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California Investor Owned Utilities' Response to Invitation to Submit Proposals - Tub Spout Diverters

Additional submitted attachment is included below.

Tub Spout Diverters

Codes and Standards Enhancement (CASE) Initiative
For PY 2017: Title 20 Standards Development

Analysis of Standards Proposal for
Tub Spout Diverters
Docket Number 17-AAER-09

12/05/2017

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1. Purpose

The Codes and Standards Enhancement (CASE) initiative presents recommendations to support California Energy Commission's (Energy Commission) efforts to update California's Appliance Efficiency Regulations (Title 20) (CEC 2017a) to include new requirements or to upgrade existing requirements for various technologies. The four California Investor Owned Utilities (IOUs) – Pacific Gas and Electric Company (PG&E), San Diego Gas and Electric (SDG&E), Southern California Edison (SCE), and SoCalGas – sponsored this effort (herein referred to as the Statewide CASE Team). The program goal is to prepare and submit proposals that will result in cost-effective enhancements to improve the energy and water efficiency of various products sold in California. This report and the code change proposal presented herein is a part of the effort to develop technical and cost-effectiveness information for potential appliance standards. This CASE Report covers a standards proposal for bath and shower diverters.

2. Product/Technology Description

Per the United States (U.S.) Environmental Protection Agency (EPA) WaterSense® staff, a "bath and shower diverter" is a "device used to direct the flow of water either toward a tub spout or toward a secondary outlet intended for showering purposes (e.g., fixed showerhead, hand-held body spray)" (U.S. EPA 2017a, 4).[1] EPA estimates that bath and shower diverters have a product service life of approximately 20 years (U.S. EPA 2017a, 8). EPA also identified multiple field studies showing that bath and shower diverters installed in existing homes often leak substantially more than expected (Taitem 2011; MaP 2014; U.S. EPA 2017b).

The diverter mechanism of bath and shower diverters is most commonly mounted on a tub spout, but also can be mounted on shower valve trim, deck-mounted (e.g., roman tub), or mounted on floor-standing faucets (e.g., roman or clawfoot tub). The following definitions will help the reader differentiate between diverter products throughout this CASE Report:

- "Bath and shower diverter" means a device used to direct the flow of water either toward a tub spout or toward a secondary outlet intended for showering purposes (e.g., showerhead, body spray) (U.S. EPA 2017a, 4);
- "Tub spout diverter" means a bath and shower diverter whose diverter mechanism is located in the tub spout;
- "Tub-to-shower diverter" means a bath and shower diverter whose diverter mechanism is not located in the tub spout; and
- "Showerhead-bath and shower diverter combination" means a group of plumbing fittings sold as a matched set and consisting of a control valve, a bath and shower diverter, a tub spout, and a showerhead.

The Statewide CASE Team's proposal covers all bath and shower diverters. Section 3 provides an outline of the proposal, and section 4 provides the recommended code language.

Title 20 defines four categories (i.e., types) of diverters based on the type of operation required to control it: lift, pull, push, or turn. However, Title 20 does not specifically define the terms lift, pull, push, and turn, which has led to some confusion. The Modernized Appliance Efficiency

[1] The term "tub spout diverter" is currently used in Title 20, but the Statewide CASE Team proposes to redefine it.

Database System (MAEDBS), which is the Energy Commission's database of Title 20 certified appliances (CEC 2017b), includes those four categories, but does not include diverter mounting location information (i.e., "tub spout diverter" versus "tub-to-shower diverter" as defined here). Such location information is used here and in the proposed code language.

Tub spout diverters where the diverter handle is on the top of the tub spout and the handle is lifted to stop flow through the tub spout outlet are usually referred to as lift-type. If the handle is on the bottom of the tub spout, they're usually referred to as pull-type or pull-down. Tub spout diverters where the diverter mechanism is mounted horizontally are also usually referred to as pull-type. Figure 1 shows example photos of these diverters.

Figure 1: Tub spout diverter product photos. [a]

Source: Home Depot.

[a] Type: Lift (Left), Pull down (Middle), and Pull (Right).

Tub-to-shower diverters usually have the diverter mechanism oriented horizontally (i.e., perpendicular to the flow of water), and the handle is either a lever or knob that is typically turned or pushed, respectively. Figure 2 shows example photos of these devices, as well as a freestanding floor-mount roman tub faucet bathtub filler that includes a hand shower, faucet, faucet handle, and a tub-to-shower diverter.

Figure 2: Tub-to-shower diverter product photos. [a]

Source: Home Depot.

[a] Type: Turn (Left and Right), Push (Middle).

Bath and shower diverters can also be categorized by whether they are "manual reset diverters" or "automatic reset diverters." "Manual reset diverter" means a bath and shower diverter that does not have the capability to automatically redirect water flow after a shower valve is closed, but instead always requires direct user operation to redirect water flow. "Automatic reset diverter" means a bath and shower diverter that automatically redirects all water flow through the tub spout after a shower valve is closed, such that when the shower valve is subsequently opened, all water initially flows through the tub spout.

The most common automatic reset diverters are lift-type tub spout diverters, like the product on the left in Figure 1. The diverter mechanism consists of a stem, gate, and washer (see Figure 3). While water is flowing through the tub spout outlet, the user lifts the stem. The water pressure seals the washer against a flat internal surface of the diverter body and stops flow through the tub spout outlet, directing the water to a showerhead or hand-held body spray. When the water supply valve(s) is closed, the reduction in water pressure releases the seal, the diverter mechanism falls to its lowest position by gravity, and water flows through the tub spout outlet again. This design typically results in some leakage during showering events, since the seal is intentionally designed to be weak enough such that a certain drop in water pressure alone will allow it to open. Manufacturers stated that a weep passageway is often included for this reason.

Figure 3: Gate style diverter mechanism.
Source: Ace Hardware (left) and http://www.lincolnrestler.org (right).

Another style of automatic reset diverter, which has a horizontal pull-type diverter handle like the product on the right in Figure 1, includes a spring that prevents leakage during showering events. Examples of this style include the BrassCraft Mixet tub spout diverter (Figure 4) and Evolve Technologies Auto-diverting Tub Spout System (Figure 5). In the absence of water, the spring keeps the tub spout outlet open. When the user opens the shower valve, the diverter remains open. For the Brasscraft Mixet, the user then pulls the tub spout handle to seat the sealing washer and close the passageway to the tub spout outlet. The spring is compressed, but the water pressure keeps the seal intact. When the user then closes the shower valve, the water pressure drops and the spring opens the diverter. For the Evolve Technologies product, a thermostatic (i.e., temperature-based) mechanism activates the seal when the pre-configured shower temperature set point is met, instead of manual operation of the tub spout diverter handle. Water is then diverted to the shower head at a low flow rate until the user operates a separate handle on the shower head arm to obtain the full flow rate. Like the Brasscraft Mixet, the spring then keeps the tub spout diverter seal intact until the user closes the shower valve.

A “pull-down” tub spout diverter (Figure 1, middle) also typically includes a spring, and automatically resets. The major difference between it and the product in Figure 4 is that the user pulls down on a handle that is vertically oriented and concentric with the outlet, instead of a horizontally oriented handle.

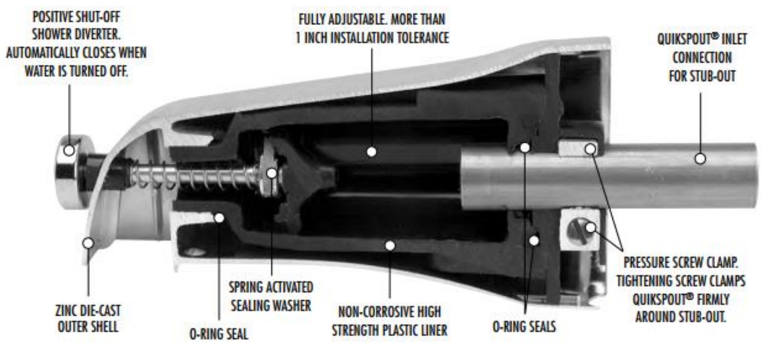

Figure 4: BrassCraft Mixet tub spout diverter.
Source: BrassCraft.

Figure 5: Evolve Technologies Auto-diverting Tub Spout System.
Source: Evolve Technologies.

Turn-type (Figure 2, left and right) and push-type diverters (Figure 2, middle) are typically manual reset diverters, and are mounted in shower valve trim. Turn-type diverters sometimes have more than two settings in order to serve body sprays. Both diverter types typically have little to no leakage during showering events due to product design and tighter fittings. For examples of the two diverter mechanisms (i.e., a push-type and turn-type), see Figure 6. Note that the turn-type mechanism is not unlike a faucet cartridge.

Figure 6: Push-type and turn-type diverter mechanisms, respectively.
Source: Home Depot.

According to manufacturers, automatic reset is a common feature in tub spout diverters, but not in tub-to-shower diverters. Research performed by the Statewide CASE Team shows that some push-button type tub-to-shower diverters have automatic reset. The distinction of automatic versus manual reset is not included in MAEDBS, and is rarely noted on manufacturer literature.

2.1 Current Title 20 Regulations

Tub spout diverters are regulated in California within Title 20 of the California Code of Regulations (CCR), and manufacturers certify their products to the Energy Commission. Title 20 Section 1604(h)(6) states (CEC 2017a), "A tub spout diverter manufactured on or after June 1, 2016 shall be tested in accordance with ASME A112.18.1-2012/CSA B125.1-12, Section 5.3.6 for the rate of leakage conducted prior to lifecycle testing and Section 5.6.1.5 for the rate of leakage conducted after life cycling testing" (CSA 2017).

American Society of Mechanical Engineers' (ASME) and Canadian Standards Associations' (CSA) ASME A112.18.1-2012/CSA B125.1-12 describes leakage rates in only *one* decimal place in gallons per minute (gpm), whereas Energy Commission instructions to manufacturers state that leakage rate results must be reported in gpm to *two* decimal places.

ASME A112.18.1-2012/CSA B125.1-12 allows conventional mathematical rounding of measurements. However, Title 20 Section 1606(a)(3)(E)(1) has stricter requirements about how tested data must be reported. It states, "For any numerical value required by Table X that is produced by a test specified in Section 1604, the reported value shall be no higher for the value for which the consumer would prefer a high number, and no lower for the value for which the consumer would prefer a low number, than the values obtained by testing; unless different specific instructions are specified in the test method specified in Section 1604." Therefore, if leakage rates are rounded, they must be rounded up.

Per ASME A112.18.1-2012/CSA B125.1-12, leakage rates are measured at the tub spout outlet during simulated five-minute showering events when the water is flowing through a secondary outlet (e.g., a showerhead). The non-lifecycle leakage rate test is performed when the diverter is new, whereas the lifecycle leakage rate test is performed after the diverter has been mechanically cycled 15,000 times to mimic mechanical wear.

Table 1 shows the allowable leakage rates in the ASME test procedure and as required in Title 20.

Table 1: Tub Spout Codes and Standards Leakage Rates

Code or Standard	Testing Conditions	Maximum Leakage Rate (gpm)
ASME A112.18.1-2012/CSA B125.1-12	When new	0.1
	After 15,000 cycles of diverting	0.2
Title 20 1605.3(h)(1)	When new	0.01
	After 15,000 cycles of diverting	0.05

Source: ASME/CSA and Energy Commission.

3. Standards Proposal Overview

The Statewide CASE Team's proposal is summarized in Table 2 below for quick reference. Revisions might be proposed after the research outlined in Appendix E: Test Plan is completed.

