Work Paper PGECODHW125
Showerheads, Thermostatic Control Valves and Aerators
Revision # 0

Pacific Gas & Electric Company

Customer Energy Solutions

Low Flow Showerheads and Aerators

Measure Codes:

Faucet Aerators 3P Measure Codes: S530, S531, S235, S236, S237, S238
Moderate Income Direct Install (MIDI) Measure Codes: 0S00, 0S01 (GP and some 3P programs)

Low Flow Showerheads 3P Measure Codes: H803, H804, G8, G11, G13, G14
MIDI Measure Codes: 0S02, 0S03

May 19, 2014

At-a-Glance Summary

Applicable Measure Codes:	S530 0S01	S531 0S00	S235	S236	S237	S238
Measure Description:	Faucet Aerator 0.5GPM (Electric WH)	Faucet Aerator 0.5GPM (Gas WH)	Faucet Aerator 1.0GPM (Electric WH)	Faucet Aerator 1.0GPM (Gas WH)	Faucet Aerator 1.5GPM (Electric WH)	Faucet Aerator 1.5Gpm (Gas WH)
Energy Impact Common Units:	Each					
Base Case Description:	Source: DEER 2011 No Aerator					
Base Case Energy Consumption:	Source: DEER11, 2.2GPM					
Measure Energy Consumption:	Source: DEER2011, ED Disposition for 13-14					
Energy Savings (Base Case – Measure):	Source: ED Dispositon 27kWh MFM to 46 kWh SFM	Source ED Disposition 2.0 TH SFM to 1.2 TH MFM	Source: ED Disposition 34kWh SFM to 20 kWh MFM	Source ED Disposition 1.5 TH SFM to 0.9 TH MFM	Source ED Disposition 22 kWh SFM to 13kWh MFM	Source ED Disposition 0.6 TH MFM to 1.0 TH SFM
Costs Common Units:	$ / aerator					
Base Case Equipment Cost ($/unit):	Source: DEER; no aerator $0					
Measure Equipment Cost ($/unit):	Source DEER; $6.54					
Gross Measure Cost ($/unit)	Source: DEER; $13.24					
Measure Incremental Cost ($/unit):	Source: DEER; $13.24					
Effective Useful Life (yr):	Source: DEER; 10 years					
Measure Application Type:	ROB					
Net-to-Gross Ratios:	Source: DEER2014 SFM=0.59 MFM=0.65					

Applicable Measure Codes:	G8	G13	G11 / 0S02	G14 / 0S03	H803	H804
Measure Description:	Low Flow Showerhead (1.6 GPM Gas WH)	Low Flow Showerhead (1.6 GPM Electric WH)	Low Flow Showerhead Thermostatic Control Valve(1.6 GPM Gas WH)	Low Flow Showerhead Thermostatic Control Valve (1.6 GPM Electric WH)	Low Flow Showerhead (2.0 GPM Electric WH)	Low Flow Showerhead (2.0 GPM Gas WH)
Energy Impact Common Units:	Each					
Base Case Description:	Source: PG&E Calculations 2.5 GPM					
Base Case Energy Consumption:	Source: DEER11, 2.5GPM					
Measure Energy Consumption:	Source: PGE Calculations	Source: PGE Calculations	Source: PGE Calculations	Source: PGE Calculations	Source: DEER2011	Source: DEER2011
Energy Savings (Base Case – Measure):	Source: ED Dispositon 6.5 TH SFM to 7.3 TH MFM	Source ED Disposition 118kWh SFM to 196 kWh MFM	Source: ED Disposition 9.6 TH SFM to10.6 TH MFM	Source ED Disposition 119kWh SFM to 198kWh MFM	Source ED Disposition 64kWh MFM to 124 kWh SFM	Source ED Disposition 7.1 TH MFM to 7.6 TH SFM
Costs Common Units:	$ / showerhead					
Base Case Equipment Cost ($/unit):	Source: DEER ED Disposition; no Showerhead					
Measure Equipment Cost ($/unit):	Source DEER $29.22	Source DEER $29.22	Source DEER $29.22	Source DEER $29.22	Source DEER $6.54	Source DEER $6.54
Gross Measure Cost ($/unit)	Source: DEER $45.96	Source: DEER $45.96	Source: DEER $45.96	Source: DEER $45.96	Source: DEER $13.24	Source: DEER $13.24
Measure Incremental Cost ($/unit):	Source: DEER $45.96	Source: DEER $45.96	Source: DEER $45.96	Source: DEER $45.96	Source: DEER $13.24	Source: DEER $13.24
Effective Useful Life (years):	Source: DEER 10 years					
Measure Application Type:	ROB					
Net-to-Gross Ratios:	Source: DEER2014 Res-sAll-mDHWshwr= 0.7					

Work Paper Approvals

The following Manager(s) approved this workpaper through the PG&E Electronic Data Routing System under Routing Requisition # ________________

Grant Brohard
Manager, Technical Product Support

Carolyn Weiner
Manager, Appliance Products

Document Revision History

Revision #	Revision Date	Section-by-Section Description of Revisions	Author (Company)
Revision 0	05/15/2014	Showerhead, TXV, Aerators Combined PGECODHW113 with PGE3PDHW117 and PGE3PDHW116	Charlene Spoor (PG&E)

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Section 1. General Measure & Baseline Data

1.1 Product Measure Description & Background

Catalog Description –

Faucet Aerators: Measures S530, 0S00, S531, and 0S01 -- faucet aerators must have a flow rate of 0.5 gallons per minute (gpm) and must be installed on a faucet with a flow rate of 2.2 gpm or higher. The faucet aerator heating source must be electric for measures S235, S237, 0S01 and S530; and gas for measures S236 S238, 0S00 and S531.

Low Flow Showerheads: Measures G8, G11, 0S02, G13, G14 and 0S03: Low flow showerheads must have a flow rate of 1.6 gallons per minute (gpm) and must replace an existing showerhead that has a flow rate of 2.5 gpm or greater. The shower water heating source must be gas for measure G8, G11 and 0S02 and electric for measures G11, G14 and 0S03.

Low Flow Showerheads: Measures H803 and H804: Low flow showerheads must have a flow rate of 2.0 gallons per minute (gpm) and must replace an existing showerhead that has a flow rate of 2.5 gpm or greater. The shower water heating source must be gas for measure H803 and electric for measure H804.

Program Restrictions and Guidelines

Faucet Aerators 3P Measure Codes: S530, S531, S235, S236, S237, S238
Moderate Income Direct Install (MIDI) Measure Codes: 0S00, 0S01 (GP and some 3P programs)

Terms and Conditions

Customer must have electricity/gas distributed by PG&E to the installation address. The customer must meet all the terms and conditions as described on the rebate application form.

Market Applicability

This measure is applicable to all residential households who have faucets with a flow of 2.2 gpm or higher. This workpaper may also be utilized by comparable building types with faucets (e.g. hotel guest rooms and mobile homes) targeted by third party and government partnership programs where DEER provides best available data. Applicable building types are as follows:

Multi Family	MFm
Single Family/ Domestic Mobile Home	SFm/DFo

Technical Description

Faucet aerators are inexpensive and easy to install. They lower flow by introducing air to the spray. The user may experience what feels like additional flow, but this is due to the air-water mixture under pressure producing a high speed spray.

