(DAYS \times PEAKHRS)}$$

$UES_{kWh} =$	*Annual electric unit energy savings (kWh/yr)*
$PPUF =$	*Peak period usage factor*
$DAYS =$	*Operating days per year (days)*
$PEAKHRS =$	*Peak hours per day*

Peak Demand Reduction Parameters

Parameter	Value	Source
Peak Period Usage Factor (PPUF)	0.37	Southern California Edison (SCE). 2019. "Water Heater - Electric Peak Usage Factor adjustment to new TOU.xlsx"
Operating days per year (days)	365	Professional judgement
Peak hours per day (hours)	5	California Public Utilities Commission (CPUC). 2018. *Resolution E-4952*. October 11. Op 1.

GAS SAVINGS (THERMS)

The gas unit energy savings (UES) of this measure is based upon the estimated decrease in hot water usage as a result of the installation of a low-flow showerhead or flow control valve. The calculation of water savings and gas energy savings are explained below.

Calculation of Water Usage and Water Savings

The calculation of water savings due to the installation of a low-flow showerhead or flow control valve is represented below. Annual water savings is calculated as the difference between the estimated base case and measure case annual water usage.

Annual water usage is a function of flow rate (gpm), the average duration of each shower, the average number of showers taken per day per household, and the average number of showerheads per household. This calculation also includes a throttling factor which is a constant that represents the assumed actual water pressure as a portion of full pressure (80 psi). The annual water use calculation also includes a normalization factor, which adjusts the estimated water consumption to account for a change in the baseline hot water consumption as per a Water Fixture Disposition issued by the Energy Division of the California Public Utilities Commission (CPUC) in 2013.[7]

The inputs to calculate base case and measure case water usage are provided in following tables. Note that this measure is applicable for single family, multifamily, and mobile home installations. Due to lack of

[7] California Public Utilities Commission (CPUC), Energy Division. 2013. "Workpaper Disposition for Water Fixtures." February 22.

data on mobile home water usage, particularly at the fixture type level (showerhead, faucet), the mobile home water usage and savings calculations adopt the more conservative multifamily values.

$$WS = WU_{base} - WU_{measure}$$

$$WU = \frac{FlowRate \times F \times Min \times Days \times QShwr}{N} \times G$$

WS =	*Annual water savings (gal/year)*
WU=	*Annual water use (gal/year), for base or measure case*
FlowRate =	*Showerhead water flow rate (gpm) for base or measure case fixtures*
F =	*Throttling factor (%)*
Min =	*Average shower time (min/day)*
QShwr =	*Number of showers per household per day*
Days =	*Shower days of operation (days/year)*
N =	*Number of showerheads per household, SF or MF*
G =	*Normalizing factor*

Base Case Water Usage Inputs

Parameter	Single Family	Multi-family / Mobile Home	Source
Base Case Flow Rate (gpm) – normal replacement, new construction	1.80	1.80	California Energy Commission (CEC). 2014. *2014 Appliance Efficiency Regulations.* CEC-400-2014-009-CMF.
Base Case Flow Rate (gpm) – accelerated replacement, add-on equipment	2.25	2.25	Sempra Energy Utilities (SEU). 2012. "SEU 2009 ASW Data REDACTED.xlsx".
Average Shower Time (min/shower)	7.4	7.4	DeOreo, W., P. Mayer, and D. Lewis. 2000. *Seattle Home Water Conservation Study: The Impacts Of High Efficiency Plumbing Fixture Retrofits In Single-Family Homes.* Prepared for the Seattle Public Utilities and the U.S. Environmental Protection Agency. Boulder, CO: Aquacraft, Inc. Water Engineering and Management.
Avg. # of Showers Taken per Day Per Household (showers/day/hh)	2.79	2.22	Single Family: Sempra Energy Utilities (SEU). 2012. "SEU 2009 ASW Data REDACTED.xlsx". Multifamily: KEMA-XENERGY, Itron, and RoperASW. 2004. *California Statewide Residential Appliance Saturation Study*. Prepared for the California Energy Commission. Contract No. 400-04-009. PG&E Banner Subset, Pages 100 and 102.
Avg. # of Showerheads per Household (showerheads/hh)	2.01	1.50	Single Family: Sempra Energy Utilities (SEU). 2012. "SEU 2009 ASW Data REDACTED.xlsx". Multifamily: U.S. Census Bureau. (n.d.). "U.S. 2000 Census Bathrooms in NC MF Units.xls."
Throttling Factor (%)	90%	90%	Biermayer, P. 2006. *Potential Water and Energy Savings from Showerheads.* Ernest Orlando Lawrence Berkeley National Laboratory,

