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California IOUs Title 20 Showerheads CASE Report - Proposed Standards

Additional submitted attachment is included below.

Showerheads

Codes and Standards Enhancement (CASE) Initiative
For PY 2015: Title 20 Standards Development

Analysis of Standards Proposal for
Showerheads
CEC Docket Number 15-AAER-05

July 31, 2015

Prepared for:

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1 Executive Summary

The Codes and Standards Enhancement (CASE) initiative presents recommendations to support California Energy Commission's (CEC) efforts to update California's Appliance Efficiency Regulations (Title 20) 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 Southern California Gas Company (SoCalGas) – sponsored this effort (herein referred to as the 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 standard proposal for showerheads.

California consumes about 2.9 trillion gallons of water per year for urban uses (Christian-Smith et al. 2012). 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. The 2.9 trillion gallons of water is associated with approximately 26.4 terawatt hours of embedded electricity, which is required for water supply, conveyance, potable water treatment and distribution, and wastewater collection and treatment.

Showers are one of the largest single uses of residential indoor water use. It is estimated that water used in showers accounts for 20 to 22 percent of all indoor residential water use. For this reason, reducing the amount of water used in showers is an effective strategy to reduce water use in California. It is estimated that 73 percent of water used in showers is hot water (Seattle & EPA 2000). Reducing total water use in showers will result an overall reduction in household hot water use thereby reducing the energy requirements for heating water. Reducing water heating load can have significant positive impacts on the whole-house energy use; water heating accounts for the largest share of natural gas usage in California homes (Hoeschele et al. 2012). Updating efficiency standards for showerheads will result in significant water, embedded energy, and on-site energy savings. Some peak demand savings are also expected.

The code change proposal presented in this report recommends revisions to the Title 20 requirements for showerheads. The revised standard would be implemented in two stages. The Tier 1 standard would take effect no later than January 1, 2016 and would align the Title 20 standards for showerheads with the existing WaterSense® Specification for Showerheads (WaterSense 2010a). The Tier 1 standard would establish a maximum flow rate of 2.0 gallons per minute (gpm) determined through testing at 20, 45, and 80 pounds per square inch (psi). Along with the maximum flow rate requirements, the CASE Team is recommending that Title 20 include the same performance requirements for showerhead flow across a range of pressures, spray force, and spray coverage that are included in the WaterSense Specification, including establishing minimum flow rate requirements. These performance requirements will help ensure that showerheads continue to perform up to consumer's expectations as efficiency improves and will thwart concerns that reducing flow rate will result in increased shower duration. The Tier 2 standard would take effect two years after the effective date of the Tier 1 standard and would establish a maximum flow rate of 1.8 gpm. In addition to updating efficiency requirements and establishing performance requirements, the CASE Team is recommending updating marking and labeling requirements for showerheads and implementing new labeling and reporting requirements for shower mixing valves to help improve the compatibility of shower systems and minimize the risk of thermal shock. Finally, the CASE Team is recommending updating the definition of a showerhead and adding definitions for hand held showerheads, shower mixing valves, supply fittings, and automatic compensating shower mixing valve.

The CASE Team estimates that during the first year the proposed Tier 1 standard is in effect (2016), it will result in an annual savings of 2.2 billion gallons of water, 11.0 million therms of natural gas and 26.8 GWh from reduced water heating load, and 10.7 GWh from reduced embedded electricity use. After full stock turnover (2025), the annual savings are projected to be 23 billion gallons of water, 118 million therms of natural gas and 279 GWh of electricity from reduced water heating load, and 112 GWh from reduced embedded electricity use. The estimated statewide peak demand reductions associated with reduced electricity use for water heating load is 3.6 MW during the first year the standard is in effect and 37 MW after full stock turnover.

The CASE Team estimates that during the first year the proposed Tier 2 standard is in effect (2018), it will result in additional savings on top of the savings achieved from the Tier 1 standard. The Tier 2 standard will result in an additional annual savings of 1.4 billion gallons of water, 7.0 million therms of natural gas and 17.0 GWh from reduced water heating load, and 7.0 GWh from reduced embedded electricity use will be realized. After full stock turnover (2027), the additional annual savings from the Tier 2 standard are projected to be 14.2 billion gallons of water, 73 million therms of natural gas and 174 GWh of electricity from reduced water heating load, and 69 GWh from reduced embedded electricity use. The estimated statewide peak demand reductions associated with reduced electricity use for water heating load is 2.0 MW during the first year the standard is in effect and 23.0 MW after full stock turnover, again in addition to the Tier 1 savings.

2 Standards Proposal Overview

2.1 Proposal Description

The code change proposal presented in this report recommends revisions to the Title 20 requirements for showerheads. The revised standard would update the maximum flow rate requirements in two stages. The first stage, Tier 1, would take effect no later than January 1, 2016 and would align the Title 20 standards for showerheads with the existing WaterSense® Specification for Showerheads (WaterSense 2010a). The Tier 1 standard would establish a maximum flow rate of 2.0 gallons per minute (gpm) determined through testing at 20, 45, and 80 pounds per square inch (psi). The proposed flow rate requirement of 2.0 gpm is consistent with the WaterSense Specification as well as CALGreen, ASHRAE 189.1 (v.2 2011, updated with addendum v), ASHRAE 191P, IAPMO Green Plumbing & Mechanical Code Supplement, and the International Green Construction Code (IgCC).The Tier 2 standard would take effect two years after the effective date of the Tier 1 standard and would establish a maximum flow rate of 1.8 gpm established through testing at 20, 45, and 80 psi.

Along with the maximum flow rate requirements, the CASE Team is recommending that the Title 20 standards include the same performance requirements for showerhead flow across a range of pressures, spray force, and spray coverage that are included in the WaterSense Specification, including establishing minimum flow rate requirements. These performance requirements will help ensure that showerheads continue to perform up to consumer's expectations as efficiency improves, and will thwart concerns that reducing flow rate will result in increased shower duration. The minimum flow rate and performance requirements will be incorporated into showerhead reporting requirements. Additionally, the CASE Team is recommending updating the marking and labeling requirements for showerheads and implementing new labeling and reporting requirements for shower mixing valves. These marking and labeling requirements will help enable consumer selection of compatible showerheads and shower mixing valves. Finally, the CASE Team is recommending updating the definition of a showerhead and adding definitions for hand held showerheads, shower mixing valves, supply fittings, and automatic compensating shower mixing valves to the standards. The update to the showerheads definition intends to clarify that a plumbing fitting intended for a shower bath is considered a single showerhead when attached to a single supply fitting. The additional definitions are intended to clearly define a hand held showerhead and add context for the inclusion of a shower mixing valve labeling requirement in Title 20. See Section 13 for more detail on the proposed changes.

According to the 2013 California Water Plan Update prepared by the Department of Water Resources (DWR), showers account for about 20 to 22 percent of indoor residential water use (CA DWR 2013). As demonstrated in Figure 1, showers are one of the highest residential indoor water uses in the state of California. For this reason, establishing more stringent efficiency standards for showerheads will have a significant impact on California's overall water and embedded energy use. Reducing the water use of showerheads is crucial to California's water reduction strategy, addressing California's resource needs during the current drought, and building resiliency for the future.

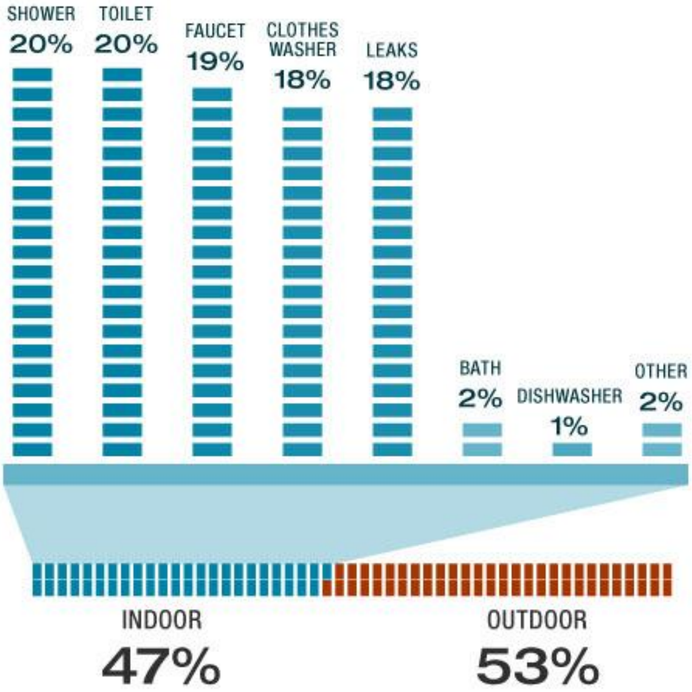

Figure 1: Household Water Use in California

Source: CEC 2015c

In addition to the benefits of reducing water use and embedded electricity use, the proposed showerhead standard will result in direct energy savings from reduced water heating load. It is estimated that 73 percent of water used in showers is hot water (Seattle & EPA 2000). Reducing total water use in showers will result an overall reduction in hot water use, which in turn will reduce the energy requirements for heating water. Reducing water heating load can have significant positive impacts on the whole-house energy use, as water heating accounts for the largest share of natural gas usage in California homes (Hoeschele et al. 2012).

2.2 Proposal History

A similar showerhead standard has not been considered in previous Title 20 rulemakings in part because states were preempted by federal law from establishing their own standards for showerheads. On December 22, 2010, the United States (U.S.) Department of Energy (DOE) waived federal preemption for energy and water conservation standards with respect to any state regulation concerning the water use or water efficiency of faucets, showerheads, and urinals (75 Fed. Reg.245, 22 December 2010). This waiver allows states to set their own standards for the relevant plumbing products as long as the state standard is as stringent as the federal standard.

A similar showerhead standard was considered during the development of the 2013 California Building Energy Efficiency Standards (California Code of Regulations, Title 24, Part 6). The proposed Title 24 measure recommended that all showerheads installed in newly constructed buildings have a maximum rated flow rate of 2.0 gallons per minute (gpm) or less when measured at 80 pounds per square inch (psi). The proposal also recommended prohibiting the use of multi-head showers unless the total flow rate from all heads operating at any given time was less than or equal to 2.0 gpm. Additionally, this proposal would have required at least four feet between showerheads to limit the allowable applications of installing multiple showerheads within the same shower stall (CA IOU C&S Team 2011).

3 Background

3.1 Regulatory Background

3.1.1 Federal Regulatory Background

Showerheads have been regulated by DOE since 1992 when the Federal Energy Policy Act of 1992 (EPACT 1992) established the maximum flow rate requirement of 2.5 gpm when measured at 80 psi for all showerheads manufactured effective January 1, 1994. EPACT 1992 referenced the efficiency requirements that were presented in *American Society of Engineers/American National Standards Institute (ASME/ANSI) Standard A112.18.1M-1989 - Plumbing Fixture Fittings* and directed DOE to waive preemption for plumbing fixtures and fittings if ASME did not revise its standards for these products within five years of the effective date (January 1, 1994).

In March 1998, DOE amended its test procedures for showerheads and faucets to incorporate by reference the updated ASME/ANSI standard A112.18.1M-1996. The water efficiency requirement remained unchanged (DOE 2013).

Since ASME did not revise the standard within the five-year timeframe, states were eligible to set their own standard after 1999. On December 22, 2010, DOE officially waived federal preemption for energy conservation standards with respect to any state regulation concerning the water use or water efficiency of faucets, showerheads, water closets, and urinals (DOE 2010).

In October 2013, DOE published a final rule for test procedures for showerheads, faucets, water closets, urinals, and commercial pre-rinse spray valves, incorporating by reference ASME

A112.18.1-2012. This final rule was not intended to change the water efficiency of products but to clarify and update the test methods used to verify compliance with the current federal standard**s** (DOE 2013).

3.1.2 California Regulatory Background

The first water efficiency standard for showerheads was introduced in California's Appliance Efficiency Regulations (Title 20) in 1978. This standard, which took effect December 22, 1978, limited the maximum flow rate to 2.75 gpm (CEC 1992). This standard was later updated to 2.5 gpm, effective March 20, 1992 (CEC 1992). Following DOE's adoption of a federal requirement, which took effect in January 1994, Title 20 was updated to reference the federal standard.

As previously noted, until December 2010 California was preempted by federal law from updating showerhead efficiency standards.

In 2009, the California Legislature enacted Senate Bill 407 (California SB 407, 2009). This bill requires non-compliant plumbing fixtures installed in residential and commercial buildings constructed before 1994 to be replaced with water-conserving plumbing fixtures by 2017 (single-family buildings) or 2019 (multi-family and commercial buildings). Toilets, urinals, showerheads, and faucets are the plumbing fixtures subject to SB 407 and a non-compliant showerhead is defined in the legislation as "any showerhead manufactured to have a flow capacity of more than 2.5 gallons of water per minute." The bill states "'water-conserving plumbing fixture' means any fixture that is in compliance with current building standards applicable to a newly constructed real property of the same type." For showerheads, this means that compliant fixtures must meet the 2.0 gpm maximum flow rate requirement that is included in California Plumbing Code (Part 5 of Title 24) and the California Green Building Standards (CALGreen or Part 11 of Title 24). Theoretically, SB 407 will result in all showerheads installed in California to be rated at 2.0 gpm by 2019. Local governments charged with enforcing this law have limited resources and it will be difficult for them to verify that non-compliant showerheads have been replaced in all buildings constructed before 1994. The CASE Team anticipates that SB 407 may result in California replacing non-compliant fixtures faster than if the law were not in place; however, it is likely that there will still be non-compliant showerheads installed in buildings after the 2019 deadline.

As mentioned above, CALGreen and the California Plumbing Code include efficiency requirements for showerheads. The 2013 CALGreen standards, which took effect in January 2014, include mandatory requirements for showerheads installed in residential and nonresidential buildings. Showerheads must have a maximum flow rate of showerheads is 2.0 gpm at 80 psi and be certified to the WaterSense performance criteria. To prevent the installation of more than one showerhead in one shower, CALGreen specifies that when a single shower is served by more than one showerhead, the combined flow rate all showerheads and/or other shower outlets controlled by a single valve cannot exceed 2.0 gpm at 80 psi or that the shower be designed to allow for only one shower outlet to be in operation at a time (CBSC 2015, Sections 4.303 and 5.303.3).

The 2013 California Plumbing Code (§401.2) requires showerheads to have a maximum flow rate of 2.0 gpm at 80 psi and must comply with Section 4.3 of CALGreen (IAPMO 2013). The California Plumbing Code is based on the Uniform Plumbing Code (UPC), a model code developed by the International Association of Plumbing and Mechanical Officials (IAPMO) using the American National Standards Institute (ANSI) process for developing consensus standards. The UPC serves as a model code for a number of states, including states that have abundant water supplies. However, California's water supply constraints necessitate more aggressive water efficiency measures than are necessary elsewhere in the country. As such, California's mandatory water efficiency standards for newly constructed buildings have been more stringent than the water efficiency standards in the UPC for quite some time.

3.2 Model Codes and Standards

A number of government and non-government entities have made substantial progress establishing model building codes and voluntary standards that address water efficiency. Many of these existing codes and standards have been developed through rigorous public vetting processes in which key industry stakeholders participated. As shown in Table 1, in most cases the water efficiency requirements in these model codes and standards are more robust than the federal and Title 20 requirements.