The rebate is a downstream third party program, incentive is provided to the contractor at the time of installation upon receipt of sales data and installation. This is a Direct-Install program as defined in DEER. .

Program Restrictions and Guidelines

Low Flow Showerheads 3P Measure Codes: H803, H804, G8, G11, G13, G14
MIDI Measure Codes: 0S02, 0S03
Terms and Conditions

- Make and model number must be included with a copy of your receipt
- Must have water heating source using natural gas or electricity distributed by PG&E
- Low flow showerhead must pass test procedure ANSI/ASME A112.18.1-2000, Section 5.5

Market Applicability

The low flow showerhead (measures H803, H804, G8 and G13) and combination low flow showerhead and thermostatic valve (measures G11 and G14) apply to all residential households, single family or multi family, who have showerheads with a flow of 2.5 GPM or greater.

The rebate is a downstream rebate provided to the contractor or customer at the time of installation upon receipt of sales data and installation. This is a Direct-Install program as defined in DEER. Applicable building types area as follows:

Multi Family	MFm
Single Family/ Domestic Mobile Home	SFm/DFo

1.2 Product Technical Description

Faucet aerators are inexpensive and easy to install. They lower flow by introducing air to the spray. The user may experience what feels like additional flow, but this is due to the air-water mixture under pressure producing a high speed spray.

Low flow showerheads are inexpensive and easy to install. They lower flow by introducing air to the spray in two ways: drawn or forced (using compressed air). It may seem like more water is flowing than it really is due to the air-water mixture under pressure produces a high speed spray. Since about 73% of water used in a typical shower is hot water, reducing the amount of water used will save energy because there is less water needed to be heated. As a result, the water heater will use less energy, creating an opportunity for savings[1].

Thermostatically initiated shower restriction valves (measures G11 and G14) are installed at the showerhead. The valve is initially open and allows cold water that has been sitting in the pipes to flow through the showerhead at full flow. When the water temperature reaches approximately 95 ºF, the valve closes and restricts the water flow to a trickle until the user enters the shower and switches the valve open again to restore full flow. The intention of this device is to prevent hot water from running down the drain during the ‘pre-useful shower’ warm-up period, i.e. the time the user lets the shower water run down the drain before the ‘useful’ shower event. This pre-useful shower period typically involves the user engaging in an activity instead of standing at the shower head, after which the user returns to the shower to find the hot water running (and the water has been hot for an unknown period of time). By preventing hot water from unnecessarily running down the drain before the useful shower event, this device reduces water heater energy consumption because the hot water demand on the water heater has temporarily been halted.

1.3 Measure Application Type

The DEER 2014 Ex Ante Database Format defines the terms as follows:

Table 1 Measure Application Type[2]

Identifies the measure application type in the Measure Implemenation table in DEER2014.

Code	Description	Comment
ER	Early retirement	*Measure is more efficient than code/std; Dual baseline, full measure costs required*
ROB	Replace on Burnout	*Single baseline (above code), incremental or full costs*
NC	New Construction	*Single baseline (above code), incremental or full costs*

REA	Retrofit Add On	*Single baseline (above pre-existing), full measure costs required*

These measures are considered ROB.

1.4 Product Base Case and Measure Case Data

1.4.1 DEER Base Case and Measure Case Information

The DEER 2014 database does not include faucet aerators or showerheads, however the DEER team, as part of their disposition A.08-07-021 et al, dated July 14, 2011, recommended statewide savings values based on DEER 2011 data for the measures included in this workpaper. DEER 2014 data does include Net to Gross and EUL data. Cost data is also referenced in DEER 2014. All other savings data is taken directly from the ED disposition recommendations for statewide savings values.

Faucet aerator and low flow shower head savings are not included in READI tool; however the DEER team recommends savings values in the DEER Database: 2011 Update Documentation. [3]

The 2011 DEER Update Report recommends using statewide averages (due to insignificant variation across utilities). The report updates values from 2005 DEER, which addresses low flow faucet aerators (Measure ID 2005-D03-934) with a flow of 2.0 gallons per minute. The report updates values from 2005 DEER, which addresses low flow showerheads (Measure ID 2005-D03-937) with a flow of 2.5 gallons per minute (gpm).

Additionally some implementers requested additional measures for faucet aerators of 1.0 gpm and 1.5 gpm to accommodate customer preference. For these measures, this workpaper assumed a linear relationship of flow rate and energy impacts. Please see Section 2 for more details.

Table 2. DEER Use and Technology Table Faucet Aerators and Showerheads

DEER USE and TECHNOLOGY TABLE			
Use Category Description	**Use Category**	**Use Sub Category Description**	**Use Sub Category**
Service and Domestic Hot Water	SHW	Hot Water Point of Use	SHW-HWPoU
Technology Groups Description	**Technology Groups**	**Technology Types Descriptions**	**Technology Types**
Plumbing Fixture	WaterFixt	Faucet Aerator	FaucetAer

DEER USE and TECHNOLOGY TABLE			
Use Category Description	**Use Category**	**Use Sub Category Description**	**Use Sub Category**
Service and Domestic Hot Water	SHW	Hot Water Point of Use	SHW-HWPoU
Technology Groups Description	**Technology Groups**	**Technology Types Descriptions**	**Technology Types**
Plumbing Fixture	WaterFixt	Showerhead	ShowerHd

Delta Wattage Assumption (ΔW):

EUL Electric Savings (ΔW): DEER Version and Impact IDs

The EUL electric savings were downloaded from DEER 2012 disposition directly, (based on DEER2011 values) they match the intended measures. EUL is based on DEER 2014 data.

Therms Savings Assumption (ΔTh) DEER Version and Impact IDs

The EUL electric savings were downloaded from DEER 2012 disposition directly, (based on DEER2011 values) they match the intended measures. EUL is based on DEER 2014 data.

Table 3 Energy Division Disposition Savings

	ED recommended		SDGE		SCG		PGE	
	SF (therms/yr)	MF (therms/yr)	SF (therms/yr)	MF (therms/yr)	SF (therms/yr)	MF (therms/yr)	SF (therms/yr)	MF (therms/yr)
Showerheads 1.7gpm	**5.5**	**6.2**	8.2	8.8	8.2	8.8		
Showerheads 1.6 gpm	**6.5**	**7.3**	9.7	10.4	9.7	10.4	6.0	11.0
Showerheads 1.5 gpm	**7.5**	**8.4**	11.2	12.0	11.2	12.0		
Thermostatic valve	**2.0**	**2.2**	2.0	2.2	2.0	2.2	2.0	3.0
Thermostatic valve and Showerhead 1.6 gpm	**9.6**	**10.6**	11.2	11.9	11.2	11.9	8.0	13.0
Faucet Aerator 1.5 gpm	**1.0**	**0.6**	13.1	13.1	13.1	13.1	2.3	2.2
Faucet Aerator 1 gpm	**1.5**	**0.9**	3.3	3.3	3.3	3.3	4.0	3.8
Faucet Aerator 0.5 gpm	**2.0**	**1.2**					5.7	5.4
Kitchen Faucet Aerator 1.5 gpm	**5.9**	**4.9**						
Therms Saver Kit	**16.4**	**15.1**	30.6	30.6	30.6	30.6		

Hours of Operation: There are no DEER hours of operation listed for this measure.