Table 2: Summary of this Proposal

Topic	Description[a]
Description of Standards Proposal	The Statewide CASE Team is proposing modifications related to definitions and the leakage rate limits. Bath and shower diverters are re-categorized based on whether they have manual reset or automatic reset, and whether they are mounted in the tub spout or elsewhere. The proposed rates are zero gpm pre- and post-lifecycle for all diverters, manual and automatic reset.
Technical Feasibility	All the proposed modifications are technically feasible. There are automatic and manual reset tub spout diverters and tub-to-shower diverters on the market that can meet the proposed leakage rates without reducing functionality.
Energy Savings and Demand Reduction	The proposed leakage rates result in first-year statewide electrical and gas usage savings of 1.04 Gigawatt hours (GWh) per year (yr) and 0.22 million therms/yr. Embedded electricity usage savings are 0.21 GWh/yr and demand reduction is 0.118 Megawatts (MW).
Water Savings	The proposed leakage rates result in first-year statewide water savings of 43.03 million gallons (Mgal) per year.
Environmental Impacts and Benefits	The proposed leakage rates result in first-year statewide greenhouse gas emissions reduction of 1,626.6 metric tons of carbon dioxide equivalent (MTCO2e) per year.
Economic Analysis	The proposed leakage rates are cost-effective. The overall lifecycle benefit to cost ratio is 4.66.
Consumer Acceptance	There will be no loss of diverter functionality. Automatic and manual reset tub spout diverters and tub-to-shower diverters products will all remain on the market.
Other Regulatory Considerations	There are no other regulatory considerations.

Source: Statewide CASE Team analysis 2017.

[a] All sections may change after the research outlined in Appendix E: Test Plan is completed.

4. Proposed Standards and Recommendations

4.1 Proposal Description

The Statewide CASE Team is proposing modifications related to definitions and the leakage rate limits. Additional items might be proposed after the research outlined in Appendix E: Test Plan is completed.

The modifications to the definitions will reduce ambiguity and overall reporting burden for manufacturers, and provide useful additional product information for retailers and consumers. The leakage rate modifications will save water and energy while being cost-effective. See Section 4.3 for the proposed modifications.

4.2 Regulation History

Tub spout diverters have been regulated in Title 20 since March 1992, when the non-lifecycle and lifecycle test leakage rate requirements were 0.1 gpm and 0.3 gpm. The current leakage rate requirements of 0.01 and 0.05 gpm went into effect in March 2003, and the breadth of products now in MAEDBS shows that this large reduction was technically feasible.

Current Title 20 states that products manufactured on or after June 1, 2016, shall be tested to excerpts of the ASME A112.18.1-2012/CSA B125.1-12 test procedure. Here is a list of the previous test procedures required under Title 20, ordered by the first year it went into effect in Title 20:

- 1992: ANSI/ASME A112.18.1M-1989
- 2002: ANSI/ASME A112.18.1-2000
- 2009: ANSI/ASME A112.18.1M-1996
- 2014: 10 C.F.R. section 430.23(s) (Appendix S to Subpart B of part 430)
- 2016: ASME A112.18.1-2012/CSA B125.1-12, Section 5.3.6 and Section 5.6.1.5

This current ASME test procedure was recertified in 2017 without modification, and was previously published in 1989, 1996, 2000, 2005, 2011, and 2012. The three earliest versions required testing at 20 pounds per square inch gauge (psig) and 60 psig, and the current version requires solely 10 psig. Tub spout diverters are not currently federally regulated, but the EPA intends to create a WaterSense specification for them (U.S. EPA 2017a).

The Energy Commission conducted two public workshops for this pre-rulemaking of tub spout diverters and accepted public comments. The first workshop was titled “Invitation to Participate, Phase 2 Pre-Rulemaking”, and was held on May 11, 2017 (CEC 2017c). The Energy Commission outlined their goals and requests for information. The second workshop was titled “Results of Invitation to Participate: Tub Spout Diverters”, and was held on July 20, 2017 (CEC 2017d). The Statewide CASE Team participated in both workshops, provided oral comments during the second workshop, and provided written comments to EPA regarding their related WaterSense tub spout diverter specification proceedings (U.S. EPA 2017c). The Statewide CASE Team also interviewed three tub spout manufacturers (one of which does their own Title 20 testing), one plumbing manufacturer trade group, and two independent Title 20 approved test laboratories (labs).

4.3 Proposed Changes to the Title 20 Regulatory Language

The proposed changes to Title 20 are provided below. Changes to the standards are marked with <u>underlining</u> (new language) and ~~strikethroughs~~ (deletions).

4.3.1 Proposed Definitions

Title 20 Section 1601(h)

(h) Plumbing fittings, which are showerheads, lavatory faucets, kitchen faucets that are consumer products, metering faucets, replacement aerators, wash fountains, ~~tub spout~~ <u>bath and shower</u> diverters, public lavatory faucets, and commercial pre-rinse spray valves.

Title 20 Section 1602(h)

<u>"Automatic reset diverter" means a bath and shower diverter that automatically redirects all water flow through the tub spout after a shower valve is closed, such that when the shower valve is subsequently opened, all water initially flows through the tub spout.</u>

<u>"Bath and shower diverter" means a device used to direct the flow of water either toward a tub spout or toward a secondary outlet intended for showering purposes (e.g., showerhead, body spray).</u>

"Leakage rate" means the rate of leakage through a ~~tub spout~~ <u>bath and shower</u> diverter directly into the bathtub when the diverter is in the diverting position, as determined using the applicable test method in Section 1604(h).

~~"Lift-type tub spout diverter" means a tub spout diverter that is operated by lifting the control.~~

<u>"Manual reset diverter" means a bath and shower diverter that does not have the capability to automatically redirect water flow after a shower valve is closed, but instead always requires direct user operation to redirect water flow.</u>

"Plumbing fitting" means a device that controls and guides the flow of water in a supply system. A plumbing fitting includes a showerhead, lavatory faucet, kitchen faucet, metering faucet, lavatory replacement aerator, kitchen replacement aerator, wash fountain, commercial pre-rinse spray valve, public lavatory faucet, or ~~tub spout~~ <u>bath and shower</u> diverter.

~~"Pull-type tub spout diverter" means a tub spout diverter that is operated by pulling the control.~~

"Showerhead-<u>bath and shower</u> ~~tub spout~~ diverter combination" means a group of plumbing fittings sold as a matched set and consisting of a control valve, <u>a bath and shower diverter</u>, a tub spout ~~diverter~~, and a showerhead.

"Tub spout diverter" means a <u>bath and shower diverter whose diverter mechanism is located in the tub spout.</u> ~~device designed to stop the flow of water into a bathtub and to divert it so that the water discharges through a showerhead.~~

<u>"Tub-to-shower diverter" means a bath and shower diverter whose diverter mechanism is not located in the tub spout.</u>

~~"Turn-type tub spout diverter" means a tub spout diverter that is operated by turning the control.~~

4.3.2 Proposed Test Procedure

The Statewide CASE Team proposes that a now outdated test procedure reference be removed, and that the term "tub spout diverter" is replaced by the term "bath and shower diverter". More proposed items may be added after the research outlined in Appendix E: Test Plan is completed.

Title 20 Section 1604(h)(5), (6)

(5) ~~A tub spout diverter manufactured before June 1, 2016 shall be tested per 10 C.F.R. section 430.23(s) (Appendix S to Subpart B of part 430).~~ A bath and shower diverter manufactured on or after June 1, 2016 shall be tested in accordance with ASME A112.18.1-2012/CSA B125.1-12, Section 5.3.6 for the rate of leakage conducted prior to life cycle testing and Section 5.6.1.5 for the rate of leakage conducted after life cycling testing.

(6) ~~A tub spout diverter manufactured on or after June 1, 2016 shall be tested in accordance with ASME A112.18.1-2012/CSA B125.1-12, Section 5.3.6 for the rate of leakage conducted prior to life cycle testing and Section 5.6.1.5 for the rate of leakage conducted after life cycling testing.~~

4.3.3 Proposed Standard Metrics

The Statewide CASE Team proposes that all diverters have leakage rates of zero gpm, and like the prior section, that the term "tub spout diverter" is replaced by the term "bath and shower diverter." Revisions may occur after the research outlined in Appendix E: Test Plan is completed.

Title 20 Section 1605.3(h)(1)

(h) Plumbing Fittings

(1)

(A) ~~Tub Spout Diverters and Showerhead Tub Spout Diverter Combinations~~ Bath and Shower Diverters and Showerhead-Bath and Shower Diverter Combinations. The leakage rate of bath and shower ~~tub spout~~ diverters manufactured on or after March 1, 2003, and before July 1, 2019, shall be not greater than the applicable values shown in Table H-2A. Showerhead-bath and shower ~~tub spout~~ diverter combinations shall meet both the standard for showerheads and the standard for ~~tub spout~~ bath and shower diverters.

Table H-2A, Standards for ~~Tub Spout~~ Bath and Shower Diverters

Appliance	Testing Conditions	Maximum Leakage Rate
Bath and shower ~~Tub spout~~ diverters	When new	0.010 gpm
	After 15,000 cycles of diverting	0.050 gpm

(B) Bath and Shower Diverters and Showerhead-Bath and Shower Diverter Combinations. The leakage rate of bath and shower diverters manufactured on or after July 1, 2019 shall be not greater than the applicable values shown in Table H-2B. Showerhead-bath and shower diverter combinations shall meet both the standard for showerheads and the standard for bath and shower diverters.

Table H-2B, Standards for Bath and Shower Diverters

Appliance	**Testing Conditions**	**Maximum Leakage Rate**
Manual reset diverters	When new	0.000 gpm
	After 15,000 cycles of diverting	0.000 gpm
Automatic reset diverters	When new	0.000 gpm
	After 15,000 cycles of diverting	0.000 gpm

4.3.4 Proposed Reporting Requirements

The Statewide CASE Team proposes that manufacturers no longer report whether a bath and shower diverter is turn, push, pull, or lift type, and instead report on the different characteristics as noted below in Table X from Section 1606(a)(3)(E). The Statewide CASE Team also proposes that the instructions should also require leakage rates to be reported to three decimal places, in units of gpm, instead of the current requirement of two decimal places.

Title 20 Section 1606(a)(3)(E)

Table X, Data Submittal Requirements

Appliance	**Required Information**	**Permissible Answers**
H, Plumbing Fittings	Type	Showerhead, lavatory faucet (independent or collective), public lavatory faucet, kitchen faucet, metering faucet (independent or collective), lavatory replacement aerator, kitchen replacement aerator, wash fountain, ~~lift-type tub spout diverter, turn-type tub spout diverter, pull-type tub spout diverter, push-type tub spout diverter~~ bath and shower diverter
	Showerhead-bath and shower diverter combination (diverters only)	True, False
	Reset Function (diverters only)	Automatic reset diverter, manual reset diverter
	Diverter Mechanism Location (diverters only)	Tub spout diverter, tub-to-shower diverter

4.3.5 Proposed Marking and Labeling Requirements

The Statewide CASE Team is proposing that manufacturers be required to mark the packaging and product literature with “automatic reset” or “manual reset” to inform consumers of that feature. Currently, such labeling is voluntary and uncommon.

Title 20 Section 1607(c)(1)

(1) For plumbing fixtures and plumbing fittings, the information required by Section 1607(b) shall be permanently, legibly, and conspicuously displayed on an accessible place on each unit or on the unit's packaging.

<u>(2) For bath and shower diverters, the packaging shall also indicate whether the product is “automatic reset” or “manual reset.”</u>

5. Analysis of Proposal

5.1 Product Efficiency Opportunities

The Statewide CASE Team is proposing zero leakage for all diverters for both the pre- and post-lifecycle tests. For manual reset diverters, the Statewide CASE Team learned from manufacturers and analysis of MAEDBS that most manual reset diverters already have zero leakage. For automatic reset diverters, there are fewer zero leakage products on the market, but the incremental cost is low and they have no loss in functionality.

5.2 Technical Feasibility

MAEDBS, which categorizes diverters by turn, push, lift, and pull-type, was used to analyze the diverter market. Turn and push-type diverters are all assumed to be manual reset diverters, while lift and pull-type diverters are assumed to all be automatic reset diverters. As of October 9, 2017, there were 3,083 diverter products by 61 manufacturers in the complete database. However, only diverters added to MAEDBS after June 1, 2016, were analyzed, since prior diverters required an outdated test procedure. These diverters consist of 1,352 products (44 percent) by 30 manufacturers (49 percent), and are shown in Table 3 below categorized by diverter type and leakage rate.

Of the manual reset diverters, 89.2 percent have pre- and post-lifecycle leakage rates of zero gpm. Therefore, technical feasibility is apparent. Of the automatic reset diverters, only 20 percent have pre- and post-lifecycle leakage rates of zero gpm. However, those diverters do not have any loss of functionality, since they also include tub spout mounted diverters. The biggest difference is that they likely have a spring in the diverter mechanism, and the handle is likely pulled horizontally or pulled down vertically rather than lifted up vertically.