Table 1: Model Codes and Standards for Showerheads

Model Code	Showerheads in Residential Buildings	Showerheads in Nonresidential Buildings
WaterSense (effective February 9, 2010)	• Maximum flow rate of 2.0 gpm determined as the highest value obtained through testing at flowing pressures of 20, 45, and 80 ± 1 psi. • The minimum flow rate, determined through testing at a flowing pressure of 20 ± 1 psi, shall not be less than 60 percent of the maximum flow rate of 2.0 gpm. The minimum flow rate determined through testing at flowing pressures of 45 and 80 ± 1 psi shall not be less than 75 percent of the maximum flow rate of 2.0 gpm. • Spray force shall be not less than 2.0 ounces at a pressure of 20 ± 1 psi at the inlet when water is flowing. • Spray Coverage: total combined maximum volume of water collected in the 2- and 4-inch annular rings shall not exceed 75 percent of the total volume of water collected and the total combined minimum volume of water collected in the 2-, 4-, and 6-inch annular rings shall not be less than 25 percent of the total volume of water collected.	
CALGreen (effective January 1, 2014)	2.0 gpm and WaterSense certified	
LEED V.4 (July 2014)	No individual maximum level specified for plumbing fixtures and fittings. Mandatory to reduce aggregate water consumption by at least 20 percent from baseline.	
ASHRAE SS189.1 (v.2-2011, updated with addendum v)	2.0 gpm maximum flow rate and WaterSense certified	N/A
ASHRAE S191P (public review draft v.1)	2.0 gpm maximum flow rate	
ICC 700-2008 (with NAHB)	2.5 gpm maximum flow rate	N/A
IAPMO Green Plumbing & Mechanical Code Supplement (2015 version)	2.0 gpm maximum flow rate and WaterSense certified; shower valve must scald-protect at showerhead flow rate	
IgCC Green Code (2015 version)	2.0 gpm maximum flow rate and WaterSense certified	

3.3 Utility and Other Incentive Programs

Several California energy and water utility programs currently offer incentives for showerheads below the current flow rate standard of 2.5 gpm, with several providing incentives for showerheads below the proposed flow rate standard of 2.0 gpm. Examples include the East Bay Municipal Utility District (EBMUD), Contra Costa Water District, San Diego Gas and Electric Company (SDG&E), and Southern California Gas Company (SoCalGas).

Both EBMUD and the Contra Costa Water District provide free high efficiency showerheads rated at 2.0 gpm to residential customers and EBMUD also provides shower diverters or shut-off valves (EBMUD 2015, CCWD 2015). SDG&E provides free water and energy-savings kits to residential customers, including a high efficiency showerhead (SDG&E 2015), while SoCalGas offers rebates for three showerheads, rated at flows of 1.6 and 1.5 gpm (SoCalGas 2015). LADWP provides free 2.0 gpm or 1.5 gpm showerheads to commercial customers (LADWP 2015).

3.4 Impetus to Pursue Water and Energy Efficiency

3.4.1 State Water Policy Goals

Water is essential to supporting and sustaining the environmental, economic, and public health needs of the state. Ongoing 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 all state agencies to take all necessary actions to prepare and respond to drought conditions (CA Proclamation, 1-17-2014). With the drought persisting, 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 include: 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,[1] the California Department of Water Resources,[2] and CEC[3] have either adopted or plan to soon adopt "emergency" or "expedited" water saving regulations.

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[1] 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.

[2] 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.

[3] On April 8, 2015, CEC adopted updated Title 20 standards for toilets, urinals and faucets. See Section 3.3.3 of this report for additional information (CEC 2015d, CEC 2015c).

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. As discussed in Section 3.4.2, 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.

3.4.1.1 Problem Statement – California's Drought Emergency

As of June 30 2015, 98.7 percent of California is in a drought, ranging from "severe drought" in 94.5 percent of the state (3 on a scale of 1 to 5, with 5 being the worst or "exceptional drought") to "exceptional drought" in 46.7 percent of the state. See Figure 2 below for a California drought map by region. As of July 2015, California's major reservoirs are at less than 35 percent of total capacity, about 75 percent below the historical average (CA DWR 2015). As of June 22, 2015, the U.S. Geological Survey reported that 54 percent of its 220 stream flow gauges in California record either "below normal" or "much below normal" flows (USGS 2015).

The California Farm Water Coalition estimates that due to the severe drought this year (2015), 41 percent of California's irrigated farmland will lose 80 percent or more of its normal surface water allocation and 620,000 acres will be fallowed (California Farm Water Coalition 2015). In 2014, the statewide economic cost of the drought totaled $2.2 billion, including loss of 17,100 seasonal and part-time jobs (UC Davis 2014). The economic impacts are projected to be worse in 2015 due to even more aggressive water shortages and even more land going fallow.

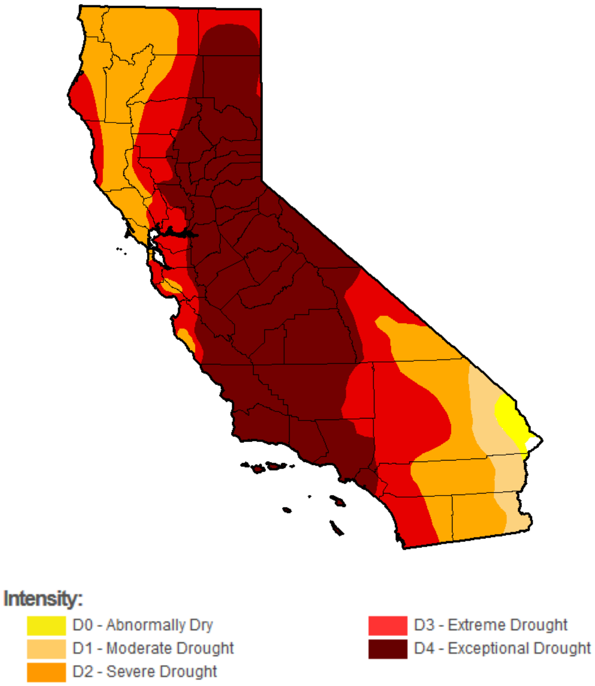

Figure 2: California Drought Classification by Region

Source: United States Drought Monitor (Updated June 30, 2015)

The installation of water-saving devices in residential, commercial, and industrial applications is crucial for addressing California's water resource needs during the drought. Water use efficiency and conservation protects the future of our state's water supply for communities, businesses, industry, and the environment. Water use efficiency decreases the need to invest in costly, large-scale infrastructure projects (e.g., dams, canals, reservoirs) as noted below, while also reducing operating costs for water utilities (e.g., pumping and treatment) (U.S. EPA 2015).

3.4.1.2 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.[4] 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 as discussed in Section 12.

3.4.1 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 the Title 20 appliance standards.

To date, California is on target to meet the goals of AB 32 (CARB 2014). In response, Governor Brown issued Executive Order (EO) 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 EO 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 2007a). Through Decision 07-10-032, CPUC adopted the 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 CEC'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).

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[4] 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.

On October 11, 2009, the California Legislature adopted Assembly Bill 758. AB 758 requires CEC 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 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.

3.4.2 Water-Energy Nexus

The relationship between water use and energy use helps to justify additional water efficiency standards. Nearly twenty percent of the electricity and thirty percent of non-power plant-related natural gas use in California is associated with meeting California's water supply needs (CEC 2006).[5] California consumes about 2.9 trillion gallons of water per year for urban uses (Christian-Smith, Heberger & Luch 2012).[6] These 2.9 trillion gallons of water correspond to approximately 26.4 terawatt hours (TWh) of embedded electricity. Figure 3 presents the embedded energy associated with various water end uses. More than 9.1 TWh of electricity is used every year to supply and treat potable water that is used inside residential buildings. Conversely, water is required to produce electricity; if electricity demand increases so does the demand for water (California Sustainability Alliance 2013).

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.[7]

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[5] 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.

[6] 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.

[7] See Appendix B for information about the methodology used to calculate the embedded energy estimates presented in this report.

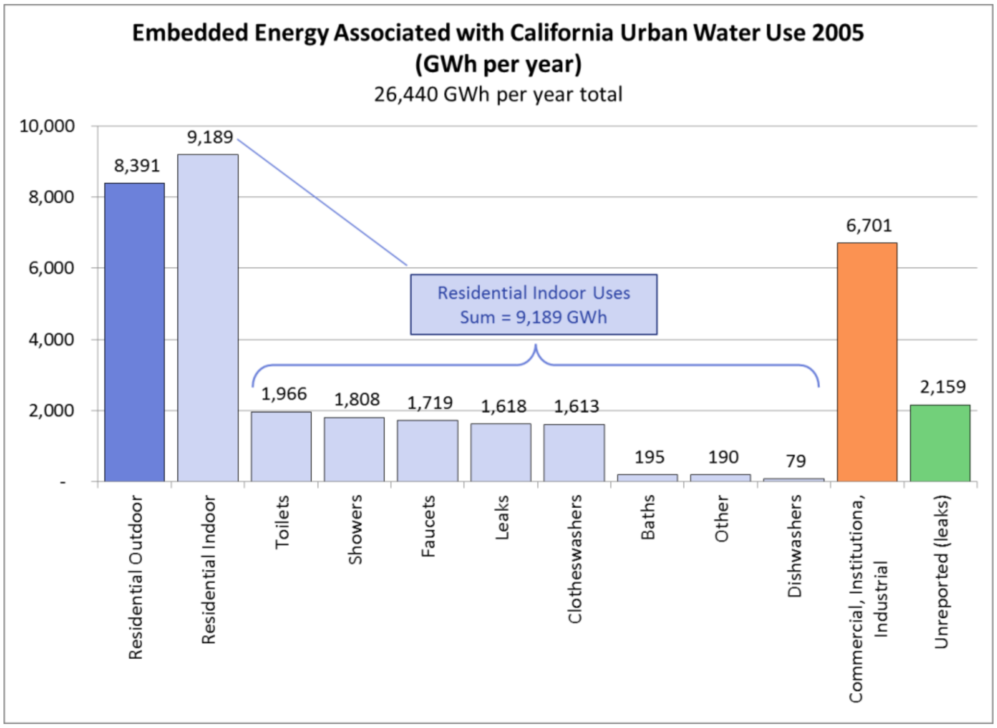

Figure 3: Embedded Energy Associated with California Urban Water Uses (2005)

Source: Christian-Smith, Heberger, Luch (2012).
Assumptions: Embedded energy factor of 8,134 kWh/MG for residential outdoor water use and unreported (leaks); embedded energy factor of 10,045 kWh/MG for residential indoor; embedded energy factor of 9,090 kWh/MG for commercial, institutional, industrial.

4 Product Description

Showerheads are perforated nozzles that disperse water in an even spray over an individual for personal hygiene, defined by CEC as plumbing fittings “through which water is discharged for a shower bath” (CEC 2015b). Showerheads are used in both residential and commercial settings. Replacing a showerhead is as simple as removing the old showerhead and screwing on the new fitting.

Showerheads may be fixed-mount or accompanied by a hose to extend the nozzle and allow it to move (referred to as a hand held showerhead). Showerheads may contain adjustable settings, allowing the user to alter the pattern of the water stream or adjust the flow, such as with a shut-off valve. Some showerheads contain premium features such as temperature setting and regulation. Body sprays, typically mounted to the wall of the shower to provide a fixed horizontal spray, are another type of showerhead device.

There are two types of high efficiency showerheads: aerating and non-aerating (also referred to as laminar-flow). Aeration is the process of circulating air with water, creating a lighter spray, either by physically mixing air and water using a turbine inside a showerhead or by using a Venturi device to allow air into the showerhead to create a vacuum that mixes the air with the water (see Figure 4). The most basic high efficiency showerheads are non-aerating and typically utilize flow restrictors, or disk inserts, to reduce water flow.

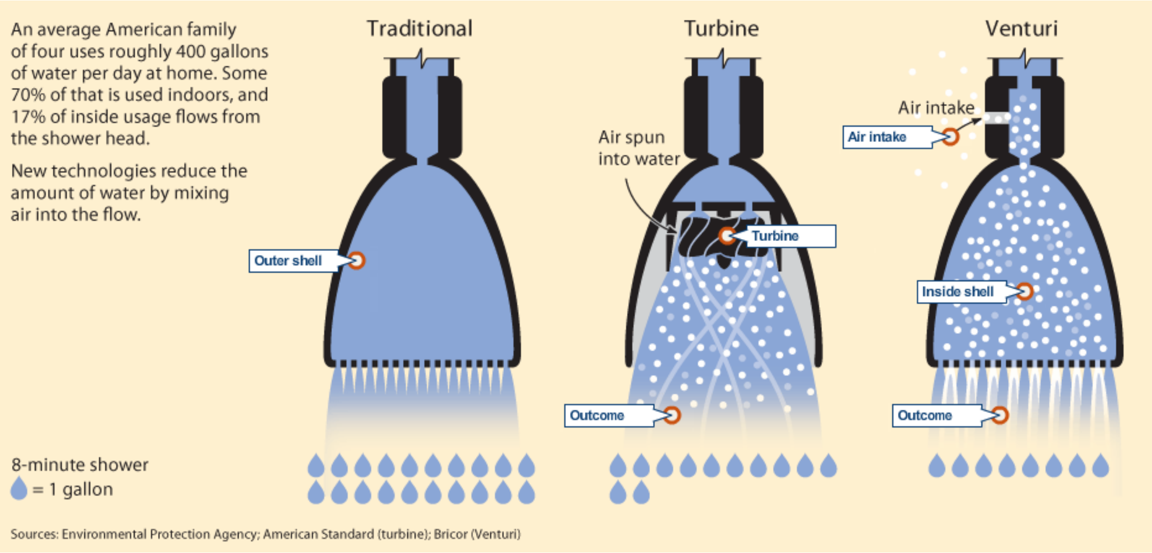

Figure 4: A comparison of showerheads demonstrates how aerating technology reduces water flow

Source: Wall Street Journal[8]

Showerheads are typically mounted on the wall inside a shower stall and are controlled by the user with a shower valve or shower faucet, which may be sold as part of a trim kit for original installations and usually sold separately from the showerhead for retrofits. Shower mixing valves mix cold and hot water to create the desired water temperature at the showerhead. They are located inside the wall behind the shower and are usually installed during initial construction. Shower mixing valves may be automatic-compensating mixing valves, which provide a means to automatically maintain the temperature selected by the user, or non-automatic compensating, which do not automatically maintain the selected temperature. Like showerheads, shower mixing valves are rated at specific pressures and flow rates. As discussed in Section 11.1.2, the risk of thermal shock is diminished if the flow rate of the shower mixing valve and the flow rate of the showerhead are compatible.

5 Market Analysis

5.1 Market Structure

Showerheads are distributed through four primary outlets:

1. Direct sales (i.e. manufacturers sell directly to homebuilders or other volume purchases);
2. Retail sales (e.g., Home Depot, Lowes, or other retailer);
3. Wholesale plumbing suppliers; and
4. Decorator showrooms.

Manufacturers sell directly to entities that can purchase a large volume of products such as homebuilders, commercial builders, or water utilities. Distributors have a limited (or non-existent)

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[8] The Wall Street Journal. Accessed July 2015: http://www.wsj.com/news/interactive/POWERSHIFT0911.

role in direct manufacturer to installer sales, so the distributor mark-ups are minimal or eliminated completely.