Base Case Costs and Measure Case Costs

The Base Case and Measure case costs were downloaded from DEER 2014 directly.

Table 4 Base Case and Measure Case Costs

Measure Code	**Measure Application Type**	**Baseline**	**Equipment Cost**	**Labor / Installation Cost**	**Maintenance / Other Cost**	**Total Measure Case Cost**
H803/H804	ROB/REA	Existing	$29.22	$16.74	$N/A	$45.96
G8-14/0S02, 0S03	ROB/REA	*Existing*	*$29.22*	*$16.74*	*$N/A*	*$45.96*
S530-S538/0S00, 0S01	ROB/REA	*Existing*	*$6.54*	*$6.70*	*$N/A*	*$13.24*

Net-to-Gross Assumption: *DEER 2014 NTG assumptions were used and downloaded directly from the READI database.*
The rebate is downstream provided to the contractor or customer at the time of installation upon receipt of sales data and installation. This is a Direct- install and an incentive based program.

Table 5 below summarizes all applicable DEER based Net-to-Gross ratios for programs that may be used by this measure.

Table 5 DEER Net-to-Gross Ratios

		DEER Spreadsheet	
Program Approach	NTG	Bldg type	Install Type
Res-sAll-mDHWshwr	0.70	Any	DI
Res-mDHWaerator	0.59	SFM	DI
Res-mDHWaerator	0.65	MFM	DI

Effective Useful Life / Remaining Useful Life:

Table 6 Effective Useful Life

Building type	Bldg Vintage	Climate Zone	Electric Savings Watts	Deer units	DEER Version	EUL	Measure	DEER ID
MFM/SFM	**Any**	**Any**	**Any**	**Each**	**2014**	**10 yrs**	**Aerators**	WtrHt-WH-Aertr
MFM/SFM	**Any**	**Any**	**Any**	**Each**	**2014**	**10 yrs**	**Shower heads**	WtrHt-WH-Shrhd

In-service rate: **DEER Version and Impact IDs**

- In-Service Rate (ISR) for aerators: 0.665 per DEER2014
- ISR for Showerheads: 0.8 , 0.59 for Shower heads with thermostatic controls per DEER2014.

Table 7 In Service Rate or GSIA

Building type/vin/CZ	measure	implementation	In-service rate	DEER Version	GSIA Ids
ANY	**Faucet aerator**	**DI**	**0.66**	**DEER 2011**	Res-LowF-FA-All
ANY	**Showerhead**	**DI**	**0.8**	**DEER 2011**	Res-LowF-SH-PGE
ANY	**Showerhead with restrictor**	**DI**	**0.59**	**DEER 2013**	Res-LowF-wRest-SH-All

1.4.2 Codes & Standards Requirements Base Case and Measure Information

Title 20: These measures do not fall under Title 20 of the California Energy Regulations.

Title 24: These measures do not fall under Title 24 of the California Energy Regulations.

Federal Standards: These measures fall under Federal DOE or EPA Energy Regulations. The Federal Energy Policy Act of 1992 requires that all faucet fixtures manufactured in the United States restrict maximum water flow at or below 2.5 gallons per minute (gpm) at 80 pounds per square inch (psi) of water pressure or 2.2 gpm at 60 psi. This ensures that most faucet products available will offer at least minimal water efficiency benefits.[4] The Federal Energy Policy Act of 1992 requires that "showerheads must use no more than 2.5 gpm"[5]. This work paper addresses above code showerheads with a flow of 1.6 and 2.0 gpm.

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

The DEER 2011 Update Documentation utilized a 2009 Residential Appliance Saturation Study (RASS)[6] for updates to water heating unit energy consumption (UEC) values. The DEER team incorporated these data into their non-weather sensitive engineering calculations.

The June 2004 RASS study[7] addressed low flow showerheads in the home for the PG&E service territory. The study addressed the question, "Do you have low flow showerheads installed in the shower(s)?" The majority of respondents had low flow for some or all showerheads in their homes. For this 2004 RASS study, low flow showerheads were defined as having a flow rate of 2.5 gpm or less; 2.5 gpm is the base case for the measure covered in this work paper, and the responses did not specify which showerheads were actually less than 2.5 gpm. Because the survey showed that over 30% of showerheads actually exceed the base case flow rate, it is reasonable to assume that the average base case is 2.5 gpm.

The RASS study also evaluated the "number of showers taken per household on a typical day" (mean of 2.52 showers for single-family households and 2.22 showers for multi-family households). These RASS values were used in the calculation of water and energy savings for all measures in Section 2 of this work paper.

1.4.4 Assumptions and Calculations from other sources—Base and Measure Cases

There are no further data or calculations provided for the support of the measures in this workpaper.

Energy Savings Assumption (ΔW, ΔTherms):

- Savings values were modified from previous DEER values per the ED Disposition
- Program is mostly run by 3P with the exception of one core measure.

1.4.5 Time-of-Use Adjustment Factor

We are required by CPUC decision 06-06-063 dated June 29, 2006 to apply time-of-use (TOU) adjustment factors on residential A/C and commercial A/C (packaged and split-system direct-expansion cooling) measures only. Since this is not an A/C measure, the TOU adjustment factor is 0.

1.5 Summary of Inputs for Savings Calculations

The following table provides references to sections that document the inputs for calculation:

Table 8 Summary of Inputs for Savings Calculations

Input Variable	Variations	Base Case 1 Average Value	Base Case 2 Average Value	Measure Case Average Value	Reference Section
Electric Savings	SFM/ MFM	2.0 to 2.6 GPM		*0.5 to 2.0 GPM*	*Section 2.1*
Gas Savings	SFM/MFM	2.0 to 2.6 GPM		0.5 to 2.0 GPM	Section 2.3
Hours of operation	N/A				N/A
Full Cost	FMC	N/A		$13.24 to $45.96	Section 4.2
Incremental Cost	FMC	N/A		$13.24 to $45.96	Section 4.2
EUL /RUL	ROB	10 yrs		10 yrs	Section 1.4.1
NTG	many	0.59 to 0.70		0.59 to 0.70	Section 1.4.1
ISR	Yes	0.59 to 0.8		0.59 to 0.8	Section 1.4.1
TOU Factor	*A/C projects only*				*Section 1.4.5*

Section 2. Calculation Methods

Table 9 Baseline by Measure Application Type

Measure Application Type	Measure Life Basis	First Baseline Period: Energy Savings Baseline	Second Baseline Period: Energy Savings Baseline
ER (early retirement)	EUL	Customer Average Baseline	Code Baseline
ROB (replace-on-burnout)	EUL	Code Baseline	N/A
NC (new construction)	RUL/EUL-RUL	Code Baseline	N/A
REA *(retrofit add on)*	EUL	Code Baseline	N/A

Notes:

- For ROB and REA measures, First Baseline is the baseline for the full EUL. There is no second baseline.
- For ER measures, First Baseline Period is the period for the RUL(remaining useful life),defined by the CPUC as RUL=1/3 EUL. Second baseline period for ER is Code baseline for the period EUL-RUL.