Table 3: Diverters Added to MAEDBS after 6/1/2016

Diverter Type	Quantity	Percent of All Diverters[a]	Pre- and Post-Lifecycle Leakage Rates = 0 gpm		Pre- and Post-Lifecycle Leakage Rates > 0 gpm	
			Quantity	Percent[b]	Quantity	Percent[b]
Manual Reset Diverters						
Turn-type	340	25.1	303	89.1	37	10.9
Push-type	76	5.6	68	89.5	8	10.5
All Manual	416	30.8	371	89.2	45	10.8
Automatic Reset Diverters						
Lift-type	778	57.5	124	15.9	654	84.1
Pull-type	158	11.7	63	39.9	95	60.1
All Automatic	936	69.2	187	20.0	749	80.0
All Diverters						
All Diverters	1352	100.0	558	41.3	794	58.7

Source: Energy Commission, MAEDBS, exported October 9, 2017.

[a] Each percentage in this column is relative to the total quantity of all diverters (1352).

[b] Each percentage in this column is relative to the quantity of diverters for the given diverter type (varies by row).

5.3 Statewide Water and Energy Savings

5.3.1 Per Unit Water and Energy Savings Methodology

This section describes the methodology the Statewide CASE Team used to estimate water, energy, and environmental impacts. The Statewide CASE Team calculated the impacts of the proposed code change by comparing non-qualifying products to qualifying products. The assumptions and per unit results are shown in Table 4 and described further in the subsequent sections. Results are grouped by manual and automatic reset diverters.

Table 4: Per Unit Water and Energy Savings Assumptions and Findings

Metric	Value	Source/Notes/Equations
Assumptions		
Average shower duration [A]	7.8 minutes/shower	(WRF 2016; U.S. EPA 2017b).
Showers per person per day [B]	0.7 showers/person/day	(U.S. EPA 2017b).
Shower days per year [C]	365 days/yr	
Shower fixtures per household [D]	1.625 shower fixtures/household	(U.S. Census 2015). See section 5.3.2.
Persons per household [E]	2.97 persons/household	(CA DOF 2017).
Savings factor [F]	0.97	(Taitem 2011, 4). Extrapolated the 52 psig regression line in Taitem's Figure 5 to 0.02 gpm.
Shower warm-up waste duration [G]	1.330 minutes	(Sherman 2014 7,11,21; Lutz 2004; Lutz 2011). See section 5.3.2.
Non-qualifying average lifetime diverter leakage flow rate [H]	Manual: 0.0016 gpm Auto.: 0.0195 gpm	(CEC 2017b). Exported post-6/1/16 MAEDBS data on 10/9/17. Turn and push type assumed to be manual. Lift and pull type assumed to be automatic. See Table 5.

Qualifying average lifetime diverter leakage flow rate [I]	Manual: 0.000 gpm Auto.: 0.000 gpm	Proposed Title 20 maximum average lifetime leakage flow rates.
Percent of water use that is hot [J]	73.1	(Seattle & EPA 2000).
Natural gas required to heat water [K]	0.0089 therms/gallon	(CEC 2015). See Equation 4 below. Assumes cold water inlet temperature is 60 °F, hot water supply is 124 °F, and average Energy Factor rating of 0.60.
Electricity required to heat water [L]	0.1647 kWh/gallon	(CEC 2015). See Equation 4 below. Assumes cold water inlet temperature is 60 °F, hot water supply is 124 °F, and average Energy Factor rating of 0.95.
Embedded electricity factor [M]	4,848 kWh/Mgal	(CPUC 2015). See Appendix D for methodology.
Peak demand load factor [N]	1	(CEC 2015). Simplified assumption that load profile is completely flat.
Results		
Duty cycle [O]	3021 minutes/diverter/yr	$O = (A - G) \times B \times C \times E \div D$
Annual water use per diverter (Non-qualifying) [P]	Manual: 4.68 gallons/diverter/yr Auto.: 58.86 gallons/diverter/yr	$P = O \times H$
Annual natural gas use for water heating per diverter (Non-qualifying) [Q]	Manual: 0.03 therms/diverter/yr Auto.: 0.38 therms/diverter/yr	$Q = P \times J \times K$
Annual electricity use for water heating per diverter (Non-qualifying) [R]	Manual: 0.56 kWh/diverter/yr Auto.: 7.09 kWh/diverter/yr	$R = P \times J \times L$
Annual embedded electricity per diverter (Non-qualifying) [S]	Manual: 0.02 kWh/diverter/yr Auto.: 0.29 kWh/diverter/yr	$S = P \times M \div 10^6$
Peak demand per diverter (Non-qualifying) [T]	Manual: 0.06 W/diverter/yr Auto.: 0.81 W/diverter/yr	$T = R \times \frac{1000\ W}{kW} \div \frac{8760\ hrs}{yr} \div N$
Annual water use per diverter (Qualifying) [U]	Manual: 0 gallons/diverter/yr Auto.: 0 gallons/diverter/yr	$U = O \times I$
Annual natural gas use for water heating per diverter (Qualifying) [V]	Manual: 0 therms/diverter/yr Auto.: 0 therms/diverter/yr	$V = U \times J \times K$
Annual electricity use for water heating per diverter (Qualifying) [W]	Manual: 0 kWh/diverter/yr Auto.: 0 kWh/diverter/yr	$W = U \times J \times L$
Annual embedded electricity per diverter (Qualifying) [X]	Manual: 0 kWh/diverter/yr Auto.: 0 kWh/diverter/yr	$X = U \times M \div 10^6$
Peak demand per diverter (Qualifying) [Y]	Manual: 0 W/diverter/yr Auto.: 0 W/diverter/yr	$Y = W \times \frac{1000\ W}{kW} \div \frac{8760\ hrs}{yr} \div N$
Annual water savings per diverter [Z]	Manual: 4.54 gallons/diverter/yr Auto.: 57.10 gallons/diverter/yr	$Z = F \times (P - U)$
Annual natural gas savings per diverter [AA]	Manual: 0.03 therms/diverter/yr Auto.: 0.37 therms/diverter/yr	$AA = F \times (Q - V)$
Annual electricity savings per diverter [BB]	Manual: 0.55 kWh/diverter/yr Auto.: 6.87 kWh/diverter/yr	$BB = F \times (R - W)$
Annual embedded electricity savings per diverter [CC]	Manual: 0.02 kWh/diverter/yr Auto.: 0.28 kWh/diverter/yr	$CC = Z \times M \div 10^6$
Peak demand reduction per diverter [DD]	Manual: 0.06 W/diverter/yr Auto.: 0.78 W/diverter/yr	$DD = BB \times \frac{1000\ W}{kW} \div \frac{8760\ hrs}{yr} \div N$

Source: The Statewide CASE Team analysis 2017.

5.3.2 Annual Water Use Per Unit Methodology

Average annual water usage per diverter is equal to duty cycle multiplied by average lifetime leakage flow rate. The duty cycle is shown in Equation 1 below and has units of minutes per diverter per year. It represents the time that the diverter is closed to the tub spout outlet and showering is occurring (i.e., structural water waste is ignored).

Equation 1: Time Each Diverter is in Use per Year

$$Duty\ cycle\ (minutes\ per\ diverter\ per\ year) = (shower\ duration - warmup\ waste\ duration) \times showers\ per\ person\ per\ day \times 365\ days\ per\ year \times persons\ per\ household \div shower\ fixtures\ per\ household$$

Shower duration and showers per person per day were obtained from the Water Research Foundation's (WRF) Residential End Uses of Water, Version 2 Executive Report (WRF 2016) and EPA WaterSense comments to the Energy Commission respectively (U.S. EPA 2017b).

Shower warm-up waste duration was derived from a study by Evolve Technologies (Sherman 2014), which was based on two studies by Lawrence Berkeley National Laboratory (LBNL) (Lutz 2004; Lutz 2011). In the 2004 study (Lutz 2004), LBNL calculated an average warm-up duration of 95 seconds (Sherman 2014, 7), which was based on data from the 1999 Residential End Uses of Water (Mayer 1999). In the 2011 study, LBNL began collecting field data and subsequently gave Evolve Technologies access to the data from 19 homes, of which they analyzed 11. Evolve Technologies calculated the average warm-up waste duration to be 64.6 seconds. They then averaged this with the 2004 study to obtain 79.8 seconds, or 1.33 minutes (Sherman 2014 7,11,21).

To calculate shower fixtures per household, bathroom quantity per household was calculated using data from the U.S. Census Bureau American Housing Survey for the year 2015 (U.S. Census 2015). The survey includes national, San Francisco, Los Angeles – Long Beach, and other non-California metro area data. The Statewide CASE Team averaged the California data to obtain 1.625 bathrooms per household.

Average non-qualifying (i.e., currently code compliant) lifetime leakage flow rate is calculated separately for manual reset and automatic reset diverters using MAEDBS. Diverters added to MAEDBS before June 1, 2016, are ignored since they might have been tested under an outdated test procedure. For each diverter, the leakage flow rate is assumed to degrade linearly from the pre- to the post-lifecycle test leakage measurement over the product's lifetime. Therefore, the average leakage flow rate is assumed to be the average of these two values. Turn and push-type diverters are assumed to be manual reset diverters, while lift and pull-type diverters are assumed to be automatic reset diverters. The grouped averages are shown below in Table 5.

Average *qualifying* lifetime leakage flow rates are based on the proposed Title 20 allowable leakage flow rates. Since zero gpm is proposed for both pre- and post-lifecycle, no average is needed here.

Table 5: Non-Qualifying Average Lifetime Diverter Leakage Flow Rates

Diverter Type	Quantity	Percent of All Diverters[a]	Non-Qualifying Average Lifetime Diverter Leakage Flow Rate (gpm)
Manual Reset Diverters			
Turn-type	340	25.1	0.00126
Push-type	76	5.6	0.00283
All Manual	416	30.8	0.00155
Automatic Reset Diverters			
Lift-type	778	57.5	0.02013
Pull-type	158	11.7	0.01633
All Automatic	936	69.2	0.01949

Source: Energy Commission, MAEDBS, exported October 9, 2017.

[a] Each percentage in this column is relative to the total quantity of all diverters (1352).

Savings are de-rated by a *savings factor* that was extrapolated for a leakage rate of 0.02 gpm from the 52 psig system water pressure regression line in Figure 5 of Taitem's diverter leakage study (Taitem 2011, 4). Savings factor is defined as the ratio of *saved water* to *tub spout leakage water* when a tub spout leak is corrected. Savings factor is not always 100 percent, because fixing a leak increases the system water pressure. If the showerhead is not pressure-compensating, the increase in system water pressure will increase the flow through the showerhead to some degree, and the savings factor is less than 100 percent. If a showerhead is pressure-compensating, the increase in system water pressure will not increase flow through the showerhead, and the savings factor is 100 percent.

5.3.3 Annual Energy Use Per Unit for Water Heating Methodology

Water heating energy usage per gallon of saved water is calculated for both gas-fired and electric water heaters (see Equation 2). All assumptions match those used by the Energy Commission in their 2015 staff report for showerheads (CEC 2015).

Equation 2: Water Heating Energy Usage per Gallon of Hot Water

$Energy\ per\ gallon\ of\ hot\ water\ =\ m \times c_p \times (T_H - T_C)/(\eta_i \times cf_i)$ where

$$m = weight\ of\ a\ gallon\ of\ water = 8.34\ lbs/gallon$$

$$c_p = heat\ capacity\ of\ water = 1\ BTU/(lb \cdot {}^\circ F)$$

$$T_H\ and\ T_C = hot\ and\ cold\ water\ temperatures = 124\ {}^\circ F\ and\ 60\ {}^\circ F$$

$$\eta_i = water\ heater\ efficiency = 0.60\ for\ gas\ and\ 0.95\ for\ electricity$$

$$cf_i = energy\ conversion\ factor = 100{,}000\ BTU/therm\ and\ 3{,}412\ BTU/kWh\ respectively$$

5.3.4 Annual Embedded Electricity Per Unit Use Methodology

Embedded electricity use for indoor water use includes electricity used for water extraction, conveyance, treatment to potable quality, water distribution, wastewater collection, and wastewater treatment. The embedded electricity values do not include onsite energy uses for water, such as on-site pumping. On-site energy impacts are accounted for in the energy savings estimates presented in this report. For more details, see Appendix D: Embedded Electricity Usage Methodology.