Retail sales are common for do-it-yourself remodels. Large retailers such as Lowes and Home Depot process a majority of the retail sales. These large retailers have a significant influence on which products reach the mainstream retail market. Retailers cannot stock a wide variety of models due, in part, to limited shelf space. The models that are stocked have a distinct advantage over models that are not stocked. Typically, water efficiency is not the primary factor retailers consider when making decisions about which products to carry; price, performance, and appearance are often weighed more heavily than efficiency.

Some manufactures have localized distribution channels that utilize wholesale distributors to deliver a tailored distribution strategy for different regions. Wholesale distributors may work with builders, water utilities, or retail stores. The wholesaler distribution model is most common for smaller manufacturers that offer specialized products, including premium efficiency toilets and urinals. Sales representatives from the wholesaler can offer personalized messaging to interested customers. Wholesalers tend to target markets with high sales or markets that have an appetite for the specialty products they carry.

Showrooms are also a distribution channel. Manufacturers that offer high-efficiency products may target green building showrooms or choose to market their products at green building trade shows.

5.2 Stock

The CASE Team used data on the existing and forecasted housing stock and estimates of the number of showerheads installed per housing unit to project the existing stock of installed showerheads and projected future showerhead sales.

The CEC Demand Analysis Office provided the CASE Team with historical and forecasted housing stock and projected annual residential dwelling starts for the single family, multi-family, and mobile sectors. This Demand Analysis Office is charged with calculating the required electricity and natural gas supply centers that need to be built in order to meet the new construction utility loads. Data was sourced from the California Department of Finance and California Construction Industry Research Board (CIRB) building permits. The Department of Finance uses census years as independent data and interpolates the intermediate years using CIRB permits. The CEC provided three projections: low, mid, and high estimates with each case broken out by Forecast Climate Zones (FCZ). The CASE Team used the mid scenario of forecasted residential new construction for statewide savings estimates.

When estimating installed showerhead stock it was assumed that there are 1.3 showerheads per single family home (DWR 2011) and that there is one showerhead per dwelling unit for the multi-family and mobile sectors. Applying these assumptions about number of showerheads per housing unit to the 2015 housing stock, the CASE Team found that on average there are 1.19 showerheads per housing unit. As discussed in Section 8.1 of this report, this statistic was used to calculate the per unit water and energy impacts of the proposed standard.

Table 2 presents the estimated showerhead stock in years 2015 – 2028. The CASE Team estimates that in 2015 there are approximately 15.4 million showerheads installed in California's residential buildings. The analysis presented in this report only includes the showerhead stock in single family, multi-family, and mobile residential buildings. While the majority of water use from showers occurs in these types of residential buildings, showers are common in many types of nonresidential buildings such as hotel, health clubs, and office buildings. The CASE Team may update the savings estimates at a future date to include savings from nonresidential buildings. For now, it should be assumed that the statewide savings estimates presented in this report are conservative because they do not include savings from showers in nonresidential buildings.

5.3 Shipments

To estimate annual shipments, the CASE Team projected the number of showerheads in existing buildings that will be replaced and the number of showerheads that will be installed in newly constructed buildings. The CASE Team estimated the quantity of shipments that would serve to replacement existing products assuming that showerheads have a 10 percent annual replacement rate—that is 10 percent of the installed stock will be replaced each year. See Section 10.2 of this report for more information on product lifetime.[9] The quantity of shipments that would be installed in newly constructed buildings was calculated using the residential construction forecast and the assumption that 1.3 showerheads would be installed in new single-family homes (DWR 2011) and 1 showerhead would be installed in each new multi-family dwelling unit and mobile dwelling unit.

Table 2 presents the estimated showerhead shipments in years 2015 – 2028. The CASE Team estimates that annual shipments in this time period will be in the range of 1.7 to 1.8 million showerheads per year. The quantity of shipments varies proportionally to the forecasted housing stock.

Table 2: California Shipments and Stock of Showerheads

Year	Annual Shipments (units)	Stock (units)
2015	1,715,385	15,447,977
2016	1,696,827	15,265,333
2017	1,707,281	15,428,602
2018	1,752,557	15,945,351
2019	1,756,696	16,092,381
2020	1,768,848	16,236,774
2021	1,779,963	16,378,223
2022	1,789,058	16,514,884
2023	1,797,894	16,647,295
2024	1,804,474	16,773,483
2025	1,813,337	16,897,110
2026	1,822,028	17,017,398
2027	1,830,562	17,134,509
2028	1,838,960	17,248,609

Source: CASE Team analysis 2015

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[9] Replacement rate is equal to the inverse of the product lifetime (e.g., if product life is 10 years, then 0.10 percent of products are replaced each year).

5.4 Market Share of Qualifying Products

5.4.1 Current Market Share

The CASE Team reviewed data from three databases to glean information about the availability of products that comply with the proposed standards. The DOE's Appliance Compliance Certification Database lists all products that are approved for sale in the United States (DOE 2015). The CEC Appliance Efficiency Database lists products that are approved for sale in California (CEC 2015a), and the WaterSense Product Database lists products that have been certified to meet the WaterSense Specification for Showerheads (WaterSense 2015). There are differences in the individual entries in the databases that stem from variations in model numbers and brand names that manufacturers use when submitting information and how frequently the database is updated to add new products and remove products that are no longer offered for sale. Although the data vary slightly in each database, information from all three databases indicates that products that comply with the proposed standard are readily available from a variety of manufacturers and brand names.

The DOE Database lists the basic model number and unique model numbers; individual model numbers are often slight variations on the basic model to account for differences in product color. As of June 2015, there were 2,754 basic showerhead models in the DOE database – 1,053 (38%) of which have a flow rate of 2.0 gpm or less. There are 4,739 unique models, 2,145 (45%) of which have a flow rate of 2.0 gpm or less. Showerheads were represented by 121 unique brand names – 79 (65%) of which offer showerheads that have a flow rate of 2.0 gpm or less. The fact that there are over 2,000 models of showerheads that would meet the proposed 2.0 gpm flow rate available today from a wide variety of brand names indicates that compliant products are readily available. The CEC database includes 4,386 unique showerhead models—1,351 (31%) of which are rated at 2.0 gpm or less. There are 212 unique brand names in the CEC database, 98 of which (46%) have products rated at 2.0 gpm or less. Finally, as of June 2015, there are 3,445 individual showerhead models from 115 brand names in the WaterSense product database (See Table 3). These data indicate that products that meet the proposed standard are readily available from a variety of manufacturers.

Table 3: Summary of Showerhead Models Available for Sale

Database	**Brand Names**			**Models**		
	Flow rate of 1.8 gpm or less	**Flow rate of 2.0 gpm or less**	**Total**	**Flow rate of 1.8 gpm or less**	**Flow rate of 2.0 gpm or less**	**Total**
DOE Appliance Efficiency Database (Basic Models)	51 (42%)	79 (65%)	121	317 (12%)	1,053 (38%)	2,754
DOE Appliance Efficiency Database (Unique Model Numbers)	51 (42%)	79 (65%)	121	613 (13%)	2,145 (45%)	4,739
CEC Appliance Efficiency Database	65 (31%)	98 (46%)	212	507 (12%)	1,351 (31%)	4,386
WaterSense	N/A	115 (100%)	115	N/A	3,445 (100%	3,445

A 2011 study funded by DWR evaluated the installed stock of showerheads in single family homes in California. The study, which evaluated the flow rate of 17,334 unique showers, found that the median measured flow rate was 1.99 gpm and that the measured flow rate was 85.6 percent of the rated flow rate and that nearly 80 percent of all installed showerheads had a rated flow rate of 2.5

gpm or less (DWR 2011). The measured flow rate is often lower than the rated flow rate for several reasons, such as the rated maximum flow is measured at 80 psi and water pressure in homes is usually lower than 80 psi.

As discussed in Section 8.2, the savings analysis presented in this report accounts for the finding that many showerheads sold in California already meet the proposed Tier 1 (≤ 2.0 gpm) and Tier 2 (≤ 1.8 gpm) efficiency levels. The CASE Team assumed a baseline in which 40 percent of the showerheads sold in a given year will meet the proposed Tier 1 level and 12 percent of the showerheads will meet the proposed Tier 2 level.

Although it is known that some showerheads that are currently installed in California homes are rated above 2.5 gpm, the water and energy savings impacts were calculated assuming that all products installed in California meet the federal efficiency requirement of 2.5 gpm. This assumption results in a conservative estimate of the water and energy savings estimates presented in this report. In reality, some of the 2.0 gpm or 1.8 gpm showerheads that are sold after the new standard takes effect will be used to replace devices that are rated above 2.5 gpm, and the per unit savings will be larger than the estimates presented in this report.

5.4.2 Future Market Adoption of Qualifying Products

The CASE Team anticipates that 2.0 gpm showerheads will continue to represent a larger portion of overall showerhead shipments in California. The current drought may inspire more Californians to select 2.0 gpm showerheads over the 2.5 gpm alternatives. Utility incentive programs that aim to replace higher-flow showerheads with more efficient models could also serve to increase the shipments of 2.0 gpm showerheads. The savings estimates presented in this report assume that higher-flow showerheads will be replaced at the end of their useful life. However, utility incentive programs could result in showerheads being replaced more quickly. If this happens, stock turnover will occur sooner than presented in this report (e.g., by year 2025 if the Tier 1 standard takes effect in 2016) and California will realize the full savings potential at an earlier date.

6 Test Methods

6.1 Current Test Methods

The California Plumbing Code requires that showerheads comply with *ASME A112.18.1 / CSA B125.1-2012 – Plumbing Supply Fittings*.[10] This standard includes test procedures to measure minimum design and performance requirements. It includes test for water efficiency (flow rate), spray force, and spray coverage. The federal test method for showerheads, *10 CFR Part 430, Subpart B, Appendix S to Subpart B of Part 430 - Uniform Test Method for Measuring the Water Consumption of Faucets and Showerheads,* references section 5.4 of ASME A112.18.1-2012.

The WaterSense Specification for Showerheads, which was published in 2010, includes test methods to measure spray force and spray coverage in Appendix A and Appendix B, respectively. The test methods that first appeared in the WaterSense Specification have been incorporated into ASME A112.18.1-2012.

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[10] Section 417.1 of the 2013 California Plumbing Code (Part 5 of Title 24).

6.2 Proposed Test Methods

California is preempted from adopting a test method that varies from the federal test method to measure the maximum flow rate. As such, the CASE Team recommends that Title 24 reference the federal test method for the maximum flow rate. Section 5.12 of ASME A112.18.1/CSAB125.1-2012, titled High-efficiency Shower Heads and Hand held Showers, includes a test methods for spray force, spray coverage and for minimum flow rates at 45, and 20 psi. The CASE Team recommends that CEC reference Section 5.12 of ASME A112.18.1 / CSA B125.1-2012 to test metrics that are not already covered in the federal test method.

7 Marking and Labeling Requirements

7.1 Current Marking and Labeling Requirements

Federal marking and labeling requirements for showerheads are detailed in 16 CFR Part 305. Showerheads must bear the following markings on the showerhead itself:

- Maximum flow rate expressed in gallons per minute;
- Manufacturer; and
- "A112.18.1M" to demonstrate compliance with ASEM A112.18.1. This marking can be a permanent mark on the showerhead itself, on the product label, or on a tag attached to the product.

In addition, the packaging for showerheads must disclose the manufacturer's name and the model number, the marking "A112.18.1M," and the maximum flow rate expressed in gallons per minute and liters per minute.

California is preempted from establishing its own marking and labeling requirements for information that is already covered by the federal standards. California can establish marking and labeling requirements that cover information that is not already covered by the federal rules. For example, the current Title 20 Standards require that the model number and the date of manufacture be clearly displayed on the unit itself or on the unit's packaging.

7.2 Proposed Marking and Labeling Requirements

The CASE Team is recommending updating showerhead labeling requirements so product packaging and labeling include the minimum flow rate at 45 psi in addition to the existing federal labeling requirements.

The CASE Team is also recommending a labeling requirement for shower mixing valves that would require the flow rate to be clearly presented on product packaging. As described in Section 11.1.3 of this report, the risk of thermal shock is diminished if the flow rate of the shower mixing valve and the flow rate of the showerhead are compatible. Currently, shower mixing valves are tested and rated at 45 psi, as required in ASSE 1016-2011/ASME A112.1016-2011/CSA B125.16-11, but the maximum flow rate of showerheads is rated at 80 psi. Showerheads are labeled with the maximum flow rate, but shower mixing valves are not labeled with their design flow rate. The proposed revision to the showerhead labeling requirements and addition of the shower mixing valve labeling requirements will make it easier for consumers to select a showerhead and shower mixing valve that is compatible.

8 Per Unit Water & Energy Impacts

8.1 Efficiency Measures

Efficiency for a showerhead is achieved by reducing the flow rate through the addition of a restricting or regulating flow control device in addition to or instead of increasing the aeration of the showerheads spray. Aeration is the process of circulating air with water, creating a lighter spray, by either physically mixing air and water using a turbine or by allowing air into the showerhead and creating a vacuum that mixes air into the water using a Venturi device. See Section 4 of this report for more information.

8.2 Per Unit Water and Energy Savings Methodology

The CASE Team calculated the impacts of the proposed standard by comparing non-qualifying products to qualifying products. Non-qualifying products are products that do not meet the proposed standard and qualifying products meet the proposed standard. Table 4 presents the assumptions and equations used to calculate per unit water and energy savings of the proposed standard. The savings estimates presented in Table 4 represent the savings achieved from the Tier 1 standard (updating maximum flow rate from 2.5 gpm to 2.0 gpm) and the Tier 2 standard (updating maximum flow rate from 2.0 gpm to 1.8 gpm). The methodology used to calculate these estimates is presented in more detail below.