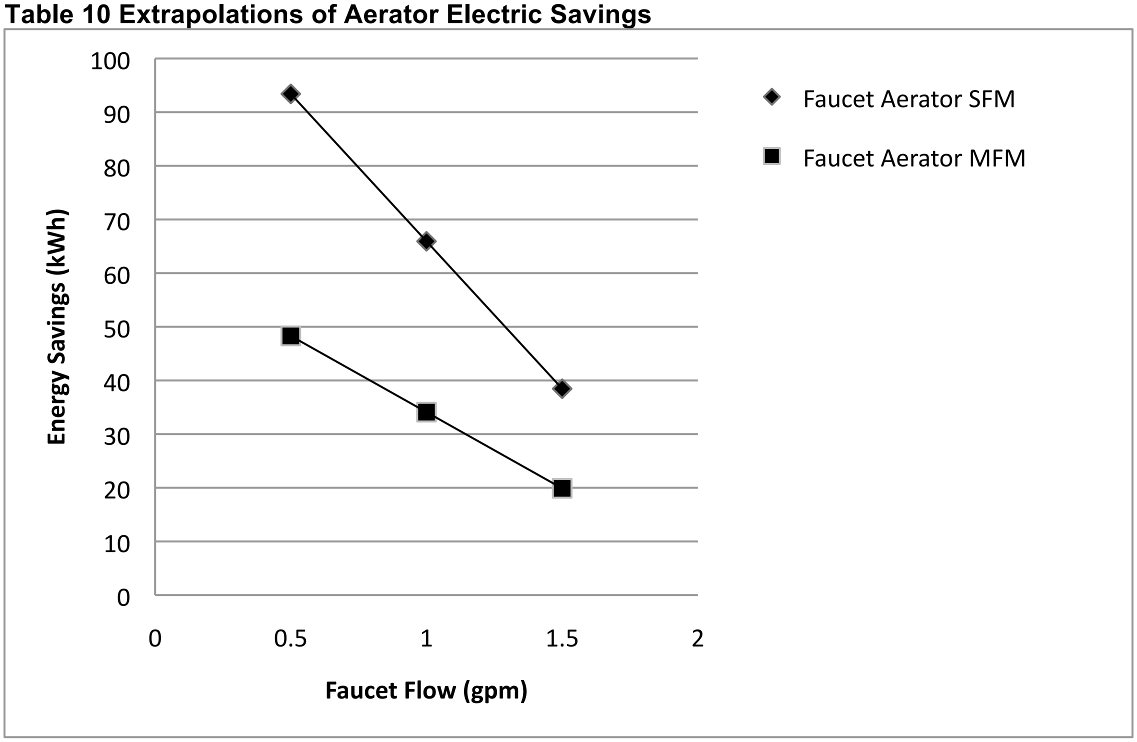
2.1 Electric Energy Savings Estimation Methodologies

Faucet Aerators: Energy savings not in READI tool, but were taken directly from statewide averages recommended in DEER Database: 2011 Update Documentation for aerators with applicable gpm.[8]

For measures S530 and S534 this work paper utilizes DEER deemed savings values which are based on non-weather sensitive engineering calculations performed by the DEER team. Measures S235, S236, S237 and S238 are for different gpm aerators. This workpaper assumes a simple linear relationship with energy savings and faucet gpm, and extrapolates the DEER energy impacts for a 0.5 gpm faucet aerator (with a baseline 2.2 gpm existing faucet).

Please see Table10 below. Savings for the three aerator gpm can be found the at-a-glance summary.

Table 10 Extrapolations of Aerator Electric Savings



The following is the electric energy savings per showerhead for residential units with electric water heaters.

For Showerhead Electric Energy Savings Per the Energy Division recommendation noted in the A.08-07-021 et al. ALJ/DMG/hkr/jt2, dated July 14, 2011, and subsequently updated in previous WP updates the following were taken into consideration:

"Approval upon inclusion of the following revisions:

1. Reduce baseline water consumption to levels supported by current available research, which reduces savings.
2. Use water heater recovery efficiency to calculate energy use instead of energy factor.
3. Reduce UES of measure by 20% to account for some installations in tub+shower combinations.

THEREFORE, a 20% reduction in kWh savings will be incorporated for this measure.

Ex: 147kWh annual savings – 20% UES = 147 – 29 = 118 kWh annual savings
245kWh annual savings – 20% UES = 245 – 49 = 196 kWh annual savings

Low Flow Showerhead (Measure G13)

Table 11 Annual Electric Savings Per Showerhead - Measure G13

Electric Savings Calculations	**Single-Family**	**Multi-Family**
Baseline Energy Usage for Electric Water Heater (kWh/yr/Showerhead)	408	681
Measure Energy Usage for Electric Water Heater (kWh/yr/Showerhead)	261	436
Energy Savings for Electric Water Heater (kWh/yr/Showerhead)	147	245

Calculations:

$$q_{electric,\ baseline} = [\ W_{baseline} * \rho * c_{p,H20} * (T_{out,tempered} - T_{in})\ ] \ /\ (\ RE_{res,elec} * C_{volume} * C_{kWh}\ )$$

$$q_{G13} = [\ W_{G8,\ G13} * \rho * c_{p,H20} * (T_{out,tempered} - T_{in})\ ] \ /\ (\ RE_{res,elec} * C_{volume} * C_{kWh}\ )$$

Annual Energy Savings for Electric Water Heater = Baseline energy usage ($q_{electric,\ baseline}$) – Measure energy usage (q_{G13})

Per the Energy Division recommendation noted in the A.08-07-021 et al. ALJ/DMG/hkr/jt2, dated July 14, 2011:

"Approval upon inclusion of the following revisions:

4. Reduce baseline water consumption to levels supported by current available research, which reduces savings.
5. Use water heater recovery efficiency to calculate energy use instead of energy factor.
6. Reduce UES of measure by 20% to account for some installations in tub+shower combinations.

THEREFORE, a 20% reduction in kWh savings will be incorporated for this measure.

Ex: 148kWh annual savings – 20% UES = 148 – 29 = 119 kWh annual savings
247kWh annual savings – 20% UES = 247 – 49 = 198 kWh annual savings

Low Flow Showerhead and Thermostatic Shower Restriction Valve (Measure G14)

Table 12 Annual Electric Savings Per Showerhead - Measure G14

Electric Savings Calculations	**Single-Family**	**Multi-Family**
Baseline Energy Usage for Electric Water Heater (kWh/yr/Showerhead)	408	681

Measure Energy Usage for Electric Water Heater (kWh/yr/Showerhead)	261	436
Measure Annual Hot Water Energy Consumption Avoidance Due to Thermostatic Shower Restriction Valve (kWh/Showerhead)	1	2
Energy Savings for Electric Water Heater (kWh/yr/Showerhead)	148	247