5.3.5 Peak Demand Methodology

Peak demand was calculated by multiplying daily electricity use by an assumed load factor. Load factor is the ratio of average annual load to coincident peak load. As the Energy Commission did in the staff report about showerheads (CEC 2015), the Statewide CASE Team assumed a flat load profile and therefore a load factor of one.

5.4 Summary of Water and Energy Use Per Unit Impacts

Annual water and energy per unit impacts are presented in Table 6 below. As previously described, non-qualifying products are products that do not meet the proposed standard, and qualifying products are products that meet the proposed standards. The methodology used to calculate these estimates is presented above in section 5.3.1.

Table 6: Annual Water and Energy Use Per Unit and Potential Savings from Qualifying Products

Diverter Product Type	Water Use per Unit (gallons/yr)	Natural Gas Use per Unit (therms/yr)	Electricity Use per Unit (kWh/yr)	Embedded Electricity Use per Unit (kWh/yr)	Peak Demand per Unit (W)
Non-qualifying Products					
Manual Reset	4.68	0.03	0.56	0.02	0.06
Automatic Reset	58.86	0.38	7.09	0.29	0.81
Qualifying Products					
Manual Reset	0	0	0	0	0
Automatic Reset	0	0	0	0	0
Savings					
Manual Reset	4.54	0.03	0.55	0.02	0.06
Automatic Reset	57.10	0.37	6.87	0.28	0.78

Source: The Statewide CASE Team analysis 2017.

5.4.1 Stock

The effective date of the proposed leakage rates is July 1, 2019, and the assumed diverter lifetime is 20 years (U.S. EPA 2017a, 8). The annual stock is calculated for July 1, 2019, and for the subsequent 20 years until June 30, 2039. For each year, the diverter stock was estimated by multiplying the diverters per household by the estimated number of occupied housing units in California.

To calculate diverters per household, bathroom quantity per household (see Table 4) was derated to account for bathrooms without bath and shower diverters (i.e., bathrooms with showerheads, but no tub spout) using the National Kitchen and Bath Association (NKBA) 2016 Kitchen and Bath Design Trends Report (NKBA 2016, 27). Per the introduction of the report, it is based on a survey of over 450 professionals in the U.S. in the kitchen and bath industry and is "most valuable in identifying trends among kitchens in the $20,000 - $49,000 price range and up and bathrooms in the $10,000 - $30,000 range and up" (NKBA 2016, ii). The Statewide CASE Team assumed that master bathrooms always have a diverter, but only 67 percent of all other bathrooms have one (NKBA 2016, 27). This a conservative estimate, because not every diverter replacement will be a deep retrofit or new construction. This results in 1.42 diverters per household.

As of January 1, 2017, the California Department of Finance estimated that there were 13,020,413 occupied housing units (CA DOF 2017). According to the California Department of Housing and Community Development, the projected annual housing need from 2015 to 2025 is 180,000 homes per year, while the state averaged less than 80,000 new homes per year from 2006 through 2015 (CA HCD 2017, 6-7). As a conservative estimate, the building stock is assumed to increase linearly every year by 80,000 households. This yields 13,220,413 households on July 1, 2019, and 80,000 more each year thereafter. MAEDBS was used to estimate the percentage of manual versus automatic reset diverters. Turn- and push-type diverters were assumed to be manual reset, while lift- and pull-type diverters were assumed to be automatic reset. The diverter stock at the end of the first year (2020) and last year (2039) of the analysis is shown in the last column in Table 7.

5.4.2 Shipments

Diverter lifetime is assumed to be 20 years, as EPA calculated (U.S. EPA 2017a, 8). Diverter stock turnover is assumed to occur over the same timeframe at a linear rate, resulting in annual diverter upgrades of five percent of the July 1, 2019, diverter stock. Annual shipments also include diverters for the assumed 80,000 new housing units per year. Since both these rates are constant, annual shipments in 2020 and 2039 are the same. The diverter shipment calculation is shown in Table 8 and the results are shown in middle column of Table 7.

Table 7: California Shipments and Stock

Year and Product Type	Annual Shipments	Stock
2020		
Manual Reset	323,543	5,807,199
Automatic Reset	727,972	13,066,198
Total	1,051,514	18,873,396
2039		
Manual Reset	323,543	6,470,858
Automatic Reset	727,972	14,559,431
Total	1,051,514	21,030,289

Source: The Statewide CASE Team analysis 2017.

5.4.3 Statewide Water & Energy Savings - Methodology

Statewide savings estimates were calculated by applying the per unit water and energy savings to the statewide stock and sales forecast presented above. Table 8 shows the assumptions and results of these calculations, in some cases referring to variables in Table 4. The percentages of households with natural gas versus electric water heating are sourced from the Energy Commission's staff report on showerheads (CEC 2015).

Table 8: Statewide Water and Energy Savings Methodology, Assumptions and Findings

Metric	Value	Source/Notes/Equations
Assumptions		
Product Useful Life [A]	20 years	(U.S. EPA 2017a, 8).
Diverters per household [B]	1.419 diverters/household	(U.S. Census 2015; NKBA 2016, 27). See section 5.4.1 above.
California, as of 7/1/2019, Occupied Housing Units [C]	13,220,413 housing units	(CA DOF 2017; CA HCD 2017). See section 5.4.1 above.
New housing units per year [D]	80,000 housing units	(CA HCD 2017).
Diverter type percentages [E]	Manual: 0.31 Auto: 0.69	(CEC 2017b). Exported post-6/1/16 MAEDBS data on 10/9/17. Turn and push type assumed to be manual. Lift and pull type assumed to be automatic. See Table 5.
Percent of households with Natural Gas Water Heating [F]	80	(CEC 2015).
Percent of Households with Electric Water Heating [G]	20	(CEC 2015).
Results		
Diverter stock, as of 7/1/2019 [H]	Manual: 5,772,269 diverters Auto: 12,987,606 diverters	$H = B \times C \times E$
Percent of Diverter Stock Upgraded Per Year [I]	5	$I = 1 \div A$
Annual Diverter Shipments [J]	Manual: 323,543 diverters Auto: 727,972 diverters	$J = (H \times I) + (B \times D \times E)$
Statewide annual water savings during first year standard is in effect [K]	Manual: 1.47 Mgal/yr Auto.: 41.56 Mgal/yr	$K = J \times (Z\ in\ Table\ 4) \div 1\ million\ gallons$
Statewide annual natural gas savings during first year standard is in effect [L]	Manual: 0.01 million therms/yr Auto.: 0.22 million therms/yr	$L = J \times \frac{F}{100} \times (AA\ in\ Table\ 4) \div 1\ million\ therms$
Statewide annual electricity savings from water heating during first year standard is in effect [M]	Manual: 0.04 GWh/ yr Auto.: 1.00 GWh/ yr	$M = J \times \frac{G}{100} \times (BB\ in\ Table\ 4) \div 1\ million\ kWh/GWh$
Statewide annual embedded electricity savings during first year standard is in effect [N]	Manual: 0.01 GWh/yr Auto.: 0.20 GWh/yr	$N = J \times (CC\ in\ Table\ 4) \div 1\ million\ kWh/GWh$
Statewide peak demand reduction during first year standard is in effect [O]	Manual: 0.004 MW Auto.: 0.114 MW	$O = J \times \frac{G}{100} \times (DD\ in\ Table\ 4) \div 1\ million\ MW/W$

Source: The Statewide CASE Team analysis 2017.

5.4.4 Statewide Water & Energy Use – Non-Standards and Standards Case

This section summarizes all the statewide calculations. Table 9 shows the results for the non-standards case, which is referred to as non-qualifying in the per unit calculations in section 5.3.3. Table 10 shows the results for the standards case, which is referred to as qualifying in the per unit calculations in section 5.3.3. Those results are all zero given the proposed leakage rates of zero gpm. Table 11 shows the comprehensive savings calculation results. Those savings results are the difference of the non-standards and standards cases, multiplied by the savings factor from section 5.3.3.

In all cases, results are categorized by annual shipments and by stock; by manual and automatic reset diverters; and by the years 2020 and 2039. The first year that the proposed standards are in effect concludes on July 1, 2020, and the stock turns over on June 30, 2039 (i.e., when every diverter has been replaced given the assumption in section 5.4.2). For each diverter type, the annual shipments in 2020 and 2039 are the same given the simplified assumptions that existing diverter stock is upgraded at a constant rate and new housing units are added at a constant rate. The stock calculations on the right side of each table shows the cumulative statewide values for each diverter group and year. The 2039 results account for the first-year shipments being in place for 20 years, the second-year shipments for 19 years, and so on.

Table 9: California Statewide Water & Energy Use for Non-Standards Case – After Effective Date

Year	Annual Shipments					Stock				
	Water Use (Mgal/yr)	Natural Gas Use[b] (million therms/yr)	Electricity Use[a] (GWh/yr)	Embedded Electricity Use (GWh/yr)	Electricity Demand (MW)	Water Use (Mgal/yr)	Natural Gas Use[b] (million therms/yr)	Electricity Use[a] (GWh/yr)	Embedded Electricity Use (GWh/yr)	Peak Demand (MW)
Manual Reset Diverters										
2020	1.52	0.01	0.04	0.01	0.004	1.52	0.01	0.04	0.01	0.004
2039	1.52	0.01	0.04	0.01	0.004	318.21	1.66	7.66	1.54	0.875
Automatic Reset Diverters										
2020	42.85	0.22	1.03	0.21	0.118	42.85	0.22	1.03	0.21	0.118
2039	42.85	0.22	1.03	0.21	0.118	8998.60	46.81	216.64	43.63	24.730

Source: The Statewide CASE Team analysis 2017

[a,b] Depends on energy source used for heating water, and accounts for the estimated percentage of each in the building stock.

Table 10: California Statewide Water & Energy Use for Standards Case – After Effective Date

Year	Annual Shipments					Stock				
	Water Use (Mgal/yr)	Natural Gas Use[b] (million therms/yr)	Electricity Use[a] (GWh/yr)	Embedded Electricity Use (GWh/yr)	Electricity Demand (MW)	Water Use (M gal/yr)	Natural Gas Use[b] (million therms/yr)	Electricity Use[a] (GWh/yr)	Embedded Electricity Use (GWh/yr)	Peak Demand (MW)
Manual Reset Diverters										
2020	0	0	0	0	0	0	0	0	0	0
2039	0	0	0	0	0	0	0	0	0	0
Automatic Reset Diverters										
2020	0	0	0	0	0	0	0	0	0	0
2039	0	0	0	0	0	0	0	0	0	0

Source: The Statewide CASE Team analysis 2017

[a,b] Depends on energy source used for heating water, and accounts for the estimated percentage of each in the building stock.

Table 11: California Statewide Water & Energy Savings for Standards Case – After Effective Date

Year	Annual Shipments					Stock				
	Water Use (Mgal/yr)	Natural Gas Use[b] (million therms/yr)	Electricity Use[a] (GWh/yr)	Embedded Electricity Use (GWh/yr)	Electricity Demand (MW)	Water Use (Mgal/yr)	Natural Gas Use[b] (million therms/yr)	Electricity Use[a] (GWh/yr)	Embedded Electricity Use (GWh/yr)	Peak Demand (MW)
Manual reset diverters										
2020	1.47	0.01	0.04	0.01	0.004	1.47	0.01	0.04	0.01	0.004
2039	1.47	0.01	0.04	0.01	0.004	308.66	1.61	7.43	1.50	0.848
Automatic reset diverters										
2020	41.56	0.22	1.00	0.20	0.114	41.56	0.22	1.00	0.20	0.114
2039	41.56	0.22	1.00	0.20	0.114	8728.64	45.41	210.14	42.32	23.989
All diverters										
2020	43.03	0.22	1.04	0.21	0.118	43.03	0.22	1.04	0.21	0.118
2039	43.03	0.22	1.04	0.21	0.118	9037.30	47.02	217.57	43.81	24.837

Source: The Statewide CASE Team analysis 2017.

[a,b] Depends on energy source used for heating water, and accounts for the estimated percentage of each in the building stock.