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

Metric	Value	Source / Notes / Equations
Assumptions		
Average shower duration [A]	8.7 minutes/shower	DWR 2011
Average number of showers per household per day [B]	1.97 showers/household/day	DWR 2011
Shower days per year [C]	365 days/yr	
Showerheads per household [D]	1.19 showerheads/household	DWR 2011 and CASE Team analysis. DWR 2011 found 1.3 showers per single-family house. Assumed 1 showerhead per multi-family unit and mobile unit.
Non-qualifying flow rate at 80 pounds per square inch (psi) [E]	Tier 1: 2.5 gallons per minute (gpm) Tier 2: 2.0 gpm	Tier 1: Current federal standard Tier 2: Proposed Tier 1 Title 20 efficiency standard
Qualifying flow rate at 20, 45, or 80 psi [F]	Tier 1: 2.0 gpm Tier 2: 1.8 gpm	Proposed Title 20 maximum flow rates
Flow rate derating factor [G]	0.86	DWR 2011
Additional water wasted when waiting for hot water to arrive, relative to 2.5 gpm showerhead [H]	71.9 gallons per showerhead per year	0.1 gallon per event × B × C Estimates of water wasted when waiting for hot water to arrive may be high. In reality not all shower events [B] will be cold start events. As a result, water savings estimates presented in this report may be understated (see Section 11.1.6).
Percent of water use that is hot	73.1%	Seattle & EPA 2003

[I]		
Natural gas required to heat water [J]	8.133 therms/1000 gallons	See Equation 4 • Assumes cold water inlet temperature is 65°F and hot water supply is 124°F (CA IOUs 2011b, CEC 2013a) • Assumes average Energy Factor rating of gas storage water heaters is 0.60 (CPUC 2014). • Assumes outlet water is at 100°F and 1 atm
Electricity required to heat water [K]	158.9 kWh/1000 gallons	See Equation 4 • Assumes cold water inlet temperature is 65°F and hot water supply is 124 °F (CA IOUs 2011b, CEC 2013a) • Assumes average energy factor of electric storage water heaters is 0.90 (CPUC 2014). • Assumes outlet water is at 100°F and 1 atm
Embedded Electricity Factor [L]	4,848 kWh/million gallons	CPUC 2015 See Appendix B for methodology
Peak demand load factor [M]	0.86	Brown & Koomey 2002
Results		
Annual water use per showerhead (Non-qualifying) [N]	Tier 1: 11,235 gallons/showerhead/yr Tier 2: 9,060 gallons/showerhead/yr	Tier 1: $N = (A \times B \times C) \div (D \times E \times G)$ Tier 2: $N = [(A \times B \times C) \div (D \times E \times G)] + H$
Annual natural gas use for water heating per showerhead (Non-qualifying) [O]	Tier 1: 66.8 therms/showerhead /yr Tier 2: 54.0 therms/showerhead /yr	$O = N \div 1000 \text{ gallons} \times I \times J$
Annual electricity use for water heating per showerhead (Non-qualifying) [P]	Tier 1: 1,305 kWh/showerhead /yr Tier 2: 1,056 kWh/showerhead /yr	$P = N \div 1000 \text{ gallons} \times I \times K$
Annual water use per showerhead (Qualifying) [Q]	Tier 1: 9,060 gallons/showerhead/yr Tier 2: 8,161 gallons/showerhead/yr	$Q = [(A \times B \times C) \div (D \times F \times G)] + H$
Annual natural gas use for water heating per showerhead (Qualifying) [R]	Tier 1: 54.0 therms/showerhead /yr Tier 2: 48.7 therms/showerhead /yr	$R = (Q \times I + H) \div 1000 \text{ gallons} \times J$
Annual electricity use for water heating per showerhead (Qualifying) [S]	Tier 1: 1,056 kWh/showerhead /yr Tier 2: 951kWh/showerhead /yr	$S = (Q \times I + H) \div 1000 \text{ gallons} \times K$
Annual water savings per showerhead [T]	Tier 1: 2,175 gallons/showerhead/yr Tier 2: 899 gallons/showerhead/yr	$T = N - Q$
Annual natural gas savings per showerhead [U]	Tier 1: 12.8 therms/showerhead/yr Tier 2: 5.3 therms/showerhead/yr	$U = O - R$
Annual electricity savings per showerhead [V]	Tier 1: 250 kWh/showerhead/yr Tier 2: 104 kWh/showerhead/yr	$V = P - S$
Annual embedded electricity savings per showerhead [W]	Tier 1: 10.6 kWh/showerhead/yr Tier 2: 4.4 kWh/showerhead/yr	$W = T \div 1 \text{ million gallons} \times L$
Peak demand reduction per showerhead [X]	Tier 1: 33.1 W/showerhead Tier 2: 13.9 W/showerhead	$X = V \div 8760 \text{ hr/yr} \div M \times 1000 \text{ W/kW}$

8.2.1 Annual Per Unit Water Use Methodology

To calculate the amount of water showerheads use in California, the CASE Team determined the amount of time each showerhead is in use on an annual basis then multiplied by the flow rate. According to a 2011 study funded by DWR, the average shower duration is 8.7 minutes and there are 1.97 shower events per household per day (DWR 2011). It was assumed that shower events would occur 365 days per year. As discussed in Section 5.2 of this report, the CASE Team calculated that on average there are 1.19 showerheads per housing unit (single family, multi-family and mobile housing units combined). The amount of time each showerhead is in use on an annual basis was determined by Equation 1.

Some stakeholders have questioned if shower duration increases if flow rate is reduced thereby negating the savings from the higher efficiency showerhead. Three studies evaluated the duration of shower events before and after retrofitting buildings with higher efficiency showerheads. In all three studies researchers found that the average shower duration decreased after the showerhead was replaced with a more efficient model (Seattle & EPA 2000, EBMUD & EPA 2003, Tampa & EPA 2004). In the savings analysis for this report the CASE Team assumed that there would be no change in shower duration as a result of using higher efficiency showerheads.

Equation 1: Duty Cycle: Time Each Showerhead is in Use per Year

$$\begin{aligned} Duty\ cycle = {} & shower\ duration\ \times showers\ per\ housing\ unit\ per\ year \\ & \div\ showerheads\ per\ household \end{aligned}$$

The measured flow rate of installed showerheads varies from the rated flow rate. The variation in rated and measured flow rate is primarily attributed to differences in the water pressure in homes and the water pressure used to establish the rated maximum flow rate. The CASE Team applied a derating factor of 0.856 to the flow rates of non-qualifying and qualifying showerheads to attain the average actual flow rates (DWR 2011).

As discussed in Section 11.1.6 of this report, as flow rate is reduced a larger volume of water is wasted as cold water is purged from the hot water distribution pipe. For qualifying products, the CASE Team accounted for additional water that is wasted when waiting for hot water to arrive into account (See Equation 2). The additional water wasted is relative to the volume of water wasted when using a non-qualifying product.

Equation 2: Additional Water Wasted When Waiting for Hot Water to Arrive at Qualifying Showerhead

$$Hot\ Water\ Wasted\ per\ Year = Volume\ Wasted\ per\ Cold\ Start \times Cold\ Starts\ per\ Year$$

Annual water use was calculated by multiplying duty cycle by average actual flow rate and then adding the hot water wasted per year determined in Equation 2. The assumptions used to calculate annual per unit water use for showerheads are shown above in Table 4.

Equation 3: Annual Water Use (gallons per year) for Qualifying Products

$$\begin{aligned} Annual\ water\ use\ \left(\frac{gallons}{yr}\right) & \\ = {} & Duty\ cycle\ \left(\frac{minutes}{yr}\right) \times Actual\ Flow\ Rate\ \left(\frac{gallons}{minute}\right) \\ & + Water\ Wasted\ When\ Waiting\ for\ Hot\ Water\ \left(\frac{gallons}{yr}\right) \end{aligned}$$

8.2.2 Annual Per Unit Energy Use for Water Heating Methodology

Energy is required to heat hot water used in showers. The CASE Team calculated energy used for water heating using Equation 4. As discussed in Section 9.1, 87 percent of California homes have natural gas water heating, 7 percent have electric water heating, and the remaining homes use a different water heating fuel (e.g., solar or propane) or do not have water heating. The CASE Team calculated the energy impacts for natural gas and electric water heating. This report does not present the energy savings from other water heating fuels. Showerhead will have either natural gas or electricity savings depending on whether the house has natural gas or electric water heating. A single showerhead will not result in both natural gas and electricity savings from reduced water heating load.

For the specific heat and mass of water it was assumed that the water temperature was 100 °F and 1 atmosphere of pressure. The CASE Team used standard energy conversion factors to convert from BTU to kWh or therms of natural gas. It was assumed that the average inlet cold water temperature is 65 °F and the average hot water supply temperature is 124 °F, for an average temperature change (ΔT) of 59 °F. The water temperature assumptions were derived using information in the Single Family Water Heating Distribution System Improvements the CASE Report that was developed for the 2013 Title 24 code cycle and the water heating modeling assumptions that are described in the Title 24 2013 Residential Alternate Calculation Method Reference Manual (CA IOUs 2011, CEC 2013a).

Assumptions about water heater efficiency (energy factors) were based on data collected for the 2012 California Lighting and Appliance Saturation Study (CLASS). The 2012 CLASS project conducted onsite observations on a sample of single-family, multi-family, and mobile home residences with individually-metered electric accounts. Field surveyors recorded onsite data at 1,987 homes across the service territories of PG&E, SCE and SDG&E. This study included a detailed inventory of water heaters that were observed in California homes in 2012. Researchers found that the average energy factors for natural gas and electric water heaters were 0.6 and 0.9, respectively (CPUC 2014). Finally, it was assumed that 73.1 percent of water used in showerheads is hot water (Seattle & EPA 2000).

Equation 4: Energy Required to Heat a Gallon of Water Equation

$$Annual\ Energy\ Use\ for\ Water\ Heating\ = \frac{cm\Delta Ta}{EF} \times annual\ hot\ water\ use$$

Where: c = specific heat of water at 100°F and 1 atm = 0.998 BTU/lb-°F

m = mass of water at 100°F and 1 atm = 8.29 lb/gal

ΔT = temperature change (°F)

a = energy unit conversion factor: 100,000BTU/therm; 3,412BTU/kWh

EF = energy factor of water heater

The CASE Team recognizes that there is an inverse relationship between flow rate and temperature losses in pipes; as flow rate decreases temperature drop increases, as discussed in Section 11.1.5 of this report. A 2005 Public Interest Energy Research (PIER) Program study evaluated how flow rates impact temperature drop. Researchers measured temperature drop when 135 °F water moves through 100 feet of pipe. They concluded that reducing flow rate from 2.0 gpm to 1.0 gpm can increase temperature losses by 0.5 -3.4 °F. The magnitude of the temperature loss depends on a number of factors including pipe size, pipe material, and insulation level (CEC 2006). In most cases, users will compensate for the temperature losses by adding slightly less cold water at the shower faucet. However, in some cases users may adjust the water heater temperature setting upward. There is a measurable energy penalty if the temperature setting on the water heater is adjusted upward; however, the energy penalty due to temperature drop is small relative to the energy savings from reduced hot water use that are achieved when using high efficiency showerheads. The analysis presented in this report does not account for temperature drop.

8.2.3 Annual Per Unit Embedded Electricity Use Methodology

Energy is required for water supply (e.g., pumping), conveyance, treatment and distribution of potable water, and collection and treatment of wastewater. For this analysis, it was assumed that every million gallons of water used for an indoor application in California is attributable to 4,848 kWh of electricity use. This value was derived from a CPUC cost-effectiveness analysis of water and energy prepared by Navigant Consulting, Inc. (CPUC 2015). See Appendix B for further discussion on the methodology used to develop the embedded energy factor.

8.2.4 Peak Demand Methodology

Peak demand was calculated by multiplying daily electricity use by the assumed load factor of 0.86 (Brown & Koomey 2002).

8.3 Summary of Per Unit Water and Energy Use Impacts

Annual per unit water and energy impacts are presented in Table 5. 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 8.2.

The CASE Team estimates that a typical non-qualifying showerhead will use approximately 11,200 gallons of water per year, which has an associated embedded electricity use of 54 kWh per year. If the showerhead is installed in a home that has natural gas water heating, a non-qualifying product will use 67 therms of natural gas per year to heat water. If the showerhead is installed in a home that has electric water heating, a non-qualifying product will use 1,305 kWh per year to heat water, which has an associated peak demand of 173 watts.

It is estimated that the proposed Tier 1 standard will result in an annual per unit water savings of 2,175 gallons, which has an associated embedded electricity savings of 11 kWh. The per unit energy savings of the Tier 1 standard that is attributed to reduced water heating load is 13 therms per year and 250 kWh per year if the house has natural gas or electric water heating, respectively. The per unit peak demand savings for homes with electric water heating is 33 watts.

The proposed Tier 2 standard will result in a per unit water savings of 899 gallons per year, which has an associated embedded electricity savings of 4 kWh per year, in addition to the savings that will be achieved by implementing the Tier 1 standard. The Tier 2 standard will result in an additional energy savings due to reduce hot water load of 5 therms per year or 104 kWh per year if the home has water heating. The additional per unit peak demand savings for homes with electric water heating is 14 watts.

The total per unit water savings of a Tier 2 (1.8 gpm) showerhead relative to a non-qualifying (2.5 gpm) showerhead is 3,074 gallons per year, which has an associated embedded electricity savings of 15 kWh per year. The per unit energy savings from reduced water heating load would be 18 therms per year or 354 kWh per year if the home has electric water heating. The per unit peak demand savings for homes with electric water heating is 47 watts.

Table 5: Per Unit Water and Energy Use of Non-Qualifying Products and Potential Savings from Qualifying Products

Showerhead Flow Rate	Water Use (gallons/yr)	Energy Savings from Reduced Hot Water Load [a]		Embedded Electricity Use (kWh/yr)	Peak Demand (W)
		Natural Gas Use (therms/yr)	Electricity Use (kWh/yr)		
Non-qualifying Products					
2.5 gpm (non-qualifying)	11,235	67	1,305	54	173
Qualifying Products (proposed efficiency levels)					
Tier 1: 2.0 gpm (qualifying)	9,060	54.0	1,056	44	140
Tier 2: 1.8 gpm (qualifying)	8,161	48.7	951	40	126
Savings					
Tier 1 Savings: (2.5 gpm to 2.0 gpm)	2,175	13	250	11	33
Tier 2 Savings: (2.0 gpm to 1.8 gpm)	899	5	104	4	14
Total Proposed Savings (2.5 gpm to 1.8 gpm)	**3,074**	**18**	**354**	**15**	**47**

Source: CASE Team analysis 2015

Note:

a. A showerhead will have either natural gas or electricity savings depending on whether the house has natural gas or electric water heating. A showerhead will not have both natural gas and electricity savings from reduced water heating load.

9 Estimated Statewide Water and Energy Savings

This section describes the estimated statewide water, energy, cost, and greenhouse gas savings associated with the proposed measure.

9.1 Statewide Water and Energy Savings Methodology

Statewide savings estimates were calculated by applying the per unit water and energy savings to the statewide stock and shipments forecast presented in Section 8 of the report. Table 6 presents the assumptions and equations used to calculate the statewide water and energy savings of the proposed standard. The savings estimates presented in this report represent the savings achieved through modifying the maximum flow rate requirement from 2.5 gpm to 2.0 gpm (Tier 1) and the additional savings that can be achieved from updating the maximum flow rate requirement from 2.0 gpm to 1.8 gpm (Tier 2). The Tier 1 standard will take effect in 2016 and the Tier 2 standard will take effect in 2018. As previously noted, the savings estimates pertain to residential buildings; savings from nonresidential buildings are not included in the analysis presented in this report.

When calculating statewide impacts, it was assumed that 40 percent of showerheads sold in a given year will meet the proposed efficiency level (Tier 1 efficiency level is 2.0 gpm) even if the proposed standard is not adopted.

Assumptions about water heating fuel types were derived using data from CEC's 2009 California Statewide Residential Appliance Saturation Study (RASS) (CEC 2009) and the 2012 CLASS analysis (CPUC 2014). This analysis assumes that 87.1 percent of California homes have natural gas water heaters, 7.3 percent have electric water heaters, 3.8 percent have propane heaters, and the remaining 1.8 percent have another water heating source (e.g. solar) or do not have a water heater. The cost and energy analyses presented in this report include energy and cost savings from homes with natural gas or electric water heaters, as these fuel types are dominant throughout the state. Reported natural gas energy saving estimates only occur in homes where natural gas water heating and electricity energy savings apply occur in homes where electricity is used to heat water.