Calculations:

$$q_{electric,\ baseline} = [\ W_{baseline} * \rho * c_{p,H20} * (T_{out,tempered} - T_{in})\ ] / \ (\ RE_{res,elec} * C_{volume} * C_{kWh}\ )$$

$$q_{G14,\ showerhead} = [\ W_{G11,\ G14,\ showerhead} * \rho * c_{p,H20} * (T_{out,tempered} - T_{in})\ ] / \ (\ RE_{res,elec} * C_{volume} * C_{kWh}\ )]$$

$$q_{G14,\ valve}\ (\text{energy avoided}) = [\ W_{G11,\ G14,\ valve} * \rho * c_{p,H20} * (T_{out,hot} - T_{in})\ ] / \ (\ RE_{res,elec} * C_{volume} * C_{kWh}\ )]$$

Annual Energy Savings for Electric Water Heater = Baseline energy usage ($q_{electric,\ baseline}$) – Measure energy usage ($q_{G14,\ showerhead}$) + Measure energy avoided ($q_{G14,\ valve}$)

2.2. Demand Reduction Estimation Methodologies

- Faucet Aerators: Per 2011 DEER Update a Peak Demand factor (kW/kWh-unit) of 0.22 (originally from 2005 DEER) was utilized. This Peak Demand factor was applied to the state-wide averages to determine peak demand savings.
- Showerheads: The following is the electric demand savings per showerhead for residential units with electric water heaters. The demand Reduction was calculated using the watt peak factor of 0.22 as stated in the 2004-2005 DEER Update Study Final Report[2].

Table 13 Demand Reduction Per Showerhead per Measure

Electric Demand Savings Calculations	**Single-Family**	**Multi-Family**
Measure G13 Low Flow Showerhead: Peak Electric Demand Savings (kW/Showerhead)	0.032	0.054
Measure G14 Low Flow Showerhead and Thermostatic Shower Restriction Valve: Peak Electric Demand Savings (kW/Showerhead)	0.033	0.054

Calculations:

Peak Electric Demand Savings = (Measure Energy savings for electric water heater)*(Watt peak factor)*1 kW/1000 W)

Per the Energy Division recommendation noted in the A.08-07-021 et al. ALJ/DMG/hkr/jt2, dated July 14, 2011:

"Approval upon inclusion of the following revisions:

1. Reduce baseline water consumption to levels supported by current available research, which reduces savings.
2. Use water heater recovery efficiency to calculate energy use instead of energy factor.
3. Reduce UES of measure by 20% to account for some installations in tub+shower combinations.

THEREFORE, a 20% reduction in kWh demand savings will be incorporated for this measure.

Ex: 0.032kW annual savings – 20% UES = 0.032 X 0.80 = 0.026

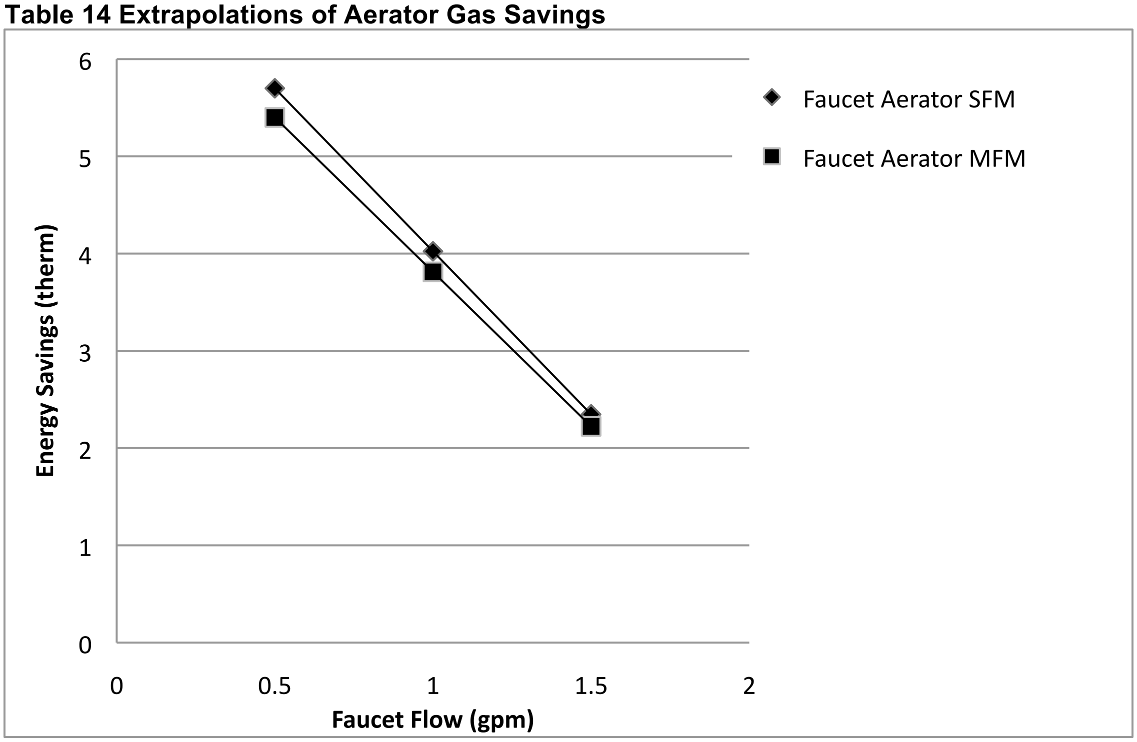
2.3. Gas Energy Savings Estimation Methodologies

Energy savings not in READI tool, but were taken directly from statewide averages recommended in DEER Database: 2011 Update Documentation.

This work paper utilizes DEER deemed savings values which are based on non-weather sensitive engineering calculations performed by the DEER team.

Similar to electric faucet aerator savings, the DEER values were extrapolated for DEER gas savings. Please see Table 14 below (energy impact values found in at-a-glance summary).

Table 14 Extrapolations of Aerator Gas Savings



Showerhead Annual Gas Savings:

The following is the natural gas energy savings per showerhead for residential units with natural gas water heaters.

Per the Energy Division recommendation noted in the A.08-07-021 et al. ALJ/DMG/hkr/jt2, dated July 14, 2011:

“Approval upon inclusion of the following revisions:

1. Reduce baseline water consumption to levels supported by current available research, which reduces savings.
2. Use water heater recovery efficiency to calculate energy use instead of energy factor.
3. Reduce UES of measure by 20% to account for some installations in tub+shower combinations.

THEREFORE, a 20% reduction in kWh savings will be incorporated for this measure.