Parameter	Single Family	Multi-family / Mobile Home	Source
			Environmental Energy Technologies Division. Contract No. DE-AC02-05CH11231. P. 6.
Operating Days (days/year)	365	365	Professional judgement.
Normalization Factor	0.670	0.702	See below.

Measure Case Water Usage Inputs – Single Family

Parameter	Single Family					Source
Measure Case Flow Rate (gpm)	1.00	1.25	1.50	1.60	1.70	-
Average Shower Time (min/shower)	7.4	7.4	7.4	7.4	7.4	See below.
Avg. # of Showers Taken per Day Per Household (showers/day/hh)	2.79	2.79	2.79	2.79	2.79	See below.
Avg. # of Showerheads per Household(showerheads/hh)	2.01	2.01	2.01	2.01	2.01	See below.
Throttling Factor (%)	90%	90%	90%	90%	90%	See below.
Operating Days (days/year)	365	365	365	365	365	Professional judgement.
Normalization Factor	0.670	0.670	0.670	0.670	0.670	See below.

Measure Case Water Usage Parameters – Multifamily / Mobile Home

Parameter	Multifamily / Mobile Home					Source
Measure Case Flow Rate (gpm)	1.00	1.25	1.50	1.60	1.70	-
Average Shower Time (min/shower)	7.4	7.4	7.4	7.4	7.4	See below.
Avg. # of Showers Taken per Day Per Household (showers/day/hh)	2.22	2.22	2.22	2.22	2.22	See below.
Avg. # of Showerheads per Household (showerheads/hh)	1.50	1.50	1.50	1.50	1.50	See below.
Throttling Factor (%)	90%	90%	90%	90%	90%	See below.
Operating Days (days/year)	365	365	365	365	365	Professional judgement.
Normalization Factor	0.702	0.702	0.702	0.702	0.702	See below.

Base Case Showerhead Flow Rate: The baseline for normal replacement (NR) showerhead installations have a single baseline flow rate that complies with the Title 20 code effective on July 1, 2016. For accelerated replacement and add-on equipment installations, the first baseline flow rate was derived as the average of measured existing showerhead flow rates from a residential field survey in Southern California. The second baseline for *accelerated replacement* installations complies with the Title 20 flow regulations effective on July 1, 2018.

Measure Case Showerhead Flow Rate: The mixed water flow rate for each measure case showerhead used in the water saving calculation.

Average Shower Time per Day: Shower duration was derived from water trace data from ten single family homes in Seattle in 1999. A study of residential end use of water conducted for the AWWA Research

Foundation found a similar result.[8] Note that the average shower time in minutes per day is fixed and varies only by housing type. The assumption that the minutes per day a showerhead is used does not change between the base case and measure case scenarios means that a reduction in the showerhead flow rate will reduce water usage.

Average Number of Showers per Day: The average number of showers per day per single-family household was derived from the 2009 residential water fixture field study conducted in Southern California. The average number of showers per day per multifamily household was derived from the 2004 California Residential Appliance Saturation Study survey data.

Number of Showerheads per Household: The average number of showerheads per single-family household was derived from the 2009 residential water fixture field study conducted in Southern California. The average number of showerheads per multifamily household was calculated from U.S. Census 2000 data as the weighted average of the number of bathrooms in new construction homes the West Region from 1978 to 2006. This calculation assumes that each bathroom contains a shower or bath with one showerhead.