5.5 Cost-Effectiveness

This section describes the methodology and approach the Statewide CASE Team used to analyze the economic impacts of the proposed standard.

5.5.1 Incremental Cost

Continuing with the assumption that the turn and push-type diverters added to MAEDBS after June 1, 2016, represent the manual diverter market, 89 percent have lifetime leakage rates of zero gpm. Since such a high percentage of these products already meet the proposed standard, incremental cost is assumed to be zero dollars.

For lift and pull-type diverters, the percentage is lower (20 percent), so their incremental cost was estimated. Online prices for popular tub spout mounted diverters on Home Depot's and Lowe's websites were used.[2] Diverter prices vary substantially due to body materials and finish. Since non-decorative chrome is most ubiquitous, that was used. This filtering yielded 38 products that ranged in price from $10.99 to $41.58. Most were lift-type and some were pull-type or pull-down type. Products were spot checked in MAEDBS to find those with zero gpm pre- and post-lifecycle leakage ratings. One pull-down diverter by Danco (Model 10766, $17.50) and two pull-type diverters by BrassCraft Mixet (Model MXT01, $19.99; Model MXT02, $20.94) met these criteria.

The Danco and Mixet products were averaged to yield an estimated qualifying product cost of $19.48. The ten lowest cost products of the 38 were averaged to yield an estimated non-qualifying product cost of $15.22. The difference of $4.25 is then assumed to be the incremental cost.

5.5.2 Design Life

As stated in section 5.4.1, diverter lifetime is assumed to be 20 years per EPA's calculation (U.S. EPA 2017a, 8).

5.5.3 Lifecycle Cost/Net Benefit

The per unit and total lifecycle costs and benefits of the proposed standard are presented in Table 12 and Table 13 below. The proposed standards for manual and automatic reset diverters are both cost-effective. For manual reset diverters, the savings are lower but the incremental cost is zero. For automatic reset diverters, the low incremental cost makes the proposal cost-effective.

[2] Data was downloaded on 10/30/2017.

Table 12: Costs and Benefits per Unit for Qualifying Products [a]

Product Class	Product Life (years)	Lifecycle Costs per Unit (2017 $) [b]	Lifecycle Benefits per Unit (2017 $)			Net Present Value per Unit (2017 $)	
		Incremental Cost [c]	Water Savings [e]	Electricity Savings [f]	Natural Gas [g] Savings	Electricity	Natural Gas
Manual Reset	20	$0.00	$0.77	$2.10	$0.83	$2.87	$1.60
Automatic Reset	20	$4.25	$9.67	$26.40	$10.41	$31.81	$15.82

[a] Cost savings will be realized through lower electricity, gas, and water bills. Average annual electricity, gas and water rates were used, starting in the effective year. The analysis does not include cost savings associated with embedded energy savings.

[b] PV = Present Value. Calculated using the Energy Commission's average statewide PV statewide energy rates that assume a 3 percent discount rate (CEC 2017).

[c] Incremental cost is the cost difference between the baseline non-qualifying product and the qualifying product.

[e] Water savings apply to all diverters regardless of the type of water heater.

[f] Electricity savings only apply to diverters installed in homes that have electric water heating.

[g] Natural gas savings only apply to diverters installed in homes that have natural gas water heating.

Table 13: Statewide Total Lifecycle Costs and Benefits for Standards Case [a]

Product Class	Lifecycle Benefit/ Cost Ratio[b]	Total Lifecycle Costs/Benefits		Net Present Value ($)[c]	
		Total Lifecycle Benefit Resulting from First Year of Implementation (Present Value $)	Total Lifecycle Cost Resulting from First Year of Implementation (Present Value $)	For First Year Shipments ($ million)	Stock Turnover[d] ($ million)
Manual Reset	n/a	$599,076	$0	$599,076	$11,981,517
Automatic Reset	4.47	$13,844,760	$3,096,548	$10,748,211	$214,964,228
Total	4.66	$14,443,836	$3,096,548	$11,347,287	$226,945,745

[a] The analysis does not include cost savings associated with embedded energy savings.

[b] Total present value benefits divided by total present value costs. Positive value indicates a reduced total cost of ownership over the life of the appliance.

[c] It should be noted that while the proposed standard is cost-effective, it may be more cost-effective if using alternative rate structures. For example, marginal utility rates may more accurately reflect what customers save on utility bills as result of the standard.

[d] Stock Turnover net present value (NPV) is calculated by taking the sum of the NPVs for the products purchased each year following the standard's effective date through the stock turnover year (i.e., the NPV of "turning over" the whole stock of less efficient products that were in use at the effective date to more efficient products, plus any additional non-replacement units due to market growth, if applicable). For example, for a standard effective in 2020 applying to a product with a 20 year design life, the NPV of the products purchased in the 20th year (2039) includes lifecycle cost and benefits through 2059, and therefore, so does the Stock Turnover NPV.

5.6 Environmental Impacts/Benefits

5.6.1 Greenhouse Gases

Table 14 presents the annual and stock greenhouse gas (GHG) savings for the first full year the standard takes effect (2020) and the year of full stock turnover (2039). The Statewide CASE Team calculated the avoided GHG emissions from the adoption of the standard assuming a 2020 emissions factor of 353 metric tons of carbon dioxide equivalent ($MTCO_2e$) per gigawatt hour (GWh) of electricity savings (CARB 2010), and 5,303 $MTCO_2e$ per million therms of gas savings (U.S. EPA 2011). These assumptions match those used by Energy and Environmental Economics, Inc in their recent rooftop solar photovoltaic system report (E3 2017).

Table 14: Estimated California Statewide Greenhouse Gas Savings for Standards Case

Product Class	Annual GHG Savings (MTCO2e/yr)	Stock GHG Savings (MTCO2e/yr)
2020 (end of first year standard is in effect)		
Manual Reset	55.6	55.6
Automatic Reset	1,571.1	1,571.1
Total	1,626.6	1,626.6
2039 (product stock turns over)		
Manual Reset	55.6	11,666.7
Automatic Reset	1,571.1	329,924.5
Total	1,626.6	341,591.2

Source: The Statewide CASE Team analysis 2017.

5.7 Impact on California's Economy

The cost-effectiveness of the proposed measures makes them beneficial to California's economy. The water and energy savings are relatively small per household, but the cumulative savings are worthwhile.

5.8 Consumer Utility/Acceptance

There are already numerous turn, push, and pull-type diverters on the market that are rated at zero gpm lifetime leakage rate. However, there are fewer lift-type tub spout diverters that are zero gpm. There may be a transition period when customers are surprised to see more pull-type tub spout diverters at hardware stores than lift-type. However, there will not be any loss of functionality.

5.9 Market Structure

Tub spout diverters are sold individually or as part of a larger shower trim kit including shower valve trim and showerheads. The same diverter mechanism is often available in multiple products with different aesthetics, such as material, color, or exterior housing shape. They are sold by plumbing parts distributors, hardware stores, and online retailers.

Diverters are most commonly located on tub spouts and have lift-type actuation. The second most common diverter location is on the shower valve trim, and these diverters typically have turn-type actuation. Manufacturers stated that tub spout diverters normally have automatic reset and require some leakage to function properly, unless they have a spring. They stated that all other diverters are typically manual reset and have zero leakage, and that the automatic reset feature is not usually indicated in product literature or packaging.

As of October 9, 2017, there were 3,083 products by 61 manufacturers in the database. Title 20 Section 1604(h)(6) states, "A tub spout diverter manufactured on or after June 1, 2016 shall be tested in accordance with ASME A112.18.1-2012/CSA B125.1-12." There are 1,352 products (44 percent) by 30 manufacturers (49 percent) that were added to the database on or after June 1, 2016. All the following analysis is based on the latter products, since they are newer and certainly based on the current test procedure.

For bath and shower diverters, the available data points are: Manufacturer, Brand, Model Number, Plumbing Fitting Type, Flow Rate, Post Test Flow Rate (diverters only), and Add Date. Plumbing Fitting Type is either lift-, turn-, pull-, or push-type. Flow Rate is the leakage rate measurement in gpm for the "when new" test, and the other flow rate is for the lifecycle test. The series of horizontal bar figures below are based solely on data in MAEDBS, have an add date on or after June 1, 2016, and use the "when new" flow rates.

In Figure 7, the data is grouped by "Plumbing Fitting Type" on the y-axis and is color coded by "Flow Rate." The inlaid table shows the percentage of products in each sub-group. The figure shows that lift-type diverters are most likely to have some leakage during the "when new" leakage test, and turn-type diverters are most likely to have zero leakage.

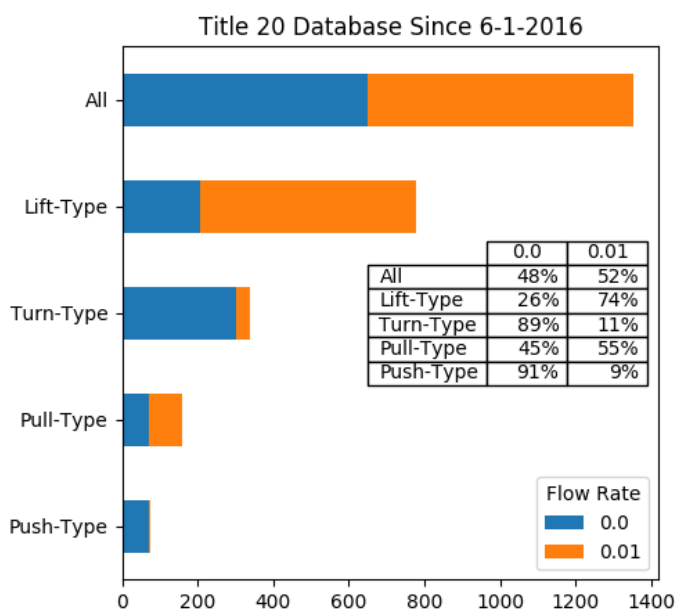

Figure 7: Products grouped by plumbing fitting type and flow rate.

Source: Energy Commission, MAEDBS, exported October 9, 2017.

In Figure 8, the data is grouped by the top 20 manufacturers according to number of products included in the database, and color coded by "Flow Rate". This figure shows that companies are more likely to have either all 0.01 gpm products or all zero gpm products, rather than a mixture of the two.

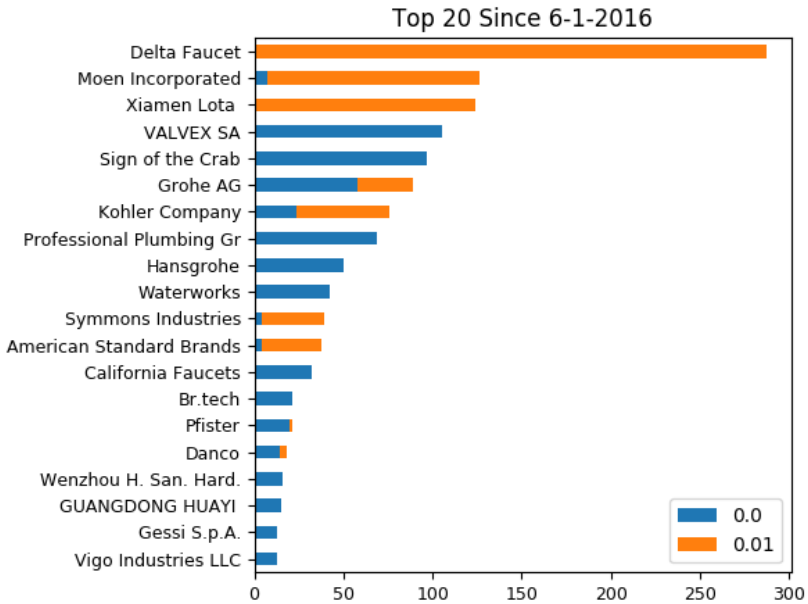

Figure 8: Products grouped by top 20 manufacturers and flow rate.

Source: Energy Commission, MAEDBS, exported October 9, 2017.

In Figure 9, only products with a "Flow Rate" of zero gpm are shown. The data is grouped by the top 20 manufacturers according to the number of products in the database, and color coded by "Plumbing Fitting Type." This figure shows that manufacturers typically manufacture multiple diverter types. A more interesting observation is that all of the Professional Plumbing Group's and most of a few other manufacturers' zero gpm products are lift-type, even though this sub-group is least common according to Figure 7.

