California Energy Commission

STAFF REPORT

STAFF ANALYSIS OF WATER EFFICIENCY STANDARDS FOR SHOWERHEADS

California Energy Commission
2015 Appliance Efficiency Rulemaking

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PREFACE

On March 14, 2012, the California Energy Commission issued an Order Instituting Rulemaking (OIR) to consider standards, test procedures, labeling requirements, and other efficiency measures to amend the *Appliance Efficiency Regulations* (California Code of Regulations, Title 20, Sections 1601 through Section 1608). In the OIR, the Energy Commission identified a variety of appliances with the potential to save energy and/or water. The OIR also authorizes the Energy Commission to investigate and adopt, if appropriate, additional priority measures as determined by the Lead Commissioner.

On January 17, 2014, Governor Edmund G. Brown Jr. proclaimed a state of emergency in response to the ongoing and persistent drought conditions that California was and is still experiencing. In a continuing response to the drought, Governor Brown issued Executive Order B-29-15 on April 1, 2015, authorizing the Energy Commission to adopt emergency regulations to establish standards that improve the efficiency of water appliances. The Energy Commission subsequently adopted emergency water efficiency standards for toilets, urinals, and kitchen and lavatory faucets on April 8, 2015, which will become effective January 1, 2016.

The Energy Commission is considering other water-saving opportunities in response to the Governor's executive order and the emergency conditions created by the drought. On July 15, 2015, the Energy Commission announced a Lead Commissioner workshop to investigate potential amendments to the lavatory faucet standards and showerhead standards. This staff analysis proposes standards for showerheads and the basis for such standards.

ABSTRACT

This staff report proposes an update to the showerhead standard in the *Appliance Efficiency Regulations* (California Code of Regulations, Title 20, Sections 1601 to 1609). California Energy Commission staff analyzed the cost-effectiveness and technical feasibility of proposed efficiency standards for showerheads. The statewide water and energy (electricity and natural gas) use and savings, and other related environmental impacts and benefits, are also included in this analysis.

California has adopted water efficiency standards for the installation of water-efficient plumbing fixtures, including showerheads, through Senate Bill 407 (Padilla, Chapter 587, Statutes of 2009). The proposed updates to Title 20 would set the maximum flow rate for showerheads at 2.0 gallons per minute from the current 2.5 gallons per minute maximum flow rate.

The proposed update to the standard for showerheads would save about 2.4 billion gallons of water, 13.0 million therms (Mtherm) of natural gas, and 83 gigawatt hours (GWh) of electricity for the first year the standard is in effect.

In addition, the proposed standard would reduce greenhouse gas emissions by 1.0 million tons of carbon dioxide equivalent annually after full stock turnover.

Keywords: Appliance Efficiency Regulations, appliance regulations, water efficiency, energy efficiency, showerheads

Steffensen, Sean. 2015. *Staff Analysis of Water Efficiency Standards for Showerheads.* California Energy Commission. Publication Number: CEC-400-2015-XXX-SD.

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EXECUTIVE SUMMARY

This report presents the California Energy Commission staff's analysis of the cost-effectiveness and technical feasibility of a proposed standard to reduce water consumption for showerheads. If adopted, the regulation would require that showerheads sold or offered for sale in California meet the following standard:

- All showerheads shall not exceed a maximum flow rate of 2.0 gallons per minute with water pressure at 80 pounds per square inch.
- All showerheads shall have a minimum flow rate of 60 percent of the maximum flow rate at 20 pounds per square inch.
- All showerheads shall have a minimum flow rate of 75 percent of the maximum flow rate at 45 pounds per square inch.

The regulation will require showerheads to meet performance requirements at three pressures. The 80 psi maximum flow rate requirement controls water consumption and will lead to water savings over the current standard. The 20 psi and 45 psi performance requirements control minimum water flow at low water pressure to ensure consumer safety and satisfaction.

This proposed standard would apply to all showerheads manufactured on or after January 1, 2016.