Table 6: Statewide Water and Energy Savings Methodology, Assumptions and Findings [a]

Metric	Value	Source / Notes
Assumptions		
Showerheads sold during first year standard is in effect [b] [A]	Tier 1 (2016): 1,696,827 Tier 2 (2018): 1,752,557	See Section 5 of this report
Percent of showerheads expected to meet proposed efficiency level without standard [B]	Tier 1: 40 percent Tier 2: 12 percent	See Section 5 of this report
Percent of households with Natural Gas Water Heating [C]	87.1 percent	CPUC 2014
Percent of Households with Electric Water Heating [D]	7.3 percent	CPUC 2014
Percent of households with no water heater, other water heating source (e.g. propane, solar) [E]	5.6 percent	CPUC 2014
Results		
Statewide annual water savings during first year standard is in effect [F]	Tier 1: 2,215 million gallons/yr Tier 2: 1,386 million gallons /yr	F = A × (1 − B) × per unit water savings ÷ 1 million gallons
Statewide annual natural gas savings during first year standard is in effect [G]	Tier 1: 11.3 million therms /yr Tier 2: 7.0 million therms /yr	G = A × (1 − B) × C × per unit natural gas savings ÷ 1 million therms
Statewide annual electricity savings from water heating during first year standard is in effect [H]	Tier 1: 26.8 GWh /yr Tier 2: 17.0 GWh /yr	H = A × (1 − B) × D × per unit electricity savings ÷ 1 million kWh/GWh
Statewide annual embedded electricity savings during first year standard is in effect [I]	Tier 1: 10.7 GWh/yr Tier 2: 7.0 GWh/yr	I = F × 4,848 kWh/million gallons ÷ 1 million kWh/GWh
Statewide peak demand reduction during first year standard is in effect [J]	Tier 1: 3.6 MW Tier 2: 2.3 MW	J = A × (1 − B) × per unit peak demand reduction ÷ 1 million W/MW

Source: CASE Team analysis 2015

Notes:

a. Tier 1 savings represent the savings of a 2.0 gpm showerhead relative to a 2.5 gpm showerhead. Tier 2 savings represent the savings of a 1.8 gpm showerhead relative to a 2.0 gpm showerhead. Total savings represents the savings of a 1.8 gpm showerhead relative to a 2.5 gpm showerhead.

b. The first year the Tier 1 standard is in effect is 2016. The first year the Tier 2 standard is in effect is 2018.

9.2 Statewide Water & Energy Savings

The estimated statewide annual water and energy use and savings are described in this section. Table 7 and Table 8 present the estimated statewide annual water and energy use associated with showerheads if the proposed changes are not adopted (i.e. Non-standards Case) and if the proposed standard is adopted (i.e. Standards Case), respectively. The estimated statewide annual water and energy savings if the proposed standards are adopted are presented in Table 9.

The annual sales values in the tables presented below represent the water or energy use (or savings in Table 9) associated with products sold during a given year. The stock values represent the water or energy use (or savings) associated with all products that are installed and operational during a given year. The CASE Team estimates that during the first year the proposed Tier 1 standard is in effect (2016), an annual savings of 2.2 billion gallons of water, 11.0 million therms of natural gas and 26.8 GWh from reduced water heating load, and 10.7 GWh from reduced embedded electricity use will be realized. After full stock turnover (2025), the annual savings are projected to be 23 billion gallons of water, 118 million therms of natural gas and 279 GWh of electricity from reduced water heating load, and 112 GWh from reduced embedded electricity use. The estimated statewide peak demand reductions associated with reduced electricity use for water heating load is 3.6 MW during the first year the standard is in effect and 37 MW after full stock turnover.

The CASE Team estimates that during the first year the proposed Tier 2 standard is in effect (2018), it will result in additional savings on top of the savings achieved from the Tier 1 standard. The Tier 2 standard will result in an additional annual savings of 1.4 billion gallons of water, 7.0 million therms of natural gas and 17.0 GWh from reduced water heating load, and 7.0 GWh from reduced embedded electricity use will be realized. After full stock turnover (2027), the additional annual savings from the Tier 2 standard are projected to be 14.2 billion gallons of water, 73 million therms of natural gas and 174 GWh of electricity from reduced water heating load, and 69 GWh from reduced embedded electricity use. The estimated statewide peak demand reductions associated with reduced electricity use for water heating load is 2.0 MW during the first year the standard is in effect and 23.0 MW after full stock turnover, again in addition to the Tier 1 savings.

The statewide savings estimates presented in this section are likely lower than what will actually be realized because savings from showerheads that are installed in nonresidential buildings are not included in this analysis.

Table 7: California Statewide Water & Energy Use – Non-Standards Case (After Effective Date)

Year	Annual Sales					Stock				
	Water Use (million gal/yr)	Natural Gas Use (million therms/yr)	Electricity Use (GWh/yr)	Embedded Electricity Use (GWh/yr)	Peak Electricity Demand (MW)	Water Use (million gal/yr)	Natural Gas Use (million therms/yr)	Electricity Use (GWh/yr)	Embedded Electricity Use (GWh/yr)	Peak Demand (MW)
2016[a]	17,588	91	216	85	29	177,614	921	2,176	861	289
2018[b]	18,166	94	223	88	30	177,915	923	2,180	863	289
2025[c]	18,796	97	230	91	31	183,124	950	2,244	888	298
2027[d]	18,974	98	233	92	31	185,700	963	2,276	900	302

Source: CASE Team analysis 2015

Notes:

a. First year Tier 1 standards are in effect.
b. First year Tier 2 standards are in effect.
c. Year stock turns over after Tier 1 standards take effect, assuming 10 year product life.
d. Year stock turns over after Tier 2 standards take effect, assuming 10 year product life.

Table 8: California Statewide Water & Energy Use – Standards Case (After Effective Date)

Year	Annual Sales					Stock				
	Water Use (million gal/yr)	Natural Gas Use (million therms/yr)	Electricity Use (GWh/yr)	Embedded Electricity Use (GWh/yr)	Peak Electricity Demand (MW)	Water Use (million gal/yr)	Natural Gas Use (million therms/yr)	Electricity Use (GWh/yr)	Embedded Electricity Use (GWh/yr)	Peak Demand (MW)
Tier 1 Standard (2.0 gpm)										
2016[a]	15,374	80	189	75	25	175,399	910	2,150	850	285
2025[b]	16,429	85	202	80	27	160,067	832	1,965	776	261
Tier 2 Standard (1.8 gpm)										
2018[c]	14,303	74	176	69	23	152,276	791	1,870	738	248
2027[d]	14,940	78	184	72	24	146,215	760	1,796	709	238

Source: CASE Team analysis 2015

Notes:

a. First year Tier 1 standards are in effect.
b. Year stock turns over after Tier 1 standards take effect, assuming 10 year product life.
c. First year Tier 2 standards are in effect.
d. Year stock turns over after Tier 2 standards take effect, assuming 10 year product life.

Table 9: California Statewide Water & Energy Savings for Standards Case (After Effective Date)

Year	Annual Sales					Stock				
	Water Use (million gal/yr)	Natural Gas Use (million therms/yr)	Electricity Use (GWh/yr)	Embedded Electricity Use (GWh/yr)	Peak Electricity Demand (MW)	Water Use (million gal/yr)	Natural Gas Use (million therms/yr)	Electricity Use (GWh/yr)	Embedded Electricity Use (GWh/yr)	Peak Demand (MW)
Tier 1 Standard (2.5 gpm to 2.0 gpm)										
2016[a]	2,215	11.3	26.8	10.7	3.6	2,215	11	27	11	3.6
2025[b]	2,367	12.1	28.6	11.5	3.8	23,057	118	279	112	37.0
Tier 2 Standard (2.0 gpm to 1.8 gpm)										
2018[c]	1,386	7	17	7	2.3	1,386	7	17	7	2
2027[d]	1,448	8	18	7	2.4	14,171	73	174	69	23
Cumulative Savings of Tier 1 and Tier 2 Standard [e] (2.5 gpm to 1.8 gpm)										
2016[a]	2,215	11.3	26.8	10.7	3.6	2,215	11	27	11	3.6
2018[c]	2,215	11.3	26.8	10.7	3.6	2,215	11	27	11	3.6
2025[b]	3,674	18.9	44.6	17.8	5.9	8,116	42	98	39	13.1
2027[d]	3,837	19.7	46.6	18.6	6.2	37,552	193	456	182	60.6

Source: CASE Team analysis 2015

Notes:

a. First year Tier 1 standards are in effect.
b. Year stock turns over after Tier 1 standards take effect, assuming 10 year product life.
c. First year Tier 2 standards are in effect.
d. Year stock turns over after Tier 2 standards take effect, assuming 10 year product life.
e. Cumulative savings represents the savings that would be achieved if the Tier 1 and Tier 2 standard are adopted.

10 Economic Analysis

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

10.1 Incremental Cost

There is no additional cost to the manufacturer or the consumer for 1.8 gpm or 2.0 gpm showerheads as compared to 2.5 gpm showerheads.

Tier 1 and Tier 2 qualifying showerheads use the same components as non-qualifying showerheads, modified to reduce the flow rate. Showerhead flow rate is largely determined by the diameter of the spray nozzles, which is not price-dependent, so higher efficiency showerheads do not present an incremental cost to manufacturers (IOU C&S team 2011).

The average price of non-qualifying showerheads on the market is higher than that of qualifying showerheads, likely attributable to the higher market share of 2.5 gpm products offering a broader range of products with more premium features, such as number of spray patterns and temperature control. However, based on products with comparable features available on the market, there is no additional cost to the consumer for showerheads with flow rates of 2.0 gpm or 1.8 gpm as compared to 2.5 gpm.

10.2 Design Life

The analysis presented in this report assumes that showerheads have a lifetime of 10 years (NREL 2013). This lifetime estimate is conservative, as there is evidence that showerheads may last for longer. A 2002 study performed by EBMUD found that about one-third of showerheads installed in residential buildings in EBMUD service territory in 2001 had rated flow rates above 2.5 gpm (EBMUD 2002).The survey only covered a small portion of the California building stock but provides some insight into the water efficiency of existing showerhead stock. In 2011, DWR funded a study that examined the water use trends in California single-family homes between 2005 and 2010. The study found that 21 percent of showerheads consumed more than 2.5 gpm. Considering California's 2.5 gpm efficiency standard took effect in 1992 (See Section 3.1 of this report), and all showerheads sold after the effective date were rated at 2.5 gpm or less, the 2.5 gpm showerheads that were still installed in California buildings in the 2005 – 2010 timeframe 13 to 18 years old (DWR 2011).

10.3 Lifecycle Cost / Net Benefit

The per unit and total lifecycle costs and benefits of the proposed standard are presented in Table 10 and Table 11. Since there is no cost premium associated with 2.0 gpm or 1.8 gpm showerheads, adopting the proposed Tier 1 and Tier 2 standard will not result in an economic burden to consumers and is estimated that over the lifetime of the product consumers will save money through reduced water and sewage costs.

For homes with electric water heating, each showerhead that complies with the Tier 1 standard will results in a lifecycle water cost savings of $183 and lifecycle electricity cost savings of $442. The total lifecycle cost savings for homes with electric water heating is $625. For homes that utilize natural gas water heating, each showerhead results in lifecycle water cost savings of $183 and lifecycle natural gas cost savings of $144 for a total lifecycle cost savings of $327 per showerhead.

The Tier 2 standard will result in additional lifecycle water cost savings of $79 for all showerheads. Homes will electric water heating will realize an additional lifecycle electricity cost savings of $189. The total lifecycle cost savings for homes with electric water heating is $268 in addition to the cost savings achieved through the Tier 1 standard. For homes that utilize natural gas water heating, each showerhead that meets the Tier 2 standard will results in an additional lifecycle water cost savings of $79 and lifecycle natural gas cost savings of $63 for a total lifecycle cost savings of $142 per showerhead.

Table 10: Costs and Benefits per Unit for Qualifying Products

Efficiency Level	Per Unit Present Value Cost [a]	Per Unit Present Value Benefit [b]				
		Water Cost Savings [c]	Electricity Cost Savings [d]	Natural Gas Cost Savings [e]	Total Cost Savings if Electric Water Heating [f]	Total Cost Savings if Natural Gas Water Heating [g]
		[A]	[B]	[C]	A + B	A + C
Tier 1 (2.5 gpm to 2.0 gpm)	$0.00	$183	$442	$144	$625	$327
Tier 2 (2.0 gpm to 1.8 gpm)	$0.00	$79	$189	$63	$268	$142
Cumulative Tier 1 & 2 (2.5 gpm to 1.8 gpm)	$0.00	$262	$631	$207	$893	$468

Notes:

a. PV = Present Value. Calculated using CEC's average statewide PV statewide energy rates that assume a 3% discount rate (CEC 2012). Incremental cost is the cost difference between the baseline non-qualifying product and the qualifying product. There are no additional maintenance costs for qualifying products.

b. 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.

c. Water savings apply to all showerheads regardless of the type of water heater.

d. Electricity savings only apply to showerheads installed in homes that have electric water heating.

e. Natural gas savings only apply to showerheads installed in homes that have natural gas water heating.

f. Includes cost savings from reduced water use and reduced electricity use for water heating.

g. Includes cost savings from reduced water use and reduced natural gas use for water heating.

Statewide, the total lifecycle benefit of the Tier 1 standard is approximately $353.3 million from first-year shipments. The net present value for stock turnover (year 2025) is approximately $4.1 billion. The Tier 2 standard will result in an additional lifecycle benefit of $232.2 million for all products that are shipped statewide during the first year the Tier 2 standard is in effect. The Tier 2 standard will result in additional $2.7 billion at full stock turn over (year 2027).

Table 11: Statewide Total Lifecycle Costs and Benefits for Standards Case[a]

Product Class	Lifecycle Benefit / Cost Ratio [b]	Total Lifecycle Benefit Resulting from First Year of Implementation (Present Value $)	Total Lifecycle Costs from First Year of Implementation (Present Value $)	Net Present Value ($)[c]	
				For First Year Shipments ($ million)	Stock Turnover [d] ($ million)
Tier 1	N/A	$353,295,342	$0	$353,295,342	$4,059,280,193
Tier 2	N/A	$232,211617	$0	$232,211,617	$2,620,267,844
Cumulative	N/A	$585,506,959	$0	$585,506,959	$6,679,548,037

Notes:

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. The Benefit/Cost Ratio is not applicable for showerheads because there is no incremental cost.

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 2015 applying to a product with a 5 year design life, the NPV of the products purchased in the 5th year (2019) includes lifecycle cost and benefits through 2024, and therefore, so does the Stock Turnover NPV.

11 Standards Implementation Issues

11.1 Infrastructure issues

11.1.1 Perception that Consumer Satisfaction is Low with Higher efficiency Showerheads

Early models of higher efficiency showerheads did not perform as well as consumers had hoped, and if consumers are not satisfied with the flow of their showerhead they may be inclined to lengthen their shower time or replace the showerhead with one that has a higher flow rate. Many high efficiency showerheads on the market today perform just as well as those with higher flow rates and a number of manufacturers are dedicated to improving public perception of high efficiency showerheads as well as finding ways to continue improving their performance.

In the development of the 2013 CASE Report that recommended Title 24 Standards for showerheads, the CASE Team conducted a literature review regarding consumer satisfaction with higher efficiency showerheads to determine the impact of consumer satisfaction on water use. Their findings indicated that consumer satisfaction with higher efficiency showerheads is high. For example, the majority (69%) of survey respondents in one study that installed a high efficiency showerhead indicated that they were "very satisfied," with 90 percent of survey respondents reporting that they preferred the new showerhead to their old one (IOU C&S Team 2011). An earlier field study prepared by Aquacraft indicated that more than 57 percent of survey respondents preferred the new high efficiency showerhead and that 81 percent of respondents would recommend the new showerhead to a friend (Tampa & EPA 2004). Only 15 percent liked the new showerhead less than the showerhead they had before the retrofit (Tampa & EPA 2004).