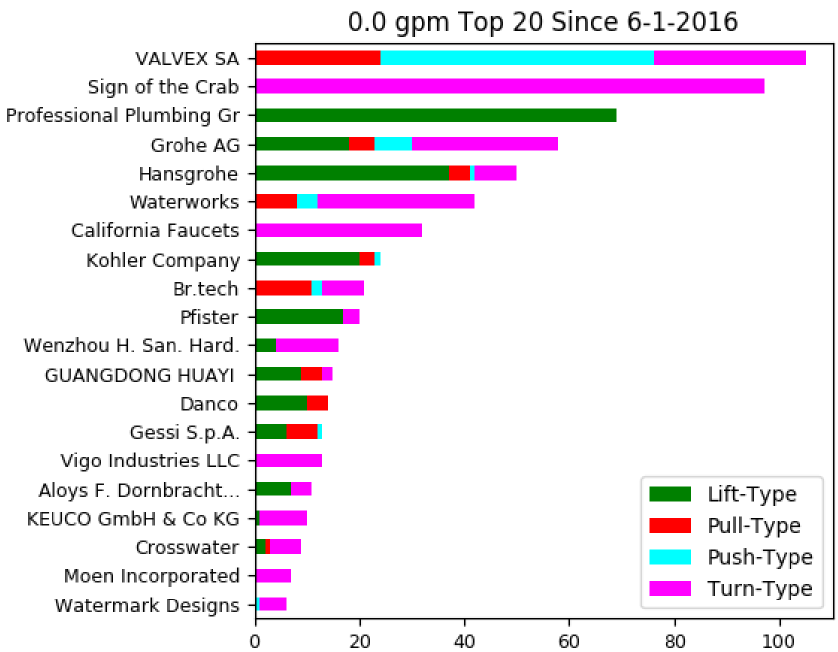

Figure 9: Zero gpm products grouped by top 20 manufacturers and plumbing fitting type.

Source: Energy Commission, MAEDBS, exported October 9, 2017.

In Figure 10, only products with a "Flow Rate" of 0.01 gpm are shown. The data is for all manufacturers, and color coded by "Plumbing Fitting Type." The figure shows that lift-type diverter products are most common here.

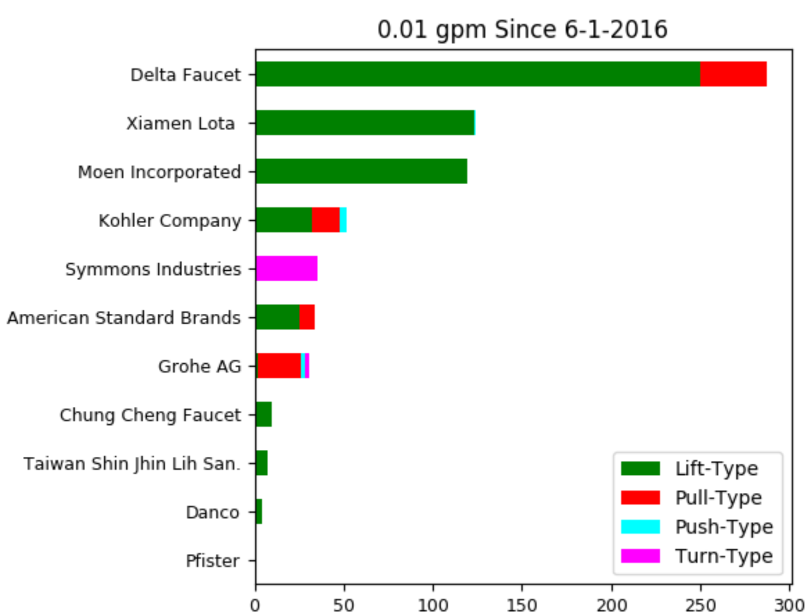

Figure 10: 0.01 gpm products by plumbing fitting type.

Source: Energy Commission, MAEDBS, exported October 9, 2017.

5.10 Stakeholder Positions

The Energy Commission hosted two stakeholder workshops on May 11, 2017, and July 20, 2017, and accepted written public comments on their docket (CEC 2017d). EPA hosted a stakeholder webinar title WaterSense Bath and Shower Diverter Notice of Intent (NOI) on February 8, 2017. The Statewide CASE Team interviewed three tub spout manufacturers (one of which does their own Title 20 testing), one plumbing manufacturer trade group, and two independent Title 20 approved test labs (Anonymous 2017).

Multiple manufacturers expressed concerns with the potential reduction of the maximum leakage rate limits and broached the topic of automatic reset.[3] They claimed that automatic reset is an important health and safety feature that users implicitly expect in tub spout mounted diverters, and that manufacturers typically include in most tub spout mounted diverters. They claimed that this feature requires some leakage to function properly if the diverter mechanism does not have a spring. With spring return, zero leakage is more feasible.[4]

One independent test lab noted during a phone interview that they were unaware of the requirement to round up water efficiency values in Title 20. The other independent test lab agreed that the mass/time method (i.e., a container and laboratory scale) is more accurate than flow meters, and that a three-decimal place reporting requirement would yield more consistent test results from test labs.

5.11 Other Regulatory Considerations

5.11.1 Federal Regulatory Background

EPA WaterSense plans to create a specification for bath and shower diverters (U.S. EPA 2017a). The initial proposal stated in the NOI was a leakage rate requirement of zero gpm, but EPA has subsequently proposed further research on automatic reset products (U.S. EPA 2017d). The Statewide CASE Team and other stakeholders provided EPA with public comments, and Appendix E: Test Plan is intended to be fully responsive to EPA's stated research needs, while addressing additional facets of product performance as well.

5.11.2 Utility and Other Incentive Programs

SoCalGas is working on a rebate for thermostatically activated tub spout diverters, such as the Evolve Technologies Auto-Diverting Tub Spout System described in Section 2. In addition to having automatic reset, spring return, and little to no leakage, these products also automatically minimize water flow when the set point temperature is met. This also reduces the water waste that is common when users do not enter the shower promptly. There are no California or federal regulations that specifically regulate this feature, but they are otherwise regulated by the Title 20 diverter regulations.

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[3] http://docketpublic.energy.ca.gov/PublicDocuments/17-AAER-09/TN219098_20170616T084907_Mark_Malatesta_Comments_LWTA_Comments_TubSpout_Diverters.pdf, http://docketpublic.energy.ca.gov/PublicDocuments/17-AAER-09/TN219174_20170616T133402_Matt_Sigler_Plumbing_Manufacturers_International_PMI_Comments_P.pdf, http://docketpublic.energy.ca.gov/PublicDocuments/17-AAER-09/TN219203_20170616T150104_Cambria_McLeod_Comments_Tub_Spout_Diverters.pdf

[4] http://docketpublic.energy.ca.gov/PublicDocuments/17-AAER-09/TN221182_20170915T112901_Matt_Sigler_Comments_PMI's_Comment_Letter_for_Docket_17AAER09.pdf

5.11.3 Model Codes and Voluntary Standards

ASME A112.18.1-2012/CSA B125.1-12 is the nationally recognized test procedure for plumbing supply fittings. It also includes minimum leakage rate requirements, but California's Title 20 leakage rate requirements take precedence here.

IAPMO will publish their 2017 Water Efficiency and Sanitation Standard (WE-Stand) in November 2017 (IAPMO 2017), and it will replace their Green Plumbing and Mechanical Code Supplement (GPMCS). WE-Stand Section 402.6.3 "Bath and Shower Diverters" states "Tub spout bath and shower diverters, while operating in the shower mode, shall perform with zero leakage."

Appendix L "Sustainable Practices" from the 2016 California Plumbing Code (CPC) (IAPMO 2016) is an optional appendix that is based on IAPMO's prior GPMCS. It has not been adopted by any local agencies according to its Matrix Adoption Table, and it is preempted by Title 20, which is stricter. CPC Appendix L 402.6.2 "Bath and Shower Diverters" states, "The rate of leakage out of the tub spout of bath and shower diverters while operating in the shower mode shall not exceed 0.1 gpm (0.4 L/m) in accordance with ASME A112.18.1/CSA B125.1."

5.12 Impetus to Pursue Water and Energy Efficiency

5.12.1 State Water Policy Goals

Water is essential to supporting and sustaining the environmental, economic, and public health needs of the state. Drought, shifts in regional climate patterns, and the state's population growth are leading to concerns about the sustainability of ever-growing demands on a limited (and shrinking) water supply. Since water security is critically important to the state, improving water efficiency is a well-established statewide policy goal. Legislation enacted in 2009 (Senate Bill X7-7, Steinberg 2009) established the goal of achieving a 20 percent reduction in urban per capita water use in California by 2020.

On January 17, 2014, Governor Brown proclaimed a state of emergency and directed state agencies to take all necessary actions to prepare and respond to drought conditions (CA Proclamation, 1-17-2014). When the drought persisted, Governor Brown issued a subsequent Proclamation of Continued State of Drought Emergency in April 2014 (CA Proclamation, 4-24-2014), and in September 2014 he issued an executive order to streamline relief efforts to those impacted by the drought (CA Exec. Order No. B-26-2014). On April 1, 2015, the Governor took further action and issued an executive order that established statewide mandatory water reductions and directed a number of state agencies to take immediate action to save water. These actions included: establishing new efficiency standards for buildings and landscaped areas, providing incentives for water efficiency, and increasing enforcement of certain existing efficiency rules (CA Exec Order No. B-29-2015). As a result, state agencies, such as the California State Water Resources Control Board,[5] the California Department of Water Resources,[6] and the Energy Commission[7] adopted "emergency" or "expedited" water saving regulations. On April 7, 2017,

[5] Information about the State Water Resources Control Board emergency regulations at: http://www.swrcb.ca.gov/waterrights/water_issues/programs/drought/emergency_mandatory_regulations.shtml.

[6] Department of Water Resources has stated that they intend to adopt an updated version of the Model Water Efficient Landscape Ordinance by July 205: http://www.water.ca.gov/calendar/materials/governors_executive_order_b-29-15_18929.pptx.

[7] On April 8, 2015, the Energy Commission adopted updated Title 20 standards for toilets, urinals and faucets.

Governor Brown ended the drought emergency in most of California, "while maintaining water reporting requirements and prohibitions on wasteful practices."[8] The drought emergency continues in the counties of Fresno, Kings, Tulare, and Tuolumne.

Finally, the California Public Utilities Commission (CPUC) has also directed the IOUs to pursue water efficiency activities such as rebate programs and codes and standards advocacy as part of their energy management portfolios. A significant amount of energy is used to fulfill California's water supply needs. CPUC has directed the energy utilities to pursue initiatives that aim to reduce the amount of energy associated with water use, including pursuing water efficiency measures.

5.12.2 Stringent Water Efficiency Standards Will Reduce the Need for Costly Water Supply Development

Establishing more stringent water efficiency standards is a cost-effective intervention for reducing California's water demand. It may be the most cost-effective intervention when compared to solutions that aim to increase and maintain reliable water supplies. For instance, projects such as ocean water desalination, dams, or new water conveyance projects cost billions of dollars.[9] The water efficiency standards presented in this report, on the other hand, will reduce Californians' expenditures on water and energy bills while supporting manufacturers and builders that offer high efficiency fixtures. In addition, in contrast to large-scale water supply projects, efficient water use is expected to result in significant environmental benefits.

5.12.3 Long-Term Energy Efficiency Initiatives

California has several long-term polices in place to enhance energy efficiency, curb greenhouse gas emissions (GHG), and reduce the demand on energy resources and the electricity grid. This section briefly describes some of the many policies adopted across the state in recent years.

Assembly Bill 32, The Global Warming Solutions Act of 2006 (AB 32), requires California to reduce its GHG emissions to 1990 levels by 2020 — a reduction of approximately 15 percent below emissions expected under a "business as usual" scenario (CARB 2015). Implementation of AB 32 is laid out in the "Climate Change Scoping Plan," last updated in May 2014. One of the key elements of the scoping plan includes expanding and strengthening energy efficiency programs, including Title 20.