The regulation would result in significant first year savings:

- 2.4 billion gallons of water
- 13 million therms of natural gas
- 83 gigawatt-hours of electricity
- 44 million dollars of savings

The regulation at full stock turnover in 2026 would result in annual savings:

- 24 billion gallons of water
- 127 million therms of natural gas
- 829 gigawatt-hours of electricity
- 440 million dollars of savings.

The proposed standard would lead to a significant reduction in greenhouse gas emissions.

CHAPTER 1: Legislative Criteria

Section 25402(c)(1) of the Public Resources Code mandates that the California Energy Commission reduce the inefficient consumption of energy and water by prescribing efficiency standards and other cost-effective measures for appliances whose use requires a significant amount of energy and water statewide. Such standards must be technically feasible and attainable and must not result in any added total cost to the consumer over the designed life of the appliance.

The Energy Commission considers the value of the water or energy saved, the effect on product efficacy for the consumer, and the life-cycle cost or benefit to the consumer for complying with the standard in determining cost-effectiveness of the proposed standard. The Energy Commission also considers other relevant factors including the effect on housing costs, the total statewide costs and benefits of the standard over the lifetime of the product, the economic impact on California businesses, and alternative approaches and associated costs.

CHAPTER 2: Efficiency Policy

The Warren Alquist Act[1] establishes the Energy Commission as California's primary energy policy and planning agency and mandates the Commission reduce the wasteful and inefficient consumption of energy and water in the state by prescribing standards for minimum levels of operating efficiency for appliances that consume a significant amount of energy or water statewide.

For nearly four decades, appliance efficiency standards have shifted the marketplace toward more efficient products and practices, reaping large benefits for California's consumers. The state's appliance efficiency regulations saved an estimated 22,923 gigawatt-hours (GWh) of electricity and 1,626 million therms of natural gas in 2012[2] alone, resulting in about $5.24 billion in savings to California consumers in 2012 from these regulations.[3] Since the mid-1970s, California has regularly increased the energy efficiency requirements for new appliances sold and new buildings constructed in the state. In addition, the California Public Utilities Commission in the 1990s decoupled the utilities' financial results from their direct energy sales, easing utility support for efficiency programs. These efforts have reduced peak load needs by more than 12,000 megawatts (MW) and continue to save about 40,000 GWh per year of electricity.[4] The Energy Commission's recently adopted appliance standards for toilets, faucets, and urinals are expected to save more than 105 billion gallons per year after full stock turnover, a savings of more than three times the annual amount of water used by the city of San Francisco.[5] Still, there remains a huge potential for additional savings by increasing the efficiency and improving the use of appliances.

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1 The Warren-Alquist State Energy Resources Conservation and Development Act, Division 15 of the Public Resources Code, § 25000 et seq., available at http://www.energy.ca.gov/2015publications/CEC-140-2015-002/CEC-140-2015-002.pdf.

2 California Energy Commission. *California Energy Demand 2014-2024 Revised Forecast, September 2013*, available at http://www.energy.ca.gov/2013publications/CEC-200-2013-004/CEC_200-2013-004-SD-V1-REV.pdf.

3 Using current average electric power and natural gas rates of residential electric rate of $0.164 per kilowatt-hour, commercial electric rate of $0.147 per kilowatt-hour, residential gas rate of $0.98 per therm and commercial gas rate of $0.75 per therm. These estimates do not incorporate any costs associated with developing or complying with appliance standards.

4 *Energy Action Plan II*, available at http://www.energy.ca.gov/energy_action_plan/2005-09-21_EAP2_FINAL.PDF, page 3.

5 *Resolution 15-4808-29 Adopting Amendments To The Appliance Efficiency Regulations*, available at http://www.energy.ca.gov/business_meetings/2015_packets/2015-04-08/Item_29_Appliance_Efficiency_Regulations/Item_29b_Emergency_Rule_Adoption_Resolution.pdf; California Energy Commission, Press Release, *Energy Commission Approves Water Appliance Standards*.