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

Normalization Factor: The 2013 "Water Fixture Disposition" adopted the assumptions for baseline daily hot water (DHW) usage in the Database for Energy Efficient Resources (DEER). As per the 2013 Water Fixture Disposition, the "DEER values for daily hot water use by end use are developed by NREL for the Building America House Simulation Protocols" (p.3). The NREL baselines standardize the daily shower hot water usage for replace-on-burnout (ROB) and early retirement (ER) measure installations to 28.01 and 23.3 gallons per day for single and multifamily, respectively.

The purpose of the normalization factor is to account for this change in assumed daily hot water baseline water usage from the daily usage derived from the residential field study to the usage adopted for DEER from the NREL study. The normalization factor shown below was calculated as the ratio of daily hot water consumption derived from the NREL study to the daily hot water consumption calculated from the 2009 field study. The inputs for this calculation are provided in the following table.

$$G = \frac{WU_{day\ DEER/NREL}}{WU_{day\ field\ study}}$$

[8] Mayer, P. and W. DeOreo. 1999. *Residential End Uses of Water 1999, Subject Area: Water Resources.* Denver, CO: American Water Works Association (AWWA) Research Foundation. Page 99.

Normalization Factor Inputs

Parameter	Single Family	Multifamily / Mobile Home	Source
Shower gpd/household (DEER assumption/NREL)	28.01	23.34	Henron, H. and C. Engebrecht. 2010. *Building America House Simulation Protocols.* Prepared for the U.S. Department of Energy Building Technologies Program. Golden, CO: National Renewable Energy Laboratory (NREL). NREL Report Number TP-550-49426. California Public Utilities Commission (CPUC), Energy Division. 2013. "Workpaper Disposition for Water Fixtures." February 22.
Shower gpd/household	48.81	33.27	Sempra Energy Utilities (SEU). 2012. "SEU 2009 ASW Data REDACTED.xlsx".

Calculation of Gas Unit Energy Savings

The gas UES is based upon the estimated decrease in hot water usage as a result of the installation of a low-flow showerhead or flow control valve.

$$UES_{therms} = \left[\frac{WS \times Cp \times WaterWeight \times \left(\frac{1\ therm}{100{,}000\ Btu}\right)(T_{mixed} - T_{ground})}{EFF_{gas}}\right]$$

$UES_{therms} =$	*Annual gas unit energy savings (therms/year)*
$WS =$	*Water savings*
$Cp =$	*Specific heat capacity of water (Btu/lb/°F), fixed constant*
$WaterWeight =$	*Weight of water (lb/gal), fixed constant*
$T_{mixed} =$	*Mixed water temperature, at faucet (°F)*
$T_{ground} =$	*Make-up groundwater temperature, (°F)*
$EFF_{gas} =$	*Water heater efficiency, gas (recovery efficiency)*

The inputs and assumptions used in these equations are specified below. Refer to the Electric Savings section for explanation of the fuel-neutral inputs. Additional explanation of the inputs that are specific only to natural gas follows.

Gas UES Inputs

Parameter	Value	Source
Specific Heat Capacity of Water (Btu/lb/°F)	1	Fixed constant
Water Weight (lb/gal)	8.34	Fixed constant
Average Make-up (Groundwater) Water Temperature (°F)	Varies by climate zone.	See below.
Mixed Water Temperature @ Faucet (°F)	106	Sempra Energy Utilities (SEU). 2012. "SEU 2009 ASW Data REDACTED.xlsx".

Parameter	Value	Source
Gas Water Heater Min. Efficiency (recovery efficiency)	0.77	Southern California Gas Company (SCG). 2010. "Gas Fired Storage Water Heater Extract from CEC Appliance Data 07.07.2010.xlsx." California Public Utilities Commission (CPUC), Energy Division. 2010. *Non-DEER Measure Review Template: PGECODHW113 – Low Flow Showerhead and Thermostatic Shower Restriction Valve.* April 27.