To date, California is on target to meet the goals of AB 32 (CARB 2014). In response, Governor Brown issued Executive Order B-30-15 on April 29, 2015 which establishes a California greenhouse gas reduction target of 40 percent below 1990 levels by 2030 (CA Exec. Order No. B-30-15). The Executive Order calls for the most aggressive greenhouse gas reductions policy in national history.

On October 18, 2007, the California Public Utilities Commission (CPUC) published Decision 07-10-032 which created a framework for long-term strategic planning of energy efficiency and other demand-reducing programs (CPUC 2007). Through Decision 07-10-032, CPUC adopted the

[8] Governor Brown's proclamation ending the drought emergency: https://www.gov.ca.gov/news.php?id=19748.

[9] Though it can produce a reliable source of water, desalination is extremely expensive technology. It has an impact on the local aquatic environment as well as electric consumers and ratepayers, as energy is the largest single cost for a desalination plant (Pacific Institute 2013). Upgrading infrastructure for water conveyance and storage can cost tens of billions of dollars. For example, the proposed twin tunnels project to convey water through the Sacramento-San Joaquin Delta to Southern California is expected to cost at least $25 billion. The Temperance Flat Dam, proposed to increase storage capacity in the San Joaquin River Basin upstream of Friant Dam is projected to cost $2.5 billion.

state's zero net energy (ZNE) goals which call for all new residential and commercial construction in California to be ZNE by 2020 and 2030, respectively. These ZNE goals have encouraged the Energy Commission's adoption of more stringent energy efficiency standards for appliances and buildings in California over the past few years. The state's building and appliance energy efficiency standards have saved Californians $74 billion in energy costs since 1977 (CARB 2014).

On October 11, 2009, the California Legislature adopted Assembly Bill 758. AB 758 requires the Energy Commission to develop a comprehensive energy efficiency program to achieve greater energy savings in the state's existing residential and commercial building stock (AB 758 2009).

On January 5, 2015, Governor Brown proposed the goal of doubling the efficiency of existing buildings by 2030 in his inaugural address, along with other goals for increasing renewable energy use and decreasing fossil fuel consumption in the transportation sector by 50% (Brown 2015).

In addition to the state's energy efficiency policies, the IOUs have a long history of implementing residential and commercial energy efficiency programs to spur market transformation of energy efficient technologies. The IOUs' Statewide Codes and Standards Enhancement program has also had a significant impact on the adoption of various appliance and building efficiency standards both in California and nationally, which have led to energy, water, greenhouse gas, and cost savings for the state.

5.12.4 Water-Energy Nexus

The relationship between water use and energy use helps to justify additional water efficiency standards. Nearly twenty percent of electricity use and thirty percent of non-power plant-related natural gas use in California is associated with meeting California's water supply needs (CEC 2006).[10] California consumes about 2.9 trillion gallons of water per year for urban uses (Christian-Smith, Heberger & Luch 2012).[11] These 2.9 trillion gallons of water correspond to approximately 26.4 terawatt hours (TWh) of embedded electricity. Figure 11 presents the embedded energy associated with various water end uses.

The California Global Warming Action Plan recognizes this water-energy nexus. The plan calls for the establishment of indoor and outdoor water efficiency standards, and water recycling initiatives to help achieve California's greenhouse gas (GHG) reduction goals.

[10] Water-related energy uses include energy consumed by water agencies for water collection, extraction, conveyance, treatment prior to use (e.g., potable), treatment and disposal after use (e.g., wastewater), and for distribution to end-users. It also includes energy used by the end-user after the water agency has delivered water, such as energy used to pump and heat water on-site.
[11] Urban uses include outdoor and indoor residential water use; water used in commercial, institutional, and industrial applications; and unreported water use, which is primarily attributed to leaks.

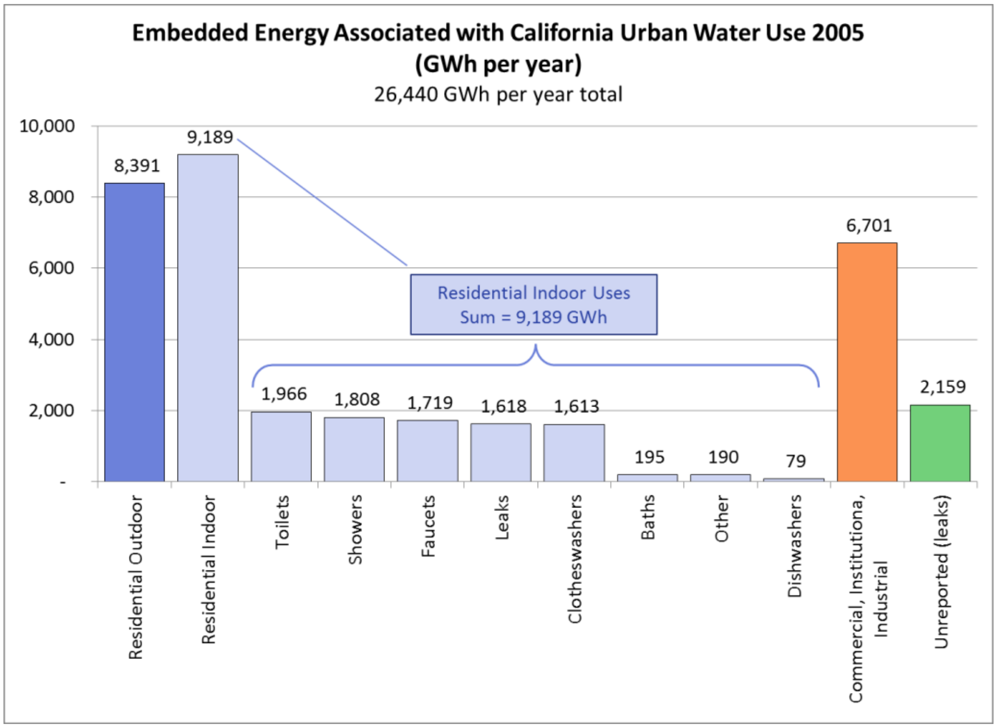

Figure 11: Embedded energy associated with California urban water uses (2005).

Source: Christian-Smith et al. (2012).

Assumptions: Embedded energy factor of 8,134 kWh/Mgal for residential outdoor water use and unreported (leaks); embedded energy factor of 10,045 kWh/Mgal for residential indoor; embedded energy factor of 9,090 kWh/Mgal for commercial, institutional, and industrial.

6. Conclusion

The Statewide CASE Team is proposing modifications related to product definitions and the leakage rate limits. The modifications to the definitions will reduce ambiguity, reduce reporting burden, and provide useful additional product information. The leakage rate modifications are cost-effective to customers and yields statewide energy and water savings. This proposal might be modified after the research outlined in Appendix E: Test Plan is completed.

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Appendix A: Electricity Rates

The electricity rates used in the Statewide CASE Team analysis were derived from projected future prices for the residential sector in the Energy Commission's "Mid-case" projection of the 2017-2027 Demand Forecast (CEC 2017f), which used a three percent discount rate and provided prices in 2015 dollars. The sales weighted average of the five largest utilities[12] in California was converted to 2017 dollars using an inflation adjustment factor of 1.04 percent (DOL 2017). See the rates by year below in Table 15. The average rate was used for all years in the cost calculations, and is conservative given that the stock turns over in 2039.

Table 15: Statewide Sales Weighted Average Residential Electricity Rates 2020 – 2028 (5 largest Utilities) in 2017 cents/kWh

Year	Residential Electricity Rate (2017 cents/kWh)
2020	18.84
2021	19.03
2022	19.02
2023	19.03
2024	19.20
2025	19.27
2026	19.38
2027	19.48
2028	19.58
Average	19.20

Source: Statewide CASE Team analysis 2017.

[12] PG&E, SCE, SDG&E, Los Angeles Department of Water and Power, and the Sacramento Municipal Utility District.

Appendix B: Natural Gas Rates

The natural gas rates used in the Statewide CASE Team analysis were derived from projected future prices for the residential sector in the Energy Commission's "2017 Draft Natural Gas Market Trends and Outlook" (CEC 2017e), which used prices in 2016 dollars. The data from the three gas IOUs in California was converted to 2017 dollars using an inflation adjustment factor of 1.04 percent (DOL 2017), then averaged. See the rates by year below in Table 16. The overall average rate of $1.401/therm was used for all years in the cost calculations, and is conservative given that the stock turns over in 2039.

Table 16: Statewide Residential Natural Gas Rates 2020 - 2029 (PG&E, SoCalGas, and SDG&E) in 2017$/therm

Year	Residential Natural Gas Rate (2017$/therm)			
	PG&E	SoCalGas	SDG&E	Average
2020	$1.556	$1.018	$1.464	$1.346
2021	$1.570	$1.025	$1.475	$1.357
2022	$1.583	$1.033	$1.488	$1.368
2023	$1.597	$1.043	$1.502	$1.381
2024	$1.612	$1.051	$1.516	$1.393
2025	$1.628	$1.062	$1.532	$1.407
2026	$1.644	$1.073	$1.547	$1.421
2027	$1.661	$1.083	$1.564	$1.436
2028	$1.672	$1.090	$1.574	$1.445
2029	$1.689	$1.101	$1.591	$1.460
Average	$1.621	$1.058	$1.525	$1.401

Source: Statewide CASE Team analysis 2017.

Appendix C: Potable Water and Wastewater Rates

Water prices from Circle of Blue (COB 2017) were used to estimate the average price of combined residential water and wastewater rates. They provide 2017 monthly bill prices for 30 major cities for a family of four at three different usage patterns: 50, 100, and 150 gallons per person per day. The included cities in California are Los Angeles, San Diego, San Francisco, and San Jose. To avoid flat rates and to provide a conservative estimate, the Statewide CASE Team calculated the average price per gallon for the incremental cost from the 50 to 100 gallons per person per day scenarios. That average rate over the four cities was $0.00847 per gallon. As a simplified and conservative estimate, that rate is used over the whole analysis period with the assumption that the price only increases with inflation.

Appendix D: Embedded Electricity Usage Methodology

The Statewide CASE Team assumed the following embedded electricity in water values: 4,848 kWh/million gallons (Mgal) of water for indoor water use and 3,565 kWh/Mgal for outdoor water use. Embedded electricity use for indoor water use includes electricity used for water extraction, conveyance, treatment to potable quality, water distribution, wastewater collection, and wastewater treatment. Embedded electricity for outdoor water use includes all energy uses upstream of the customer; it does not include wastewater collection or wastewater treatment. The embedded electricity values do not include onsite energy uses for water, such as on-site pumping. On-site energy impacts are accounted for in the energy savings estimates presented in this report.

These embedded electricity values were derived from research conducted for CPUC Rulemaking 13-12-011 (CPUC 2013). The CPUC study aimed to quantify the embedded electricity savings associated with IOU incentive programs that result in water savings, and the findings represent the most up-to-date research by CPUC on embedded energy in water throughout California (CPUC 2015). The CPUC analysis was limited to evaluating the embedded electricity in water and does not include embedded natural gas in water. Since accurate estimates of the embedded natural gas in water were not available at the time of writing, this CASE Report does not include estimates of embedded natural gas savings associated with water reductions.

The CPUC embedded electricity values used in the CASE Report are shown in Table 17. These values represent the average energy intensity by hydrologic region, which are based on the historical supply mix for each region regardless of who supplied the electricity (IOU supplied and non-IOU supplied). The CPUC calculated the energy intensity of marginal supply, but recommended using the average IOU and non-IOU energy intensity to estimate total statewide average embedded electricity of water use in California.

Table 17: Embedded Electricity in Water by California Department of Water Resources Hydrologic Region (kWh per acre foot)

Region	Extraction, Conveyance, and Treatment	Distribution	Wastewater Collection + Treatment	Outdoor (Upstream of Customer)	Indoor (All Components)
NC	235	163	418	398	816
SF	375	318	418	693	1,111
CC	513	163	418	677	1,095
SC	1,774	163	418	1,937	2,355
SR	238	18	418	255	674
SJ	279	18	418	297	715
TL	381	18	418	399	817
NL	285	18	418	303	721
SL	837	163	418	1,000	1,418
CR	278	18	418	296	714

Hydrologic Region Abbreviations:
NC = North Coast, SF = San Francisco Bay, CC = Central Coast, SC = South Coast, SR = Sacramento River, SJ = San Joaquin River, TL = Tulare Lake, NL = North Lahontan, SL = South Lahontan, CR = Colorado River
Source: Navigant team analysis

Source: CPUC 2015b.