Ex: 6 therms – 20% UES = 6 – 1.2 = 5 therms annual savings

Low Flow Showerhead (Measure G8)

Table 15 Annual Natural Gas Savings per Showerhead - Measure G8

Gas Savings Calculations	Single-Family	Multi-Family
Baseline Energy Usage for Natural Gas Water Heater (therms/yr/Showerhead)	18	30
Measure Energy Usage for Natural Gas Water Heater (therms/yr/Showerhead)	11	19
Energy Savings for Natural Gas Water Heater (therms/yr/Showerhead)	6	11

Calculations:

$$q_{gas,\ baseline} = [\ W_{baseline} * \rho * c_{p,H20} * (T_{out,tempered} - T_{in})\ ] \ /\ (\ RE_{res,gas} * C_{volume} * C_{therm}\ )$$

$$q_{G8} = [\ W_{G8,\ G13} * \rho * c_{p,H20} * (T_{out,tempered} - T_{in})\ ] \ /\ (\ RE_{res,gas} * C_{volume} * C_{therm}\ )$$

Energy Savings for Natural Gas Water Heater = Baseline energy usage ($q_{gas,\ baseline}$) – Measure energy usage (q_{G8})

Low Flow Showerhead and Thermostatic Shower Restriction Valve (Measure G11)

Table 16 Annual Natural Gas Savings per Showerhead - Measure G11

Gas Savings Calculations	Single-Family	Multi-Family
Baseline Energy Usage for Natural Gas Water Heater (therms/yr/Showerhead)	18	30
Measure Energy Usage for Natural Gas Water Heater (therms/yr/Showerhead)	11	19
Measure Annual Hot Water Energy Consumption Avoidance Due to Thermostatic Shower Restriction Valve (therms/yr/Showerhead)	2	3
Energy Savings for Natural Gas Water Heater (therms/yr/Showerhead)	8	13

Calculations:

$$q_{gas,\ baseline} = [\ W_{baseline} * \rho * c_{p,H20} * (T_{out,tempered} - T_{in})\ ] \ /\ (\ RE * C_{volume} * C_{therm}\ )$$

$$q_{G11,\ showerhead} = [\ W_{G11,\ G14,\ showerhead} * \rho * c_{p,H20} * (T_{out,tempered} - T_{in})\ ] \ /\ (\ RE_{res,gas} * C_{volume} * C_{therm}\ )]$$

$$q_{G11,\ valve} \text{(energy avoided)} = [\ W_{G11,\ G14,\ valve} * \rho * c_{p,H20} * (T_{out,hot} - T_{in})\ ] \ /\ (\ RE_{res,gas} * C_{volume} * C_{therm}\ )]$$

Energy Savings for Natural Gas Water Heater = Baseline energy usage ($q_{gas, baseline}$) – Measure energy usage ($q_{G11, showerhead}$) + Measure energy avoided ($q_{G11, valve}$)

Section 3. Load Shapes

Load Shapes are an important part of the life-cycle cost analysis of any energy efficiency program portfolio. The net benefits associated with a measure are based on the amount of energy saved and the avoided cost per unit of energy saved. For electricity, the avoided cost varies hourly over an entire year. Thus, the net benefits calculation for a measure requires both the total annual energy savings (kWh) of the measure and the distribution of that savings over the year. The distribution of savings over the year is represented by the measure's load shape. The measure's load shape indicates what fraction of annual energy savings occurs in each time period of the year. An hourly load shape indicates what fraction of annual savings occurs for each hour of the year. A Time-of-Use (TOU) load shape indicates what fraction occurs within five or six broad time-of-use periods, typically defined by a specific utility rate tariff. Formally, a load shape is a set of fractions summing to unity, one fraction for each hour or for each TOU period. Multiplying the measure load shape with the hourly avoided cost stream determines the average avoided cost per kWh for use in the life cycle cost analysis that determines a measure's Total Resource Cost (TRC) benefit.

3.1 Base Case Load Shapes

The base case load shape would be expected to follow a typical multifamily residential hot water end use load shape.

Table 17 Base Case Building Types and Load Shapes

Building Type	E3 Alt. Building Type	Load Shape
RESIDENTIAL	Any	PGE:Residential:21 = Res. Wtr. Heating

3.2 Measure Load Shapes

For purposes of the net benefits estimates in the E3 calculator, what is required is the load shape that ideally represents the *difference* between the base equipment and the installed energy efficiency measure. This *difference* load profile is what is called the Measure Load Shape and would be the preferred load shape for use in the net benefits calculations.
The measure load shape for this measure is determined by the E3 calculator based on the applicable residential market sector and hot water end-use.

Section 4. Base Case & Measure Costs

Table 18 DEER 2014 Base Case & Measure Case Cost Definitions

Measure Application Type	Measure Life Basis	First Baseline Period Full Measure Cost (RUL)	Second Baseline Period Full Measure Cost (EUL – RUL)
NC (new construction)	EUL	Calculated as Incremental Measure Cost	N/A
ROB(replace on	EUL	Calculated as Incremental	N/A

burnout)		Measure Cost	
ER (early retirement)	RUL/ EUL-RUL	Calculated as Full Gross Measure Cost	Calculated as Negative Full Gross Base Case Cost
REA (retrofit add on)	EUL	Calculated as Full Gross Measure Cost	N/A

4.1 Base Case(s) Costs

These are direct install measures therefore base case costs are not applicable. Costs are based on the full cost of install similar to an ER measure.

4.2 Measure Case Costs

Costs from the DEER 2014 database were used (although these values have not been updated since the DEER 2008 cost data update). The following Measure Application Types are appropriate to these measures. The Measure Case Costs are noted in Table 19 below:

Table 19 Measure Case Costs

Measure Code	**Measure Application Type**	**Baseline**	**Equipment Cost**	**Labor / Installation Cost**	**Maintenance / Other Cost**	**Total Measure Case Cost**
H803/H804	ROB/REA	Existing	$29.22	$16.74	$N/A	$45.96
G8-14/0So2, 0S03	ROB/REA	*Existing*	*$29.22*	*$16.74*	*$N/A*	*$45.96*
S530-S538/0S00, 0S01	ROB/REA	*Existing*	*$6.54*	*$6.70*	*$N/A*	*$13.24*

All costs are noted as $ per measure unit

4.3 Incremental & Full Measure Costs

Table 20 DEER 2014 Incremental and Full Measure Case Cost Definitions

Measure Application Type	**Full Measure Cost (RUL Period/First Baseline)**	**Full Measure Cost (EUL-RUL Period/ Second Baseline)**	**Incremental Measure Cost**
ER	Measure Equipment Cost +Measure Labor Cost	(-1)x(Base Equipment Cost + Base Labor Cost)	Measure Equipment Cost – Base Case Equipment Cost
ROB	Measure Equipment Cost – Base Case Equipment Cost	N/A	Measure Equipment Cost – Base Case Equipment Cost
NC	Measure Equipment Cost – Base Case Equipment Cost	N/A	Measure Equipment Cost – Base Case Equipment Cost
REA	Measure Equipment Cost – Base Case Equipment Cost	N/A	Measure Equipment Cost – Base Case Equipment Cost

4.3.1 Full Measure Cost

Full Measure Cost is the cost to install an energy efficient measure per the CPUC calculators. This definition implies a different meaning depending on the Measure Application type.

This Measure Application Type is: **ROB**, however since it is direct install the the Full Measure Cost (FMC) is used and the base case cost in no subtracted as is represented by the equation below:

FMC = (Measure Equipment Cost + Measure Labor Cost) –
(Base Case Equipment Cost + Base Case Labor Cost)

DI FMC = Measure Equipment Cost +Measure Labor Cost

See table above in Section 4.2 for specific measure values.

4.3.2 Incremental Measure Costs

Incremental Measure Cost is the premium cost to install an energy efficient measure over a standard efficiency measure or code baseline measure. In this case the Incremental Measure Cost is the same as the Measure Cost noted in section 4.2.

Section 5. 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[9]. Below is a summary of their conclusions.

5.1 Reliability

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

5.2 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.