Groundwater Temperature: The ground water temperature is a key factor in determining the amount of hot water that is needed to achieve a mixed water temperature of 106 °F, which is a typical mixed-water temperature exiting the showerhead. To reflect differences across climate zones, this analysis includes the average groundwater temperature for each California climate zone, developed from California climate zone weather data. Specifically, the groundwater temperatures used for this analysis are based upon the weather files adopted for the 2013 update of the California Building Efficiency Standards. The average ground water temperatures utilized in this analysis are provided below.

Make-up (Groundwater) Water Temperatures by Climate Zone

Climate Zone	Make-up (Groundwater) Temperature (°F)	Source
CZ 1	51.4	Reeves, P. (Consultant to California Public Utilities Commission, Energy Division). 2013. "Comparison-of-Ground-Temperatures-v2_byPaulReeves.xlsx."
CZ 2	57.3	
CZ 3	57.1	
CZ 4	59.5	
CZ 5	55.8	
CZ 6	61.8	
CZ 7	62.6	
CZ 8	63.7	
CZ 9	63.8	
CZ 10	64.2	
CZ 11	63.2	
CZ 12	60.9	
CZ 13	64.1	
CZ 14	62.7	
CZ 15	75.5	
CZ 16	51.8	

Mixed Water Temperature at Showerhead Outlet: For low-flow showerheads, the outlet water heater temperature was derived from the Sempra Energy Utilities (San Diego Gas and Electric and the Southern California Gas Company) 2009 field survey data. The mixed water temperature reflects that hot water does not comprise the entire shower flow and the tempering of the hot water with cold water to establish full shower flow.

Recovery Efficiency: To convert the water heating load to gas energy use at the water heater, the recovery efficiency (RE) is used. Recovery efficiency is a measure of how efficiently the heat from the energy source is transferred to the water (the ratio of energy output used to heat the water divided by energy input). A weighted RE value was derived from the natural-gas fired, storage-type water heaters extracted from the California Energy Commission database of certified equipment (without limit to the listed equipment energy factor, EF). RE was subsequently stipulated by the Energy Division of the CPUC.[9]

LIFE CYCLE

Effective Useful Life (EUL) is an estimate of the median number of years that a measure installed through a program is still in place and operable. Remaining Useful Life (RUL) is an estimate of the median number of years that a technology or piece of equipment replaced or altered by an energy efficiency program would have remained in service and operational had the program intervention not caused the replacement or alteration.

The methodology to calculate the RUL conforms with Version 5 of the Energy Efficiency Policy Manual, which recommends “one-third of the effective useful life in DEER as the remaining useful life until further study results are available to establish more accurate values.”[10] This approach provides a reasonable RUL estimate without the requiring any a priori knowledge about the age of the equipment being replaced.[11] Further, as per Resolution E-4807, the California Public Utilities Commission (CPUC) revised add-on equipment measures so that the EUL of the measure is equal to the lower of the RUL of the modified system or equipment or the EUL of the add-on component.” [12]

The EUL and RUL adopted for this measure are specified below. For a *normal replacement* installation, only the EUL is applicable. For *accelerated replacement and add-on equipment* installations, the first period savings utilizes the RUL period of one-third of the EUL. The second period savings for accelerated replacement utilizes the (EUL minus RUL) value.

Effective Useful Life and Remaining Useful Life

Type	Gas	Electric	Source
Single Baseline for Normal Replacement / New Construction			California Public Utilities Commission (CPUC). 2014. “DEER2014-EUL-table-update_2014-02-05.xlsx.”
EUL	10.00	10.00	
RUL	n/a	n/a	
Dual Baseline for Accelerated Replacement			California Public Utilities Commission (CPUC), Energy Division. 2013. *Energy Efficiency Policy Manual Version 5*. Page 32.
RUL =1/3 EUL	3.33	3.33	
EUL minus RUL	6.67	6.67	

[9] California Public Utilities Commission (CPUC), Energy Division. 2013. “Workpaper Disposition for Water Fixtures.” February 22.

[10] California Public Utilities Commission (CPUC), Energy Division. 2013. *Energy Efficiency Policy Manual Version 5*. Page 32.

[11] KEMA, Inc. 2008. "Summary of EUL-RUL Analysis for the April 2008 Update to DEER." Memorandum submitted to Itron, Inc.