Appendix E: Test Plan

California Title 20 Appliance Efficiency

2017 Pre-Rulemaking

Tub Spout Diverters – Test Plan

September 18, 2017

Prepared by:

NegaWatt Consulting, Inc. on behalf of the CA IOUs.

Introduction

The four California Investor Owned Utilities (CA IOUs) – Pacific Gas and Electric Company (PG&E), San Diego Gas & Electric (SDG&E), Southern California Edison (SCE), and SoCalGas® (also referred to as the Team) – are writing a Title 20 Codes and Standards Enhancement (CASE) Report on tub spout diverters and will facilitate laboratory research to help inform the Report. The Team participated in the Energy Commission meetings on tub spout diverters held on May 11, 2017,[13] and July 20, 2017.[14] The Team has also reviewed the associated stakeholder comments,[15] and the documents on EPA's WaterSense webpage,[16] including the EPA testing research proposal.[17] The Team subsequently interviewed three manufacturers (one of which does their own Title 20 testing), a plumbing manufacturer trade organization, and two independent test labs.

The Team concluded that there are four main topics worthy of laboratory research: automatic reset versus manual reset diverters, data accuracy, water quality issues, and savings factor. Where possible, the test plan aligns with the EPA testing research proposal. The Team has additional test ideas beyond those outlined below that are intended to evaluate a) performance over an extended life cycle; and b) the variability of performance of products of the same brand and model as an indicator of quality control. However, these tests will not be posed until after this research has been completed and the results have been reviewed, so that their usefulness can be determined from the data.

The Team requests that the laboratory submit their results, aside from the lengthy water quality tests, as soon as possible. The water quality test results should be submitted as soon as possible thereafter.

Automatic Reset versus Manual Reset Diverters

Manufacturers stated that automatic reset diverters require a small amount of inherent leakage to function properly, whereas manual reset diverters do not. They also stated that most diverters located in tub spouts have automatic reset, while most "within-wall" mounted diverters have manual reset, which typically control different combinations of outlets rather than simply a tub spout and showerhead. The Team would like to obtain data on this topic to determine the feasibility of reducing leakage rates while maintaining automatic reset as a feature for those product subgroups where it is common, and users value it.

Data Accuracy

The ASME A112.18.1/CSA B125.1-2012 test procedure allows the use of either flow meters or containers, but doesn't mandate instrument accuracy. The Title 20 Regulations require data reporting to two decimal places for gallons per minute (gpm), and state that rounding up is required. A significant percentage of products in the Title 20 database are rated at zero gpm, but

[13] http://docketpublic.energy.ca.gov/PublicDocuments/17-AAER-05/TN217523_20170510T135340_Invitation_to_Participate_Presentation.pdf
[14] http://docketpublic.energy.ca.gov/PublicDocuments/17-AAER-05/TN220257_20170719T094511_Presentation__Results_of_Invitation_to_Participate__Tub_Spout_D.pdf
[15] https://efiling.energy.ca.gov/Lists/DocketLog.aspx?docketnumber=17-AAER-09
[16] https://www.epa.gov/watersense/bath-and-shower-diverters
[17] https://www.epa.gov/sites/production/files/2017-07/documents/ws-products-bath-and-shower-diverter-research-proposal.pdf

it's possible these regulations are being interpreted inconsistently and/or that instrumentation accuracy is not sufficient. The Team would like to obtain data on this topic to determine whether the Title 20 Regulations can be improved to yield more accurate results.

ASME A112.18.1/CSA B125.1-2012 Section 5.4.2.2 allows flow rates to be measured via fluid meters or the "time/volume method". However, low non-continuous flow rates are difficult to measure with flow meters, and very low volumes are difficult to measure with graduated cylinders. Graduated cylinder calibration is often verified by comparing the measured volume of water to a calculated volume using its mass and known densities at different temperatures. For this reason, a container and laboratory balance shall be used to conduct all tests.

Water Quality Issues

Numerous manufacturers stated that poor water quality, poor maintenance, and slow replacement cycles are to blame for reduced diverter performance over time, and the leakage rates from field studies cited by EPA are not indicative of the aged performance of current products. A test lab stated that each cycle in the ASME life cycle test is approximately 6 seconds, which means that the test doesn't account for degradation due to corrosion or scale forming. The Team would like to obtain data on this topic to determine how various diverters perform after being exposed to poor water quality for extended periods.

The CA IOUs prefer to test water quality issues using an industry accepted method and propose Sections 15.1 and 15.2 of ASME A112.18.3-2002.

Savings Factor

Savings factor is defined as the ratio of *saved water* to *tub spout leakage water* when a tub spout leak is corrected. Savings factor is not always 100 percent, because fixing a leak increases the system water pressure. If the showerhead is not pressure-compensating, the increase in system water pressure will increase the flow through the showerhead to some degree, and the savings factor is less than 100 percent. If a showerhead is pressure-compensating, the increase in system water pressure will not increase flow through the showerhead, and the savings factor is 100 percent.

In Taitem's "Leaking Shower Diverters" report,[18] the authors measured savings factor for a variety of conditions, and they concluded that a 70% savings factor was appropriate and conservative for tub spout diverter retrofits. However, they did not perform any tests below a leakage rate of 0.05 gpm, which is the appropriate range for new construction in California. The CA IOUs would like to perform tests similar to Taitem's, but at leakage rates in that omitted range.

General Test Setup and Methodology

Objectives and Methodology

1. Evaluate automatic and manual reset diverters, per the product sampling section below, in accordance with all marked tests for "fitting type" of "bath or shower with diverter" in Table B.1 in ASME A112.18.1/CSA B125.1-2012; and the Title 20 Regulations; but with the following directives and additions:

[18] http://www.taitem.com/wp-content/uploads/Diverter-Valve-Tech-Tip-2011.7.20.pdf.

Directives:

ASME A112.18.1/CSA B125.1-2012 Section 5.4.2.2 allows flow rates to be measured via fluid meters or the "time/volume method." Then, it states, "if the time/volume method is used, the container shall be of sufficient size to hold the collected water for at least 1 min." The CA IOUs require that the "time/volume method" be used with the following conditions, which are not specified in ASME A112.18.1/CSA B125.1-2012 or the Title 20 Regulations, but that nevertheless comply:

- Use container(s) and calibrated laboratory scale(s) (not flow meters)
- The container(s) shall meet the requirements of its respective laboratory scale (e.g., less than or equal to the maximum tare weight)
- The laboratory scale(s) shall have the following specifications:
  - Maximum capacity: At least 500 grams (g)
  - Readability: At least 0.1 g
  - Repeatability: At least 0.1 g
- For leakage tests, report measured leakage mass to the greatest accuracy of the instrumentation, and report the related measurement duration. The maximum error of the duration measurement shall be +- 0.5 seconds.
- Convert mass and duration to flow rate in gpm, following Annex A "Unit conversion and rounding criteria" from ASME A112.18.1/CSA B125.1-2012, and using the following equation:

$$(volumetric\ flow\ rate\ [gpm]) = \left(\frac{(mass\ [grams])}{(duration\ [minutes])}\right) x \left(\frac{1}{992{,}200\frac{grams}{meter^3}}\right) x (264.172\frac{gallons}{meter^3})$$

Additions:

These additional tests go beyond ASME A112.18.1/CSA B125.1-2012 without invalidating it:

- Report leakage mass for the 1 minute starting at diverter closure, and ending at the beginning of the ASME mandated measurement window. Also, convert to gpm per above.
- For automatic reset diverters, measure time from shower termination to the automatic release of the tub spout diverter.
- For each test, or at least once per day, measure and report the water quality of the water source used for the tests. The water quality measurements shall include pH, calcium concentration, hardness, dissolved solids content, and Langelier Saturation Index (LSI; a measure of water corrosivity).[19] A different measure of water corrosivity can be proposed by the laboratory.

[19] This list was chosen upon review of the section "Detecting Corrosive Water Problems" at http://extension.psu.edu/natural-resources/water/drinking-water/water-testing/pollutants/corrosive-water-problems.

- If an automatic reset diverter "fails" per ASME A112.18.1/CSA B125.1-2012 Section 5.6.1.5.2, still report all other test results since it could simply be that the product was misidentified as automatic reset.
- For a subset of products (10 automatic reset diverters across the product sampling categories below), perform the non-life cycle leakage test at 80 pounds per square inch gauge (psig) as well as, and after, the 10 psig tests. This will allow the Team to explore diverter performance at the high end of water pressure that might occur in a residential building.

2. Evaluate the impact of water quality on diverter performance for a subset of products (10 automatic reset diverters across the product sampling categories below). This subset of products should be a second copy of those products. Conduct the water quality tests in Sections 15.1 and 15.2 in ASME A112.18.3-2002. After these tests, perform both leakage tests from ASME A112.18.1/CSA B125.1-2012. For each specimen: perform the initial leakage test (clause 5.3.6.1.2) 3 times and report all individual results; perform the life cycle test (clause 5.6.1.5.1) 3 times, and report all individual results.

3. Perform "savings factor" tests similar to "Test 1" in Taitem,[20] but for leakage rates of 0.005 gpm, 0.01 gpm, 0.02 gpm, 0.03 gpm, 0.04 gpm, 0.05 gpm, and 0.8 gpm. Use system static pressures of 10, 20, 30, 40, 50, 60, 70, and 80 psig. Perform all these tests with five different showerheads: 1.8 gpm pressure-compensating showerhead, 1.8 gpm non-pressure-compensating showerhead, 2.0 gpm pressure-compensating showerhead, 2.0 gpm non-pressure-compensating showerhead, and 2.5 gpm non-pressure-compensating showerhead. Allow the Team to review the selected showerhead products (i.e., make and model) prior to testing.

Product Sampling

New products in original packaging are to be selected for testing as follows: Select two automatic reset diverters and two manual reset diverters in each of the following groups, taking care to select products from various manufacturers (Note: When searching the Title 20 database, select "Add Date" after June 1, 2016):

1. Diverters that are rated at *0.00 gpm* and that are *lift-type* per the Title 20 database.
2. Diverters that are rated at *0.01 gpm* and that are *lift-type* per the Title 20 database.
3. Diverters that are rated at *0.00 gpm* and that are *pull-type* per the Title 20 database.
4. Diverters that are rated at *0.01 gpm* and that are *pull-type* per the Title 20 database.
5. Diverters that are rated at *0.00 gpm* and that are *turn-type* per the Title 20 database.
6. Diverters that are rated at *0.01 gpm* and that are *turn-type* per the Title 20 database.
7. Diverters that are rated at *0.00 gpm* and that are *push-type* per the Title 20 database.
8. Diverters that are rated at *0.01 gpm* and that are *push-type* per the Title 20 database.

[20] See Figure 5 in Taitem's report. Note, however, that data accuracy protocols of the Team's test plan are to be followed.

The Team will assist the laboratory as needed to determine the above products, especially given the potential difficulty in determining which products are automatic reset versus manual reset. Allow the Team to review the lab's selected diverter products (i.e., make, model, and any info from below) prior to testing.

In addition, include the following two specific diverter products:

- Evolve Technologies auto-diverting tub spout system[21]
- Brasscraft Mixet Positive Action Shut Off Diverter (SWD0407)

For every diverter, list the following:

1. Make and model.
2. Pictures of the diverter and the test setup.
3. Activation mode in the Title 20 database (e.g., lift, pull, turn, or push). Include a product description, since the activation modes might be interpreted differently by manufacturers.
4. Automatic or manual reset. Indicate whether the manufacturer states the unit is automatic or not, if available. Some installation manuals may state "some leakage is standard."
5. Leakage rates in the Title 20 database. Include the date it was added to the database.
6. The number of outlets that the diverter controls, and what those outlets are typically connected to (e.g., tub spout, showerhead, hand shower, etc.).
7. Cost and purchase location.
8. Start and finish time of each set of tests. Date and time of completion of the test. Duration of test.
9. Tests each specimen underwent.
   Any claims by manufacturers or in their product literature about corrosion protection, scaling protection, and the use of special coatings.

[21] http://thinkevolve.com/products/auto-diverting-tub-spout-system/.