Input Appendices

Figure 1Sources for Data and Assumptions, Conversion Factors

Data and Assumptions	**Source**
Showerheads per Household	U.S Census Bureau (Weighted average of new units completed in the West region from 1978-2006) [11]
Showers per Household per Day	RASS[4], p. 100 of PG&E Banner Data
Average Pre-Useful Shower Hot Water Wait Time	*Shower Behavior: Attitudes, Awareness, and Usage Survey*[8], question #8; *New Studies on Estimated and Actual Toothbrushing Times and Dentifrice Use*[9]; *Evaluation of Residential Hot Water Distribution Systems by Numeric Simulation*[10], Appendix A
Throttling Factor	*Potential Water and Energy Savings from Showerheads*[3], p. 6
Baseline Flow (gpm rated @ standard 80 psi)	Maximum allowable flow used as baseline[1].
Measure Flow (gpm)	Assumed for this work paper.
Average Shower Flow	PG&E Calculations, derived from *Potential Water and Energy Savings from Showerheads*[3], p. 4 and RASS[4], p.121
Cold water heater inlet temperature (°F)	*Potential Water and Energy Savings from Showerheads*[3], p. 4
Hot water heater outlet temperature (°F)	*Potential Water and Energy Savings from Showerheads*[3], p. 4
Shower temperature (°F)	*Potential Water and Energy Savings from Showerheads*[3], p. 4
Electric Water Heater Efficiency	*California Title 20 Appliance Regulations*[12], p. 89
Gas Water Heater Efficiency	*California Title 20 Appliance Regulations*[12], p. 89
Watt Peak Factor	*2004-2005 DEER Update Study Final Report*[2], p. 2-23
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*
kWh/btu	*Marks' Handbook for Mechanical Engineers*

Number of Bathrooms per Household

(Calculations)

Figure 2 Weighted Average Number of Bathrooms (Showerheads) in the West Region

	Multi-family			
# Baths	**1**	**1.5**	**2+**	
Year				
1978	102	18	40	
1979	104	16	49	
1980	84	16	53	
1981	55	10	46	
1982	41	7	34	
1983	59	10	35	
1984	92	10	62	
1985	117	15	76	
1986	112	17	87	
1987	91	13	87	
1988	71	10	74	
1989	56	8	67	
1990	53	7	62	
1991	32	7	48	
1992	22	5	31	
1993	19	2	23	
1994	20	3	28	
1995	26	2	36	
1996	28	4	45	
1997	33	3	41	
1998	33	3	42	
1999	34	4	47	
2000	33	3	41	
2001	32	2	46	
2002	38	4	47	
2003	29	3	41	
2004	31	5	39	
2005	24	4	41	
2006	28	4	42	
Total	1499	215	1410	
%	0.48	0.07	0.45	
Wt. Avg.	0.48	0.10	0.90	1.49
			Rounded	1.50

	Single-Family				
# Baths	**1.5**	**2**	**2.5**	**3+**	
Year					
1978	62	200	95	N/A	
1979	64	189	85	N/A	
1980	47	129	57	N/A	
1981	40	98	45	N/A	
1982	28	66	27	N/A	
1983	41	113	46	N/A	
1984	33	132	68	N/A	
1985	38	133	68	N/A	
1986	33	137	83	N/A	
1987	29	134	51	45	
1988	21	117	61	50	
1989	14	118	63	61	
1990	14	112	61	68	
1991	14	93	47	51	
1992	15	102	69	46	
1993	17	113	74	43	
1994	20	129	84	52	
1995	16	114	74	49	
1996	15	118	81	54	
1997	12	112	79	56	
1998	13	112	90	68	
1999	13	122	100	75	
2000	15	110	88	74	
2001	12	111	101	79	
2002	11	120	103	90	
2003	11	127	116	108	
2004	10	152	127	120	
2005	12	143	152	130	
2006	13	117	157	128	
Total	683	3573	2352	1447	
%	0.08	0.44	0.29	0.18	
Wt. Avg.	0.13	0.89	0.73	0.54	2.28
				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.

Figure 3 below lists the data, assumptions and conversion factors used in the calculations for this work paper. Figure 4 below defines the water and energy variables stated in the calculation formulas. The sources for these assumptions are listed in the Appendix. The calculations will be similar to the method used in the Lawrence Berkeley National Laboratory (LBNL) study[3]. Factors that are not intuitive are explained. The variables used in the water and energy savings analysis are listed in table form below as well.

The following Low Flow Showerhead analysis can be further validated by using the U.S. Department of Energy's (DOE) "Energy Cost Calculator for Faucets and Showerheads" with inputs from Table 3[10].

Figure 3 Data and Assumptions, Conversion Factors

Constant	Definition	Value	Units
$Vdot_{base}$	baseline showerhead water flow (volumetric flow rate)	2.5	gpm
$Vdot_{low}$	low flow showerhead water flow (volumetric flow rate)	1.6	gpm
T_{in}	water temperature entering water heater	65	ºF
$T_{out,tempered}$	water temperature exiting showerhead (adjusted for tempering)	105	ºF
$T_{out, hot}$	water temperature exiting water heater	120	ºF
Δt_{shower}	average shower duration	8.2	minutes / shower
Δt_{valve}	average hot water waste time before user gets in shower (pre-useful shower hot water waste time)	0.56	minutes / shower
C_{volume}	volumetric conversion constant for cubic feet to gallons	7.481	gal / ft^3
$C_{days/year}$	time conversion constant from days to years	365	days / year
C_{therm}	energy conversion constant from Btu's to therms	100,000	Btu / therm
C_{kWh}	energy conversion constant from Btu's to kilowatt hours	3,412	Btu/kWh
$C_{W/kW}$	energy conversion constant from Watts to Kilowatts	1,000	W / kW

Figure 3 Data and Assumptions, Conversion Factors, Continued

Constant	Definition	Value	Units
ρ	density of water at 60 ºF	62.468	lbm / ft^3
F_{throtl}	throttling factor to account for the effects of pipe clogging and/or pressure less than 80 psig on flow rate	0.9	unitless
$N_{showers, SF}$	average number of showers per single-family household per day	2.52	showers / household
$N_{showers, MF}$	average number of showers per multi-family household per day	2.22	showers / household
$N_{showerheads, SF}$	average number of showerheads per single-family household	2.5	showerheads / household
$N_{showerheads, MF}$	average number of showerheads per multi-family household	1.5	showerheads / household
$RE_{res,gas}$	Gas water heater recovery efficiency (excludes standby efficiency)	0.76	unitless
$RE_{res,elec}$	Electric water heater recovery efficiency (excludes standby efficiency)	0.98	unitless
H_{base}	Gallons of 105ºF water used per household per day (assumed typical household with baseline showerhead flow)	28	gallons/day
WP	Watt Peak Factor, kWh / Peak Watts used by DEER for water heat measures	0.22	$kWh / Watts_{peak}$