The 2010 CEC PIER consumer satisfaction laboratory study conducted by Robert Mowris and Associates (RMA) showed that there was manufacturer and consumer support for high efficiency showerheads but that those involved in the survey valued the standard flow rate, indicating that other aspects of performance are important in overall consumer satisfaction. The study also noted that manufacturers supported the voluntary WaterSense standard, which includes performance requirements that ensure even flow across ranges of pressure, spray force, and spray coverage (CEC 2010). Overall, the study suggested that consumers preferred higher flow showerheads. However, shower flow only explained 18 percent ($R^2 = 0.18$) of the difference in consumer satisfaction between showerheads (CEC 2010). This indicates that other variables contribute significantly to consumer satisfaction. Manufacturers may be able to make up for any reduction in consumer satisfaction due to flow rate by improving other aspects of performance in showerheads, such as ensuring even flow across ranges of pressure, spray force, and spray coverage.

Additionally, as described in Section 3.2 of this report, a number of voluntary program requirements reference the showerhead Specification set forth by WaterSense, which includes additional performance standards. Including additional performance standards, such as spray force and spray coverage, in Title 20 will help address concerns about consumer satisfaction. Manufacturers have had the opportunity to address these performance aspects using the WaterSense test methods since the Specification was released in 2010.

Finally, variable orifice shower products, which use pressure-compensating technology to deliver the same flow rate across varying household water pressures, are available on the market today. These products ensure consumer satisfaction with higher efficiency showerheads (i.e. sufficient flow and performance) no matter the building's water pressure. As such, variable orifice technology ensures that sufficient flow for a showerhead rated at 2.0 gpm or 1.8 gpm will be achieved even if the household water pressure is quite low.

11.1.2 Thermal Shock

Thermal shock is the phenomenon of very hot or very cold water suddenly flowing out of the showerhead due to a change in water pressure and catching the user off guard, potentially causing bodily harm. The potential for temperature shifts is present in all showers regardless of showerhead flow rate, particularly if the shower is an older two-handle type without a mixing valve, or if the shower mixing valve installed in the shower wall is not an automatic compensating shower mixing valve. However, even when an automatic mixing valve is present, more efficient showerheads may be more sensitive to sudden changes in water pressure if the flow rate of the showerhead is less than the flow rate for which the protective components of the valve have been designed. The potential for thermal shock is more prevalent in buildings that were built before 1987 when codes began requiring thermal mixing valves because shower mixing valves are not being replaced as often as showerheads, thereby making the difference between mixing valve and showerhead flow rates greater. However, thermal shock is influenced by plumbing fixture location and piping configuration within buildings, and may not be severe in buildings without thermal mixing valves.

Market share of high efficiency showerheads is high. With over 40 percent of showerheads certified in the Appliance Efficiency Database below 2.5 gpm and over 3,000 WaterSense certified products as of July 2015, it is clear that a large number of showerheads below 2.5 gpm are being offered for sale in California. Disclaimers on thermal shock appear to be absent from manufacturer literature and incentive program information. As discussed in Section 3.3 of this report, several utilities offer incentives for showerheads with flow rates below 2.5 gpm without providing messages about the potential for thermal shock. The CASE Team assumes that if manufacturers and incentive program administrators were receiving legitimate complaints about thermal shock they would issue disclaimers or warnings indicating how high efficiency showerheads should be installed. The lack of disclaimers in most manufacturer and incentive program literature suggests that consumers are installing high efficiency showerheads but not experiencing or reporting significant thermal shock issues.

Concerns around thermal shock were raised during the 2013 Title 24 code change cycle and the development of the WaterSense Specification for showerheads. In the evaluation of flow rate and temperature changes associated with pressure change conducted by WaterSense and the American Society of Mechanical Engineers (ASME)/Canadian Standards Association (CSA) Joint Harmonization Task Force, it was determined that the issue of thermal shock cannot be fully addressed through showerhead design as this issue involves the entire plumbing system (WaterSense 2010c).WaterSense noted that industry is working to harmonize automatic compensating mixing valve standards and showerhead standards to resolve incompatibilities and minimize risks. The proposed standard intends to harmonize Title 20 Appliance Efficiency Regulations for showerheads with shower mixing valve standards.

Temperature actuated flow reduction valves automatically reduce flow to 0.25 gpm or less if the outlet water temperature exceeds 120°F. These devices, which are ANSI-listed products, can protect bathers from spikes in water temperature by minimizing exposure to hot water. Consumers who are concerned about temperature spikes have the option of installing temperature actuated flow reduction devices.

11.1.3 Compatibility of Showerheads and Shower Mixing Valves

The risk of thermal shock is increased when the flow rate of the shower's mixing valve is not compatible with the showerhead flow rate. Increased consumer education regarding how to match showerheads to the appropriate mixing valve rated at the same flow rate when renovating a bathroom or in new construction would be beneficial for making it easier for builders to select mixing valves that are compatible with high efficiency showerheads. This could take the form of outreach and educational materials, pursuing a mixing valve labeling requirement under Title 20, or both.

This issue can be addressed by the proposed labeling requirements for showerheads and shower mixing valves presented in this report, as manufacturers must clearly display compatible flow rates on each unit's packaging. The proposed shower mixing valve reporting requirements will also help improve compatibility by enabling designers and those that specify products to confirm the compatibility of the shower valve with the showerhead at the design stage, rather than at the job site. This proposal is an important step towards harmonizing showerhead and mixing valve standards to resolve incompatibilities and minimize risk.

11.1.4 Showerhead Flow Rate and Risk of Legionella

There has been discussion about the implications of reducing showerhead flow rates and the risk of exposure to Legionella and other opportunistic pathogens. Concerns are based on the speculation that the design of plumbing fitting aerators is conducive to biofilm growth and will therefore lead to increased risk of exposure to Legionella. The CASE Team evaluated recent research available on hot water distribution systems and risk of Legionella to determine whether or not lower showerhead flow rates increase the risk of Legionella.

A study published in the Journal of Applied Microbiology in 2006 is the only study, to our knowledge, that looked directly at the impact of flow rate on Legionella growth within plumbing systems. The study attempted to prove the widely believed hypothesis that stagnation is a key factor in Legionella colonization and growth; however, research "failed to show that stagnation promoted growth of Legionella" (Liu et al. 2006). In fact, the stagnant flow regime resulted in the lowest concentrations of Legionella in all test cases and turbulent flow promoted the growth of Legionella.

A second study evaluated the effect of aerators and laminar flow devices on growth of Legionella through testing in a hospital with a history of Legionella colonization (Huang & Lin 2007). The study concluded that using aerators or laminar flow devices to reduce flow rate do not increase the concentration of Legionella in water or biofilm samples.

A third study evaluated and compared the presence of Legionella in water within the plumbing system of a hospital and from water collected from faucet outlets (Cristina, et. al. 2014). The study indicated that Legionella contamination is mostly attributable to the water system rather than the plumbing fixture. The presence of an aerator does not increase the likelihood of Legionella contamination in a plumbing fixture, although more research is necessary to conclude whether or not flow rates affect the concentration of existing pathogens. The conclusion that Legionella contamination is mostly attributable to the water system rather than a specific plumbing fixture indicates that both faucets and showerhead design does not increase the risk of Legionella contamination.

After completing a review of published research on opportunistic pathogens in plumbing systems, the CASE Team has concluded that the existing body of research is insufficient to prove there is a correlation between showerhead flow rate and an increased risk of exposure to opportunistic pathogens. Existing research provides insufficient evidence that a showerhead's characteristics, including its flow rate, have a significant impact on the growth of Legionella in potable water supplies. While reducing flow rate of all fixtures within the house can increase retention time, and longer retention times have been hypothesized (but not proven) to increase growth of Legionella in buildings where Legionella is already present, there is no conclusive evidence that a reduction of flow rate of showerheads, especially a reduction from 2.5 gpm to 2.0 gpm or from 2.0 gpm to 1.8 gpm, will lead to either the prominence of or increased concentration of Legionella and other opportunistic pathogens.

11.1.5 Heat Loss from Higher efficiency and Increased Aeration

Some stakeholders have questioned if reducing flow rates and increasing aeration can lead to water losing more heat as it travels from the showerhead to the bather leading to increased energy usage as consumers raise the water temperature to offset heat loss. In the development of the WaterSense showerheads Specification, WaterSense determined that this was not a significant concern because spray force and coverage requirements exclude products that would encourage the consumer to raise the water temperature while showering (WaterSense 2010c). Additionally, WaterSense determined that a consumer could raise the hot to cold water ratio up to 18 percent and still achieve energy savings with a higher efficiency showerhead (WaterSense 2010c).

The CASE Team incorporated spray force and coverage performance requirements into the proposed Title 20 standards to address this issue and ensure consumers remain satisfied with the showerhead performance even as water efficiency is improved.

11.1.6 Water Wasted when Waiting for Hot Water to Arrive

There is a potential that reducing the flow rate of showerheads could result in longer hot water wait times, and therefore, an increase in the volume of water wasted when waiting for hot water to arrive. Assessing the performance of residential hot water distribution systems is complex. Hot water wait time and the amount of water that is wasted when waiting for water that is hot enough to arrive depends on many factors including: plumbing system design (including whether there is a hot water recirculation system), hot water temperature, initial pipe temperature, ambient air and inlet water temperature, pipe material, pipe size, pipe length, pipe insulation, flow rate, and time between hot water draws (CEC 2005). Given the number of factors that contribute to hot water wait time and the reality that hot water distribution systems within existing buildings in California have not been well characterized, it is difficult to determine how much water will be wasted statewide when waiting for hot water to arrive at showerheads.

A 2005 CEC PIER report evaluated the impact of hot water distribution design on hot water wait times and volume of water wasted when waiting for hot water to arrive at the fixture. The study found that performance of hot water delivery systems varies widely based on the plumbing system design, temperature settings, and ambient conditions. Figure 5 and Figure 6 present the results of testing performed for the 2005 CEC PIER Report. The tests were conducted on ¾ inch insulated (Figure 5) and uninsulated (Figure 6) PEX piping (CEC 2005).

While the variability in water distribution system design makes it difficult to quantify the potential amount of wasted water associated with reducing faucet flow rates, the savings estimates presented in this report assume that for each cold start event 0.1 gallons would be wasted when waiting for hot water to arrive using a showerhead that is rated at 2.0 gpm or 1.8 gpm relative to a showerhead that is rated at 2.5 gpm. As evidenced by the results of the 2005 CEC PIER analysis, the actual change in wait time and volume of water wasted will vary. Based on data from the 2005 CEC PIER analysis, the assumption that 0.1 gallons will be wasted per cold start event is within the range that is expected when pipes are insulated pipes and there is approximately one gallon of water entrained within the pipe analysis. This assumption will provide a reasonable estimate of the volume of water that will be wasted per event if a more efficient showerhead is used. The CASE Team did not have a reliable data source on the percentage of total shower events are cold starts. To be conservative, the CASE Team assumed that every shower event will be a cold start, but in reality not all shower events will be cold start events. As a result of this assumption, estimates of water wasted when waiting for hot water to arrive likely high and the overall water savings estimates presented in this report may be understated.

The CASE Team recognizes that additional water may be wasted when using a 1.8 gpm fixture relative to a 2.0 gpm fixture. The magnitude of additional wasted water is small when compared to the water that will be saved as a result of the proposed flow rate requirements, and a more refined estimate of wasted water will not have an impact on the cost-effectiveness of the proposed standard or the overall finding that both the Tier 1 and Tier 2 standards results in significant water and energy savings and there is no incremental cost. The analysis presented in this report assumes that the same volume of water will be wasted if using a 2.0 gpm or 1.8 gpm showerhead.

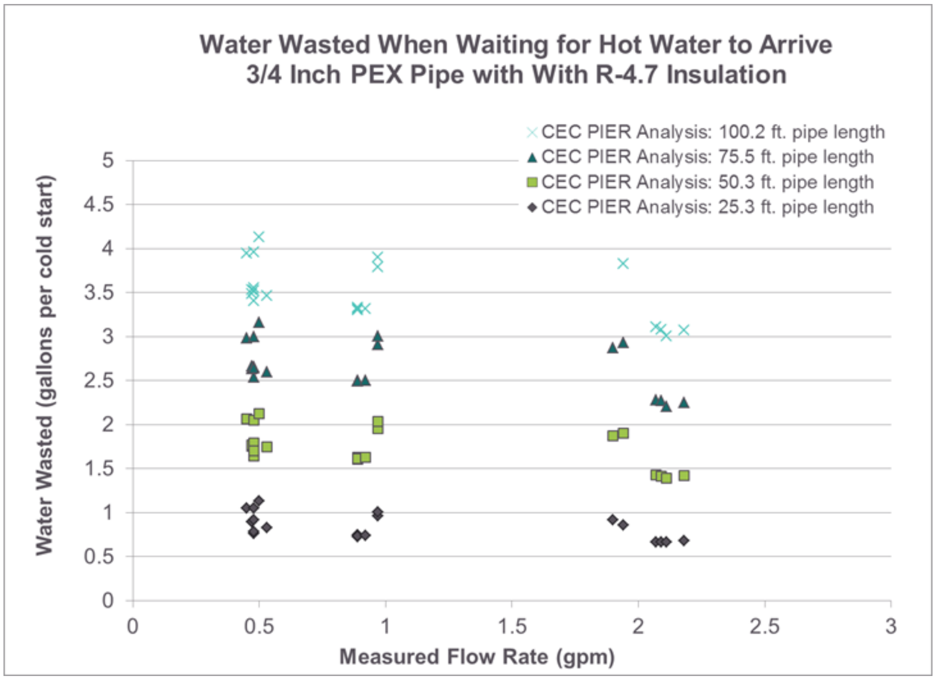

Figure 5: Results of CEC PIER Study (2006) Showing Wasted Water When Waiting for Hot Water to Arrive Through ¾ inch PEX Pipe with R-4.7 Insulation

Source: CEC 2005

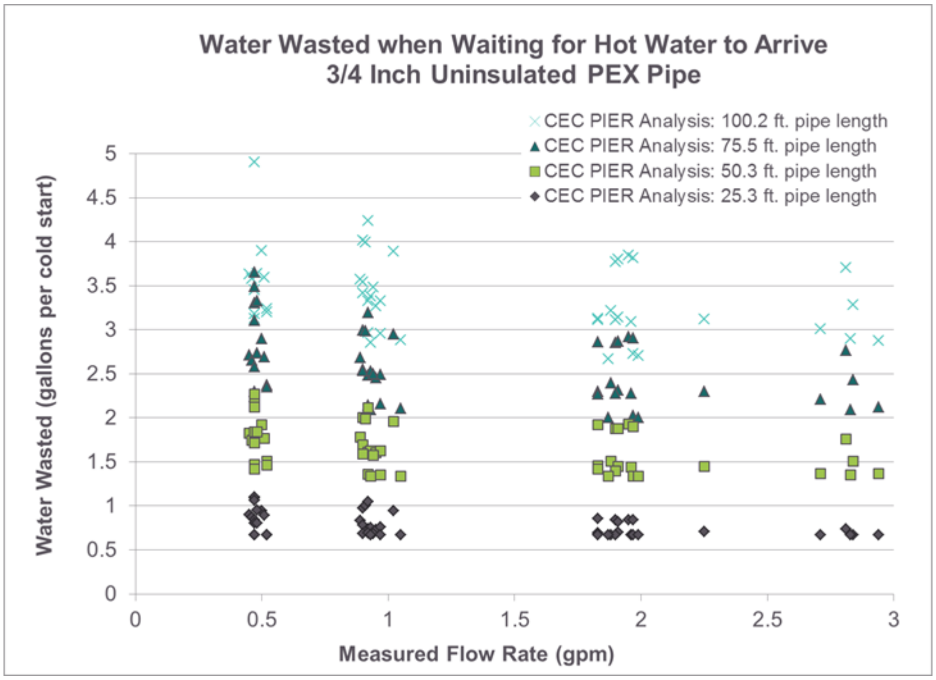

Figure 6: Results of CEC PIER Study (2006) Showing Wasted Water When Waiting for Hot Water to Arrive Through Uninsulated ¾ inch PEX Pipe

Source: CEC 2005

11.2 Stakeholder Positions

The 2010 CEC PIER consumer satisfaction laboratory study conducted by RMA noted that 54 percent of manufacturers surveyed (representing around 11 percent of showerhead market share) supported a mandatory standard for new construction to reduce the maximum showerhead flow rate below 2.5 gpm (CEC 2010). There may be similar support from manufacturers on updating Title 20 to reduce the maximum showerhead flow rate below 2.5 gpm.