[12] California Public Utilities Commission (CPUC). 2016. *Resolution E-4807.* December 16. Page 13.

BASE CASE MATERIAL COST ($/UNIT)

Base case material costs for *normal replacement* and *new construction installations* were developed from the revised measure costs summary for the Database of Energy Efficient Resources (DEER).[13]

Base case material costs for *accelerated replacement and add-on equipment installations* are equal to $0 in the first baseline period. Material cost for the second baseline period for *accelerated replacement* were drawn from the 2010-2012 Ex Ante Measure Cost Study conducted by Itron, Inc.[14]

MEASURE CASE MATERIAL COST ($/UNIT)

The measure case material cost of a low-flow showerhead for *all installation types* was drawn from the 2010-2012 Ex Ante Measure Cost Study conducted by Itron, Inc.[15] The resultant cost was derived from unit price data from contractors that provided direct installation services to the California IOUs during the 2010-2012 and 2013-2014 program cycles. The study validated the direct installation program prices against data obtained from RSMeans, Grainger, and Home Depot.

The measure case material cost of all flow control valve flow rates and all installation types were drawn from their original workpapers from SoCalGas, WPSCGCCWH180504A-R0. The cost from these workpapers stem from research done through existing distributors and manufacturers.

BASE CASE LABOR COST ($/UNIT)

Base case labor costs for *normal replacement* and *new construction installations* were developed from the revised measure costs summary for the Database of Energy Efficient Resources (DEER).[16]

Base case labor costs for *accelerated replacement and add-on equipment installations* are equal to $0 in the first baseline period. The labor cost for the second baseline period for accelerated replacement were drawn from the 2010-2012 Ex Ante Measure Cost Study conducted by Itron, Inc.[17]

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[13] California Public Utilities Commission (CPUC), Energy Division. 2008. "Revised DEER Measure Cost Summary (05_30_2008) Revised (06_02_2008).xlsx." See Res - Shwrhd & Aerators tab.

[14] Itron, Inc. 2014. *2010-2012 WO017 Ex Ante Measure Cost Study Final Report.* Prepared for the California Public Utilities Commission. Table 3-23.

[15] Itron, Inc. 2014. *2010-2012 WO017 Ex Ante Measure Cost Study Final Report.* Prepared for the California Public Utilities Commission. Table 3-23.

[16] California Public Utilities Commission (CPUC), Energy Division. 2008. "Revised DEER Measure Cost Summary (05_30_2008) Revised (06_02_2008).xlsx." See Res - Shwrhd & Aerators tab.

[17] Itron, Inc. 2014. *2010-2012 WO017 Ex Ante Measure Cost Study Final Report.* Prepared for the California Public Utilities Commission. Table 3-23.

MEASURE CASE LABOR COST ($/UNIT)

The labor cost for the installation of a low-flow showerhead and flow control valves for *all installation types* was drawn from the 2010-2012 Ex Ante Measure Cost Study conducted by Itron, Inc.[18] The resultant cost was derived from labor costs obtained from contractors that provided direct installation services to the California IOUs during the 2010-2012 and 2013-2014 program cycles. The study validated the direct installation program prices against data obtained from RSMeans, Grainger, and Home Depot.

NET-TO-GROSS (NTG)

The net-to-gross (NTG) ratio represents the portion of gross impacts that are determined to be directly attributed to a specific program intervention The NTG ratio for direct installations was specified in the Workpaper Disposition for Water Fixtures disposition issued by the Energy Division of the California Public Utilities Commission (CPUC) in 2013. The NTG ratio for all other delivery channels is based upon the average of all NTG ratios for all evaluated 2006 – 2008 residential programs, as documented in the 2011 DEER Update Study conducted by Itron, Inc. This sector average NTG ("default NTG") is applicable to all energy efficiency measures that have been offered through residential sector programs for more than two years and for which impact evaluation results are not available.