Figure 4 Water and Energy Variables

Variable	Definition	Value	Units
$W_{baseline}$	annual water consumption for baseline case	See Tables 3 and 4	gal / showerhead - yr
$W_{G8, G13}$	annual water consumption for measures G8 and G13, low flow showerhead alone	See Table 3	gal / showerhead - yr
$W_{G11, G14, showerhead}$	annual water consumption attributable to the low flow showerhead for measures G11 and G14	See Table 4	gal / showerhead - yr
$W_{G11, G14, valve}$	annual water *savings* attributable to the thermostatic restriction valve for measures G11 and G14	See Table 4	gal / showerhead - yr
$q_{electric, baseline}$	annual electrical energy consumption for baseline case	See Tables 5 and 6	kWh / showerhead-yr
$q_{gas, baseline}$	annual gas energy consumption for baseline case	See Tables 8 and 9	therms / showerhead-yr
q_{G8}	annual electrical energy consumption for Measure G8	See Table 8	therms / showerhead-yr
q_{G13}	annual electrical energy consumption for Measure G13	See Table 5	kWh / showerhead-yr
$q_{G11, showerhead}$	annual electrical energy attributable to the low flow showerhead for measure G11	See Table 9	therms / showerhead-yr
$q_{G11, valve}$	annual electrical energy required by shower water during behavioral loss period	See Table 9	therms / showerhead-yr
$q_{G14, showerhead}$	annual electrical energy attributable to the low flow showerhead for measure G14	See Table 6	kWh / showerhead-yr
$q_{G14, valve}$	annual electrical energy required by shower water during behavioral loss period	See Table 6	kWh / showerhead-yr

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

The *total* pre-useful shower water waste time was based on the assumption that most people either brush their teeth while waiting for the shower to warm up, or do an activity or series of activities comparable in time length (e.g., undressing or using the toilet). A shower behavior survey of approximately 162 people conducted by Hotwire Development, LLC[11] supported this assumption and was the only survey of this nature that could be found. An average teeth-brushing time of 78.15 seconds was estimated from a study done by the University of Zurich, Switzerland[12]. This time is likely conservative, as it is based on the time the toothbrush is actually in the mouth, and not the time it takes to prepare the brush and then rinse and clean it. The time also does not account for other activities done in addition to teeth brushing before getting in the shower, which was indicated by many respondents to the Hotwire survey.

The *cold* water waste time was then approximated as 44.6 seconds using a study done by Oakridge National Lab[13]. This study evaluated the length of time it took for hot water to get to the farthest fixture in the house through a variety of hot water distribution systems in California. Various piping, insulation, and run lengths were evaluated based on typical old and new construction houses, and a flow rate of 2.25 gpm. For House Models 1 through 5 (new construction) and 6 and 7 (old construction), the "Typical Hot Water Wait Times" for both clustered events and cold water draw were averaged. The averaged typical wait times excluded those times associated with centrally located water heaters, parallel PEX and demand recirculation systems as these configurations were deemed non-representative of the average home in PG&E territory.

An average hot water wait time, adjusted for 1.6 gpm (the flow rate for measure G8 and G11), was derived from the different run cases. The time was then weighted based on the percentage of new and old construction (10% and 90% respectively) homes the study indicated were in California. The times were not weighted according to the distribution of the different types of piping and insulation configurations are actually found in homes, as this weighted distribution is unknown. This study also assumed the water was turned to full hot, soliciting maximum hot water flow from the water heater.

Persons per household: acquired data from the 2000 Census for California[14]. It was assumed that owner-occupied and renter-occupied units corresponded to single and multi-family units, respectively.

Weighted Average Showerheads per Household: acquired data from the U.S. Census Bureau[11] was used to calculate the weighted average showerheads per household. The data for number of bathrooms per household for new construction of single and multi-family units between the years 1978-2006 was used. After the weighted average was calculated, the result was rounded up to the nearest tenth. Savings are conservative since rounding this number up results in lower savings. The calculations are shown in the appendix.

Throttling factor: 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[3].

Watt Peak Factor: Calculates the peak demand (Watt) from energy savings (kWh). The same energy (kWh)/peak (Watt) factor used in the 2001 DEER update is utilized[2].

Showerhead Temperature: For low flow showerheads measure G8, the outlet water heater temperature is assumed to be 105ºF to account for tempering of the hot water with cold water to establish full shower flow, consistent with the study done by Peter Biermayer at LBNL[3]. Hot water does not comprise the entire shower flow, so evaluating a smaller water heater temperature rise (from 65 to 105 ºF) limits the water heater energy attributable to entire shower flow. A conservative value of 65ºF was used for water heater entering water temperature.

Electric and Gas water heater recovery efficiencies: It is assumed that the majority of water heaters in the PG&E service territory are approximately at the Title 20[15] Minimum required efficiency levels.

Gallons per Household per day: According to an NREL (and per ED recommendation) it is assumed that the average single family household consumes 28 gallons of water per day for shower usage with domestic hot water at a tempered temperature of approximately 105 °F. This water usage was assumed for single family and multifamily homes.

References

[1] Flex Your Power – Residential Product Guides – Showerheads. 2007. Retrieved December 14, 2007 from http://www.fypower.org/res/tools/products_results.html?id=100160
[2] The DEER Measure Cost Data Users Guide found on www.deeresources.com under DEER2011 Database Format hyperlink, DEER2011 for 13-14, spreadsheet SPTdata_format-V0.97.xls.
[3] Database for Energy Efficiency Resources: 2011 Update. Page 5-2. Itron, November 8, 2011
[4] Flex Your Power: http://www.fypower.org/res/tools/products_results.html?id=100160
[5] Flex Your Power – Residential Product Guides – Showerheads. 2007. Retrieved December 14, 2007 from http://www.fypower.org/res/tools/products_results.html?id=100160
[6] 2009 Residential Appliance Saturation Study- http://websafe.kemainc.com/rass2009/
[7] California Statewide Residential Appliance Saturation Study (RASS - 2004). Contract No. 400-04-009. Prepared for the California Energy Commission by KEMA-XENERGY, Itron, and RoperASW. 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
[8] Database for Energy Efficiency Resources: 2011 Update. Itron, November 8, 2011 http://www.deeresources.com/DEER2011/download/2011_DEER_Documentation.pdf
[9] 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
[10] Retrieved from http://www1.eere.energy.gov/femp/procurement/eep_faucets_showerheads_calc.html
[11] Hotwire Development, LLC. Shower Behavior: Attitudes, Awareness, and Usage Survey. (2005). Survey Question #8, "What do you do while waiting for your shower to warm up (mark or list all that apply)".
[12] Saxer UP, Barbakow J, Yankell SL . New Studies on Estimated and Actual Toothbrushing Times and Dentifrice Use. Prepared for the Department of Preventive Dentistry Periodontology and Cariology, University of Zurich, Switzerland.
Retrieved from PubMed, a service by the U.S. National Library of Medicine: http://www.ncbi.nlm.nih.gov/pubmed/10518854
[13] Wendt, Baskin, & Durfee. (2004). Evaluation of Residential Hot Water Distribution Systems by Numeric Simulation, Appendix A. Oak Ridge National Laboratory. Prepared for Davis Energy Group and California Energy Commission. Retrieved from http://www.cuwcc.org/res_hot_water/ORNL_Hot_Water_Distr_Study_March-2004.pdf
[14] U.S. Census Bureau, 2000 Census.
Bathrooms per household CA data retrieved from http://www.census.gov/const/www/charindex_excel.html#singlecomplete
[15] California Energy Commission, Appliance Efficiency Regulations, Page 83. Effective 12/27/2007.