Stakeholders raised concerns around thermal shock and heat loss in both the development of the WaterSense showerhead Specification and the showerheads standard proposal for the 2013 Title 24 update. We presume that thermal shock will still be a concern expressed by stakeholders and that CEC will need to work closely with EPA and stakeholders to address the compatibility of showerhead components. We also presume that stakeholders will continue to express concerns regarding heat loss and potential increased energy usage due to consumers raising the temperature of a shower to offset lost heat due to higher efficiency and increased aeration. As mentioned above in Section 11.1, incorporating spray force and coverage performance requirements into Title 20 addresses this issue.

11.3 Compliance Issues

11.3.1 Multiple Showerheads in One Shower

Home builders may wish to install multiple showerheads in order to increase water flow. The CASE Report submitted for the 2013 Title 24 Standards addressed this issue by requiring the total flow rate for all showerheads installed in one shower stall that are operating at any given time to be equal to or less than 2.0 gpm (IOU C&S Team 2011). In 2010, DOE issued a draft interpretive rule on the definition of a showerhead that stated any showerhead with multiple spraying components sold together as a single unit is considered a single showerhead and the total water use from the combination of all sprays and nozzles in such a unit must meet the federal standard of 2.5 gpm. DOE provided an enforcement grace period until 2013 to allow manufacturers to sell remaining inventory of multi-nozzle showerheads (DOE 2011a).

The proposed code language addresses this issue by specifying that the total flow rate of showerheads with multiple nozzles must be less than or equal to the maximum flow rate of 2.0 gpm when all nozzles are in use at the same time.

11.3.2 Instructions for Overriding Maximum Flow Rate

As mentioned in Section 4, the most basic high efficiency showerheads typically utilize flow restrictors, or disk inserts, as a cost-effective and easy solution to reduce water flow in an existing showerhead. Stakeholders have raised concerns regarding the ease of removing these devices, thus increasing the flow of the showerhead. In particular, stakeholders have voiced concerns regarding manufacturers providing instructions to consumers on how to remove flow restrictors, in essence allowing the manufacturer to continue selling products that do not comply with the standard.

The WaterSense Specification includes a requirement that states, "the showerhead shall not be packaged, marked, or provided with instructions directing the user to an alternative water-use setting that would override the maximum flow rate, as established by this Specification. Any instruction related to the maintenance of the product, including changing or cleaning showerhead components, shall direct the user on how to return the product to its intended maximum flow rate," (WaterSense 2010, Section 2.3). CEC might consider adopting a similar labeling requirement to ensure that water savings from the showerhead flow rate requirement persist over time.

12 Environmental Impacts

12.1 Hazardous Materials

The proposed code change will not result in any change to the type of materials used in showerheads, the quantity of materials used, or significant modifications to the manufacturing process. Therefore, there are no expected impacts on the use of hazardous materials.

12.2 Greenhouse Gases

Table 12 presents the annual and stock greenhouse gas (GHG) savings for the first year the standard takes effect (2016) and the year of full stock turnover (2025). The CASE Team calculated the avoided GHG emissions from the adoption of the standard assuming emission factors of 353 metric tons of carbon dioxide equivalent ($MTCO_2e$) per GWh of electricity savings (CARB 2010) and 6,500 $MTCO_2e$ per million therms of natural gas savings[11] (EPA 2011, CEC 2007).

The CASE Team used California Air Resources Board (CARB) data to determine an avoided carbon dioxide emission factor. CARB prepared an analysis of increasing California's Renewable Portfolio Standard (RPS) from 20 percent renewables by 2020 to 33 percent renewables by 2020 with different future electricity demand scenarios.[12] The emissions factor used in this report is intended to provide a benchmark of emissions reductions attributable to energy efficiency measures that would help achieve the low load scenario. The emissions factor is calculated by dividing the difference between California emissions in the high and low generation forecasts by the difference between total electricity generated in those two scenarios. While emission rates may change over time, 2020 is a representative year for this measure.

As show in Table 12, the estimated annual statewide GHG savings of the Tier 1 standard is 86,911 $MTCO_2e$ the first year the standard is in effect (2016) and 92,882 $MTCO_2e$ after full stock turnover in 2025. The stock GHG savings is 904,910 $MTCO_2e$ in year 2025. The Tier 2 standard will result in an additional savings of 55,045 $MTCO_2e$ the first year it is in effect (2018) and an additional 562,697 $MTCO_2e$ after full stock turnover (2027).

Table 12: Estimated California Statewide Greenhouse Gas Savings for Standards Case

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[11] The natural gas emissions factor represents direct and fuel production, transportation and distribution emissions. Natural gas upstream production emissions are derived from CEC's 2007 forecasts for 2022 natural gas well to point of use for distributed transportation sources, which are likely similar to distributed use for hot water and home heating.

[12] CARB calculated GHG emissions for two scenarios: (1) a high load scenario in which load continues at the same rate and (2) a low load rate that assumes the state will successfully implement energy efficiency strategies outlined in the AB32 (Global Warming Solutions Act) scoping plan, which would reduce overall electricity load in the state (CARB 2010).The CASE Team calculated the emissions factors of the incremental electricity savings between the low and high load scenarios.

Year	Annual GHG Savings First Year Sales ($MTCO_2e/yr$)	Stock GHG Savings ($MTCO_2e/yr$)
Tier 1 Standard (2.5gpm to 2.0 gpm)		
2016[a]	86,911	86,911
2025[b]	92,882	904,910
Tier 2 Standard (2.0 gpm to 1.8 gpm)		
2018[c]	55,045	55,045
2027[d]	57,496	562,697
Combined Tier 1 and Tier 2 (2.5 gpm to 1.8 gpm)		
2016[a]	86,911	86,911
2018[c]	144,811	319,169
2025[b]	149,836	1,352,884
2027[d]	151,260	1,480,341

Source: CASE Team analysis 2015

Notes:

a. First year Tier 1 standards are in effect.
b. Year stock turns over after Tier 1 standards take effect, assuming 10 year product life.
c. First year Tier 2 standards are in effect.
d. Year stock turns over after Tier 2 standards take effect, assuming 10 year product life.

13 Proposed Code Language

The proposed changes to the Title 20 standards are provided below. Changes to the 2015 standards are marked with underlining (new language) and ~~strikethroughs~~ (deletions). Three dots or "…" represents the regulatory text that exists between the proposed language and current language.

13.1 Summary of Proposed Standard(s)

The recommended code change will:

1. Update the maximum allowable flow rate for all showerheads obtained through testing at 20, 45, and 80 ± 1 psi in two stages;
2. Establish minimum flow rate requirements for showerheads at 20 and 45 ± 1 psi;
3. Establish performance requirements across a range of spray force and spray coverage through explicit reference to Section 5.12 (high-efficiency shower heads and hand held showers) of ASME A112.18.1 / CSA B125.1-2012;
4. Update marking and labeling requirements for showerheads;
5. Update showerheads reporting requirements in Table X to include proposed minimum flow rate and performance requirements; and
6. Establish a marking and labeling requirement for shower mixing valves.
7. Establish a reporting requirement for shower mixing valves.

The proposed Tier 1 and Tier 2 water efficiency standards for showerheads, which would take effect in 2016 and 2018 respectively, are summarized in Table 13. The Tier 1 standard for showerheads would reduce the maximum flow rate to 2.0 gpm. Two years later, the Tier 2 standard for showerheads would reduce the maximum flow rate to 1.8 gpm. Both Tier 1 and Tier 2 would have minimum flow rate requirements at 20 and 45 psi.

Table 13: Proposed Maximum and Minimum Flow Rate Requirements

Water Pressure (psi)	Maximum Flow Rate (gpm)		Minimum Flow Rate (gpm)
	Tier 1: Effective 2016	Tier 2: Effective 2018	
80 psi	2.0	1.8 gpm	N/A
45 psi			75 percent of maximum flow rate
20 psi			60 percent of maximum flow rate

The proposed code change would establish a minimum spray force of 2.0 ounces at a pressure of 2.0 ± 1 psi at the inlet when water is flowing and minimum spray coverage where the total combined maximum volume of water collected in the 2- and 4-inch annular rings shall not exceed 75 percent of the total volume of water collected and the total combined minimum volume of water collected in the 2-, 4-, and 6-inch annular rings shall not be less than 25 percent. The proposed measure would establish additional marking instructions that prevent the showerhead from being accompanied with literature that provides instructions directing the user to alter the maximum flow rate of the showerhead.

The proposed standard modifies Section 1604, Test Methods for Specific Appliances; Section 1605.1(h)(1), Federal and State Standards for Federally Regulated Appliances; Section 1605.2(h), State Standards for Federally Regulated Appliances; Section 1605.3(h), State Standards for non-Federally Regulated Appliances; and Section 1607, Marking of Appliances in the Title 20 Appliance Efficiency Regulations.

13.2 Proposed Changes to the Title 20 Code Language

Section 1602. Definitions

…

(h) Plumbing Fittings.

…

"Automatic compensating mixing valve" means a mixing valve that is supplied with hot and cold water and that provides a means of automatically maintaining the water temperature selected for an outlet.

…

"Hand held showerhead" means a showerhead that is accompanied by a hose that extends the nozzle and allows it to move.

…

"Mixing valve" means a supply fitting with a movable part that regulates the flow of hot and cold water through one or more passages.

…

"Showerhead" means a ~~device~~ component or set of components distributed in commerce for attachment to a single supply fitting through which water is discharged for a shower bath. Showerhead means any showerhead (including a body spray or a hand held showerhead), ~~except a~~ excluding safety showerheads.

~~"Showerhead" means a device through which water is discharged for a shower bath.~~

"Supply fitting" means a plumbing fitting that controls and guides the flow of water in a supply system.

Section 1604. Test Methods for Specific Appliances.

(h) Plumbing Fittings.

(1) The test method for commercial pre-rinse spray valves is 10 C.F.R. sections 431.263 and 431.264.

(2) The test method for showerheads and hand held showerheads is as follows:

  (A) 10 C.F.R. section 430.23(s) (Appendix S to Subpart B of part 430)

  (B) Section 5.12 (high-efficiency shower heads and hand-held showers) of ASME A112.18.1 / CSA B125.1-2012.

(3) The test method for other plumbing fittings is 10 C.F.R. Section 430.23(s) (Appendix S to Subpart B of part 430).

(4) Showerhead-tub spout diverter combinations shall have both the showerhead and tub spout diverter tested individually.

Section 1605.1. Federal and State Standards for Federally-Regulated Appliances.

(h) Plumbing Fittings.

(1) **~~Showerheads,~~ Metering Faucets~~,~~ and Wash Fountains.** The flow rate of ~~showerheads,~~ wash fountains~~,~~ and metering faucets shall not be greater than the applicable values shown in Table H-1. ~~Showerheads shall also meet the requirements of ASME/ANSI Standard A112.18.1-2012.~~

Table H-1 Standards for Plumbing Fittings

APPLIANCE	Maximum Flow Rate
~~Showerheads~~	~~2.5 gpm at 80 psi~~
Wash fountains	$2.2 \times \frac{rim\ space\ (inches)}{20}\ gpm\ at\ 60\ psi$
Metering faucets	0.25 gallons/cycle[1,2]
Metering faucets for wash fountains	$0.25 \times \frac{rim\ space\ (inches)}{20}\ gpm\ at\ 60\ psi$[1,2]

[1] **Sprayheads with independently controlled orifices and metered controls.** The maximum flow rate of each orifice that delivers a pre-set volume of water before gradually shutting itself off shall not exceed the maximum flow rate for a metering faucet.

[2] **Sprayheads with collectively-controlled orifices and metered controls.** The maximum flow rate of a sprayhead that delivers a pre-set volume of water before gradually shutting itself off shall be the product of (a) the maximum flow rate for a metering faucet and (b) the number of component lavatories (rim space of the lavatory in inches (millimeters) divided by 20 inches (508 millimeters)).

…

(5) **Lavatory faucets, kitchen faucets, aerators, and public lavatory faucets, showerheads and hand held showerheads.** See Section 1605.3(h)(~~2~~3) for standards for all lavatory faucets, kitchen faucets, aerators, ~~and~~ public lavatory faucets, showerheads and hand held shower heads sold or offered for sale in California.

Section 1605.3. State Standards for Non-Federally-Regulated Appliances.

(h) Plumbing Fittings.

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

Table H-2
Standards for Tub Spout Diverters

Appliance	*Testing Conditions*	*Maximum Leakage Rate*
Tub spout diverters	When new	0.001 gpm
	After 15,000 cycles of diverting	0.05 gpm

(2) **Faucets and Aerators.** The flow rate of lavatory faucets, kitchen faucets, replacement accessories, lavatory replacement aerators, and kitchen replacement aerators~~, wash fountains, and metering faucets~~ shall not be greater than the applicable values shown in Table H-3.

Table H-3
Standards for Faucets and Aerators~~Plumbing Fittings~~

Appliance	*Maximum Flow Rate*	
	Sold or offered for sale prior to January 1, 2016	**Sold or offered for sale on or after January 1, 2016[1]**
Lavatory faucets and aerators	2.2 gpm at 60 psi[2,3]	1.2 gpm at 60 psi[2,3]
Kitchen faucets and aerators	2.2 gpm at 60 psi	1.8 gpm with optional temporary flow of 2.2 gpm at 60 psi
Public lavatory faucets	2.2 gpm at 60 psi	0.5 gpm at 60 psi

[1] For the items identified in Table H-3, noncompliant products may not be sold or offered for sale on or after January 1, 2016, regardless of manufactured date.

[2] **Sprayheads with independently-controlled orifices and manual controls.** The maximum flow rate of each orifice that manually turns on or off shall not exceed the maximum flow rate for a lavatory faucet.

[3] **Sprayheads with collectively-controlled orifices and manual controls.** The maximum flow rate of a sprayhead that manually turns on or off shall be the product of (a) the maximum flow rate for a lavatory faucet and (b) the number of component lavatories (rim space of the lavatory in inches (millimeters) divided by 20 inches (508 millimeters)).

(3) **Commercial Pre-rinse Spray Valves.**

(A) Commercial pre-rinse spray valves manufactured on or after January 1, 2006, shall be capable of cleaning 60 plates in an average time of not more than 30 seconds per plate.

(B) See Section 1605.1(h) for water consumption standards for commercial pre-rinse spray valves.