Net-to-Gross Ratios

Parameter	Electric	Gas	Source
NTG – Residential, direct install	0.70	0.70	California Public Utilities Commission (CPUC), Energy Division. 2013. "Workpaper Disposition for Water Fixtures." February 22. Page 6. California Public Utilities Commission (CPUC), Energy Division. 2013. "2013-2014_DHWFixtureMeasures_Disposition-1March2013.xls." February 22. See ED_NTG tab.
NTG – Residential default, non-direct install	0.55	0.55	California Public Utilities Commission (CPUC), Energy Division. 2013. "Workpaper Disposition for Water Fixtures." February 22. Page 6. Itron, Inc. 2011. *DEER Database 2011 Update Documentation.* Prepared for the California Public Utilities Commission. Page 15-4 Table 15-3.

[18] Itron, Inc. 2014. *2010-2012 WO017 Ex Ante Measure Cost Study Final Report.* Prepared for the California Public Utilities Commission. Table 4-15.

GROSS SAVINGS INSTALLATION ADJUSTMENT (GSIA)

The gross savings installation adjustment (GSIA) rate represents the ratio of the number of verified installations of the measure to the number of claimed installations reported by the utility. This factor varies by end use, sector, technology, application, and delivery method. This GSIA value complies with the Workpaper Disposition for Water Fixtures disposition issued by the Energy Division of the California Public Utilities Commission (CPUC) in 2013 and was derived as the gross savings weighted installation rate reported in the 2006-2008 Residential Retrofit impact evaluation report.

Gross Savings Installation Adjustment Rates

Parameter	Electric	Gas	Source
GSIA	0.737	0.737	California Public Utilities Commission (CPUC), Energy Division. 2013. "2013-2014_DHWFixtureMeasures_Disposition-1March2013.xls." February 22. See ED_IR tab. The Cadmus Group, Inc. 2010. *Residential Retrofit High Impact Measure Evaluation Report.* Prepared for the California Public Utilities Commission Energy Division.

NON-ENERGY IMPACTS

Non-energy impacts that result from the installation of a low-flow showerhead or flow-control valve is the reduction of water usage. Insofar as energy savings is a function of water savings, the calculation of water savings is explained in the Gas Savings section.

DEER DIFFERENCES ANALYSIS

This section provides a summary of DEER-based inputs and methods, and the rationale for inputs and methods that are not DEER-based.

DEER Difference Summary

DEER Item	Comment / Used for Workpaper
Modified DEER methodology	No
Scaled DEER measure	No
DEER Base Case	No
DEER Measure Case	No
DEER Building Types	No
DEER Operating Hours	No
DEER eQUEST Prototypes	No
DEER Version	n/a
Reason for Deviation from DEER	DEER contained similar measures which have since been removed.
DEER Measure IDs Used	DEER does not contain this type of measure.
NTG	Source: DEER and 2013 CPUC Water Fixture Disposition. The value of 0.70 is associated with NTG ID: *Res-sAll-mDHWshwr,* the value of 0.55 is associated with NTG ID: *Res-Default>2*
GSIA	Source: DEER. The value of 0.737 is associated with GSIA ID: *Res-LowF-SH-All*
EUL/RUL	Source: DEER. The value of 10 years is associated with EUL ID *Wtr-WH-Shrhd.*

REVISION HISTORY

Measure Characterization Revision History

Revision Number	Revision Complete Date	Primary Author, Title, Organization	Revision Summary and Rationale for Revision Effective Date and Approved By
01	03/31/2018	Jennifer Holmes Cal TF Staff	Draft of consolidated text for this statewide measure is based upon: SCGWP100303A Revision 4 (April 22, 2016) Consensus reached among Cal TF members.
	01/30/2019	Jennifer Holmes, Cal TF Staff	Revisions for submittal of version 01.
02	06/11/2019	Matthew Mendoza, SoCalGas Jennifer Holmes, Cal TF Staff	Addition of measures for flow control valves (FCV) placed on showerheads Revisions for submittal of version 02
	03/30/2021	Soe K Hla PG&E	Adopted all remaining measures for PG&E Fixed the incorrect ElecImpactProfile ID NTG adjustment factor is removed from NTG section per DEER Resolution E-5009.