(4) **Showerheads and Hand held Showerheads.**

(A) **Showerheads and hand held showerheads sold or offered for sale prior to January 1, 2016**. Showerheads and hand held showerheads sold or offered for sale prior to January 1, 2016 shall have a maximum flow rate of 2.5 gpm at 80 psi and shall meet the requirements of ASME/ANSI Standard A112.18.1-2012.

(B) **Showerheads and hand held showerheads sold or offered for sale on or after January 1, 2016**. Showerheads and hand held showerheads sold or offered for sale on or after January 1, 2016, regardless of manufacture date, shall:

(i) Comply with the spray force and spray coverage requirements in Section 5.12 of ASME/ANSI Standard A112.18.1-2012 and meet all other requirements of ASME/ANSI Standard A112.18.1-2012.

(ii) Meet the maximum and minimum flow rate requirements in Table H-4.

(iii) The total flow rate of showerheads with multiple nozzles must be less than or equal to the maximum flow rate in Table H-4 when all nozzles are in use at the same time.

Table H-4
Standards for Showerheads and Hand held Showerheads Sold or Offered for Sale on or After January 1, 2016[1]

Appliance	**Maximum Flow Rate[2]**		**Minimum Flow Rate at 20 psi**	**Minimum Flow Rate at 45 psi**
	Sold or offered for sale after January 1, 2016 and prior to January 1, 2018	**Sold or offered for sale on or after January 1, 2018**		
Showerheads and Hand held	2.0 gpm	1.8 gpm	60 percent of the maximum flow rate	75 percent of the maximum flow rate

showerheads				
[1] For the items identified in Table H-4, noncompliant products may not be sold or offered for sale on or after January 1, 2016, regardless of manufactured date. [2] The maximum flow rate shall be the highest value obtained through testing at flowing pressures of 20, 45, and 80 ± 1 psi.				

(5) **Other Plumbing Fittings.** See Section 1605.1(h) for energy efficiency standards for plumbing fittings that are federally-regulated consumer products.

Section 1606. Filing by Manufacturers; Listing of Appliances in Database.

Table X
Data Submittal Requirements

	Appliance	*Required Information*	*Permissible Answers*
	All Appliances	* Manufacturer's Name	
		* Brand Name	
		* Model Number	
		Regulatory Status	Federally-regulated consumer product, federally-regulated commercial and industrial equipment, non-federally-regulated
H	Plumbing Fittings	* Type	Showerhead, hand held 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, shower mixing valve
		Maximum Flow Rate	
		Minimum Flow Rate at 20 psi (for showerheads sold or offered for sale after January 1, 2016)	
		Minimum Flow Rate at 45 psi (for showerheads and shower mixing valves sold or offered for sale after January 1, 2016)	
		Minimum Flow Rate at 80 psi (for showerheads sold or offered for	

		sale after January 1, 2016)	
		Pulsating (for showerheads only)	Yes, no
		Rim Space (for wash fountains only)	
		Tub Spout Leakage Rate When New	
		Tub Spout Leakage Rate After 15,000 Cycles	

* "Identifier" information as described in Section 1602(a).

Section 1607. Marking of Appliances.

(d) Energy Performance Information.

(1) Federally-Regulated Consumer Products.

(A) The marking required by 16 C.F.R part shall be displayed as required for all federally-regulated consumer products of the following classes:

Refrigerators
Refrigerator-freezers
Freezers
Central air conditioners
Heat pumps
Dishwashers
Water heaters
Room air conditioners
Warm air furnaces
Boilers
Pool heaters
Clothes washers
Fluorescent lamp ballasts
Showerheads
Faucets
Water closets
Urinals
General service fluorescent lamps
General service incandescent reflector lamps
General service incandescent (other than reflector) lamps
Medium-base compact fluorescent lamps
Metal halide lamp fixtures
Televisions
Ceiling fans

(B) **Showerheads.**

(i) The showerhead shall legibly and conspicuously display the statement "For use with automatic compensating valves rated at xxx gpm (yyy L/min) or less", where xxx gpm (yyy L/min) is the lowest minimum flow rate recorded in accordance with ASME A112.18.1-2012 Clause 5.12.2.2.2.

(ii) The showerhead shall not be packaged, marked, or provided with instructions directing the user to an alternative water-use setting that would override the maximum flow rate shown in Table H-4. Any instruction related to the maintenance of the product, including changing or cleaning showerhead components, shall direct the user on how to return the product to its intended maximum flow rate.

(C) **Shower Mixing Valves.** For shower mixing valves, the rated flow and tested pressure must be legibly and conspicuously displayed on an accessible place on the unit's packaging and in the products technical specifications literature.

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Appendix A: Water, Natural Gas and Electricity Rates

14.1 Potable Water and Wastewater Rates

The potable water rates used in the analysis are based on water rate data from Raftelis Financial Consultants Inc. (Raftelis 2008, Raftelis 2011). The residential potable water rate was derived using data from a 2011 study of rates from 216 water utilities in California. The commercial rates are derived from the 2008 American Water Works Association Water and Wastewater Survey using values from the western region.

Wastewater rates are based on data from Black & Veatch on rates in the eight largest cities13 in California (Black & Veatch 2010). About 30 percent of Californians live in one of these eight cities, and it is assumed that these city's rates are representative of rates throughout the state. The CASE analysis uses the population-weighted wastewater rate from the eight cities. The 2009 residential rate is based on cost data that assumes customers use 15,000 gallons per month. The 2009 commercial wastewater rates were derived from cost data that assumes customers use 100,000 gallons per month.

Future potable water and wastewater rates were projected based on the Consumer Price Index (CPI) for Water and Sewer Maintenance and assuming a 3 percent annual discount rate. In recent years water rates have been increasing faster than CPI projections (Black & Veatch 2010, Raftelis 2011). It is likely that water rates will increase faster than the CASE analysis predicts, and it follows that the cost savings presented in this report could understate the true potential savings. See the rates by year in Table 14.

Table 14: Statewide Average Residential Potable Water and Wastewater Rates 2016 - 2028 in 2015$/1000gallons

Year	Residential Water Rates (2015$/1000gallons)		
	Potable Water	Waste-water	Total Water Cost
2016	$2.94	$4.86	$7.80
2017	$3.01	$4.97	$7.97
2018	$3.07	$5.07	$8.15
2019	$3.14	$5.18	$8.32
2020	$3.20	$5.29	$8.49
2021	$3.27	$5.40	$8.67
2022	$3.33	$5.51	$8.84
2023	$3.40	$5.61	$9.01
2024	$3.47	$5.72	$9.19
2025	$3.53	$5.83	$9.36
2026	$3.60	$5.94	$9.54
2027	$3.66	$6.05	$9.71
2028	$3.73	$6.15	$9.88

14.2 Natural Gas Rates

The natural rates used in the analysis presented in this report were derived from projected future prices for residential, commercial and industrial sectors in the CEC's "Mid-case" projection of the

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[13] The eight largest cities in California are: Fresno, Long Beach, Los Angeles, Oakland, Sacramento, San Diego, San Francisco, and San Jose.

2014-2024 Demand Forecast (CEC 2013), which used a 3 percent discount rate and provide prices in 2010 dollars. The sales weighted average of the three largest utilities in California was converted to 2015 dollars using an inflation adjustment of 1.04 (DOL 2012). See the rates by year below in Table 15.

Table 15: Statewide Sales Weighted Average Residential Natural Gas Rates 2016 - 2028 (PG&E, SCE, and SDG&E - 3 largest Utilities) in 2015$/therm

Year	Residential Natural Gas Rate (2015$/therm)
2016	1.07
2017	1.14
2018	1.11
2019	1.14
2020	1.17
2021	1.18
2022	1.21
2023	1.24
2024	1.28
2025	1.33
2026	1.38
2027	1.43
2028	1.48

14.3 Electricity Rates

The electricity rates used in the analysis presented in this report were derived from projected future prices for residential, commercial and industrial sectors in the CEC's "Mid-case" projection of the 2014-2024 Demand Forecast (CEC 2013), which used a 3 percent discount rate and provide prices in 2012 dollars. The sales weighted average of the 5 largest utilities in California was converted to 2015 dollars using an inflation adjustment of 1.04 (DOL 2012). See the rates by year below in Table 16.

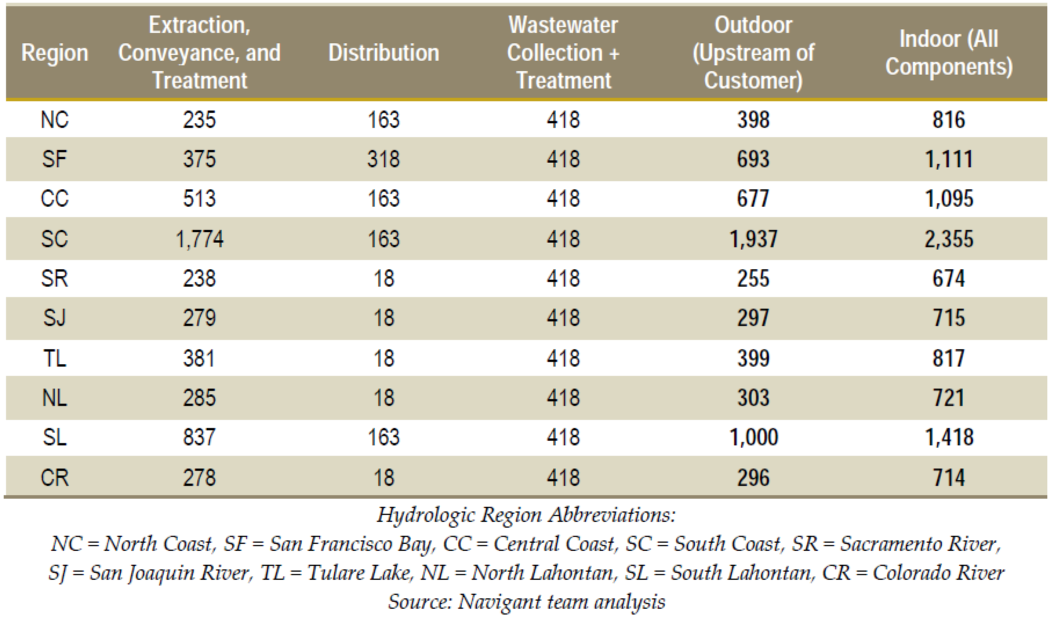
Table 16: Statewide Sales Weighted Average Residential Electricity Rates 2016 – 2026 (PG&E, SCE, SDG&E, LADWP and SMUD - 5 largest Utilities) in 2015 cents/kWh

Year	Residential Electricity Rate (2015 cents/kWh)
2016	17.26
2017	17.40
2018	17.65
2019	17.86
2020	18.08
2021	18.26
2022	18.44
2023	18.60
2024	18.74
2025	18.88
2026	19.02
2027	19.16
2028	19.31
2028	19.31

Appendix B: Embedded Energy in Water

The embedded electricity values used in the CASE Team's analysis are 4,848 kWh/million gallons of water (MG) for indoor water use and 3,565 kWh/MG for outdoor water use. These values were derived from a California Public Utilities Commission study (CPUC 2015), which aimed to quantify the embedded electricity savings that result from programs that save both water and energy.

Table 17: Recommended Embedded Energy Estimates by DWR Hydrologic Region



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 2015. Table 16.

The values shown in Table 17 were weighted based on the population in each hydrologic region in 2014 (U.S Census Bureau). Indoor water use energy intensity includes energy used for water extraction, conveyance and treatment, water distribution, and wastewater collection and treatment. Outdoor water use energy intensity includes only energy uses upstream of the customer; it does not include wastewater collection and treatment. The embedded electricity values presented here do not include on-site energy uses for water, such as water heating and on-site pumping. The indoor embedded energy values apply for water uses that occur solely indoors, such as showerhead, tub, and dishwasher water use, and the outdoor embedded energy values apply for outdoor water uses such as agricultural and landscape irrigation.

The CPUC has made notable progress in improving understanding of the relationship between water and energy in California. CPUC's Decision 07-12-050, issued December 20, 2007, authorized the largest electricity utilities to partner with water utilities and administer pilot programs that aimed to save water and energy (CPUC 2007b). Decision 07-12-050 also authorized three studies to validate claims that saving water can save energy and explore whether embedded energy savings associated with water use efficiency are measurable and verifiable. The pilot programs succeed at demonstrating that water conservation measures also result in energy savings.

The CPUC studies were effective at obtaining a more granular understanding of how energy use varies based on a number of factors including supply, (e.g., surface, ground, brackish, or ocean desalination), geography, and treatment technology. Although the data collected for the studies is the most comprehensive set of data on energy used to meet water demand, the data is still just a small sampling of all the potential data points in California. Since at that time the authors did not find strong patterns within the sample data and there was no strong evidence that the sample data was representative for a particular region, process or technology type, they did not have a strong basis to estimate the embedded energy values for specific geographic regions.

CPUC Rulemaking 13-12-011 builds on both this previous work and new analysis, incorporating the data from the previous CPUC studies into new tools with the aim to develop a framework for water and energy agencies to jointly administer partnership programs that reduce water sector energy consumption by reducing water use (CPUC 2013). The recent CPUC report cited above was developed as a part of this rulemaking. The values presented in Table 17 represent the most up-to-date research by the CPUC on embedded energy in water. These values represent only embedded electricity and do not include embedded gas energy in water because statewide gas energy intensity values were not available at the time the research was conducted.

While the analysis contained in this CASE Report uses the embedded energy values associated with water supply and conveyance, there is no evidence that reducing water use at the building level will impact water supply and conveyance activities. Thus, water efficiency standards may result in reductions to energy used to supply and convey water.

Appendix C: Residential Housing Forecast

The residential housing forecast dataset is data that is published by the California Energy Commission's (CEC) demand forecast office. This demand forecast office is charged with calculating the required electricity and natural gas supply centers that need to be built in order to meet the new construction utility loads. Data is sourced from the California Department of Finance and California Construction Industry Research Board (CIRB) building permits. The Department of Finance uses census years as independent data and interpolates the intermediate years using CIRB permits.

The CEC Demand Analysis office provided the projected annual residential dwelling starts for the single family, multi-family, and mobile sectors through 2024. CEC provided three projections: low, mid and high estimates with each case broken out by Forecast Climate Zones (FCZ). The CASE Team used the mid scenario of forecasted residential new construction for statewide savings estimates. The estimates are for dwellings that are not apartments. The CASE Team used the average rate of change between 2020 and 2024 to project housing units from 2024 through 2028. See the residential construction forecast in Table 18.

Table 18: Statewide Residential Housing Forecast 2016 – 2026

Year	Housing Units in California			
	Single Family	Multi-family	Mobile	TOTAL
2016	8,276,906	4,225,286	462,713	12,964,905
2017	8,157,014	4,224,411	436,805	12,818,229
2018	8,262,045	4,251,958	435,986	12,949,989
2019	8,594,722	4,311,776	460,437	13,366,935
2020	8,687,462	4,338,451	460,229	13,486,142
2021	8,778,107	4,365,321	459,915	13,603,342
2022	8,868,321	4,389,951	459,454	13,717,727
2023	8,956,508	4,412,612	458,813	13,827,932
2024	9,042,970	4,433,108	458,325	13,934,404
2025	9,126,267	4,451,710	457,626	14,035,603
2026	9,207,798	4,469,033	457,939	14,134,770
2027	9,287,601	4,485,164	458,353	14,231,118
2028	9,365,712	4,500,186	458,898	14,324,796
2028	9,442,168	4,514,174	459,616	14,415,958