Addressing Drought Conditions

On January 17, 2014, with California facing water shortfalls in the driest year in recorded state history, Governor Brown proclaimed a state of emergency[6] and directed state officials to take all necessary actions to prepare for and respond to drought conditions. The Energy Commission's prioritization of water efficiency measures for faucets, toilets, and urinals, and now showerheads implements the Governor's call for all Californians to conserve water in every way possible.

On April 1, 2015, the Governor signed Executive Order B-29-15, authorizing the Energy Commission to adopt emergency regulations establishing standards that improve the efficiency of water appliances for sale and installation in new and existing buildings.[7] These emergency regulations are exempt from the administrative requirements in the Administrative Procedure Act, the Warren-Alquist Act, and the California Environmental Quality Act. In response to the Governor's executive order, the Energy Commission adopted standards for toilets, faucets, and urinals, which are projected to save more than 10 billion gallons per year in the first year that they are implemented. The Energy Commission is now considering standards for showerheads to continue water consumption reductions in the face of the ongoing drought.

Figure 1: Drought Conditions at Folsom Lake, California, Winter 2013-2014

Photo Credit: California Department of Water Resources

6 Office of Edmund G. Brown Jr., "Governor Brown Declares Drought State of Emergency," January 17, 2014. Retrieved from http://gov.ca.gov/news.php?id=18368.
7 http://gov.ca.gov/docs/4.1.15_Executive_Order.pdf.

CHAPTER 3: Background

Water – A Scarce Resource

The Energy Commission staff estimates that California consumes about 186 billion gallons of water per year for showerheads.[8] Amended standards for showerheads have the potential to reduce this consumption by 24 billion gallons after all existing showerheads are replaced. In California, water is a scarce resource that is often taken for granted. California relies on rainfall and the annual snowpack, which accounts for about a third of the state's water supply. Rainfall was lower than normal in 2012, and 2013 was the driest year in recorded history for many areas in California. As of July 12, 2015, reservoir levels in California remain low, with many of the larger reservoirs at less than 50 percent of average.[9] Low water levels are also leading to an increase in wildfire conditions, and California is monitoring the status of wells in the state and taking steps to address vulnerable drinking water systems.[10]

According to information provided by California investor-owned utilities in response to the rulemaking on toilets, urinals, and faucets, California consumes about 2.9 trillion gallons of water per year for residential indoor, outdoor, commercial, and industrial uses.[11] Water usage for showerheads is a significant component of urban indoor water use.[12] Thus, reducing the water consumption by establishing minimum efficiency standards for them is a key component of California's drought response, as well as its energy efficiency strategy.

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8 Table B-4, Appendix A, page A-5.

9 *California Drought Update* (July 15, 2015), available at: http://ca.gov/drought/pdf/Weekly-Drought-Update.pdf.

10 *Ibid.*

11 CASE Report, *Toilets & Urinals Water Efficiency* (July 29, 2013), at p. 1 (citing Christian-Smith, Juliet; Heberger, Matthew; and Luch Allen. *Urban Water Demand in California to 2100: Incorporating Climate Change*. 2012. Pacific Institute, available at http://www.pacinst.org/reports/urban_water_demand_2100/full_report.pdf) available at: http://energy.ca.gov/appliances/2013rulemaking/documents/proposals/12-AAER-2C_Water_Appliances/California_IOUs__and__Natural_Resources_defense_Councils_Responses_to_the_Invitation_for_Standards_Proposals_for_Toilets__and__Urinals_2013-07-29_TN-71765.pdf.

12 CASE Report, *Toilets & Urinals Water Efficiency* (July 29, 2013), at p. 5

CHAPTER 4:
Product Description

Showerheads

Showerheads are devices that deliver a controlled amount of water at a desired pressure to users for bathing.

Showerheads are designed to be fixed to a wall, or can be handheld, allowing the user to move and direct the flow of water. Both types of showerheads are designed to deliver a mix of hot and cold water to the user. Showerheads can have a single nozzle or multiple nozzles.

Body sprayers are a third type of showerhead device typically mounted to the wall of the shower and intended to provide a fixed horizontal spray. The body sprayer is used in addition to the showerhead.

Figure 2: Shower Products

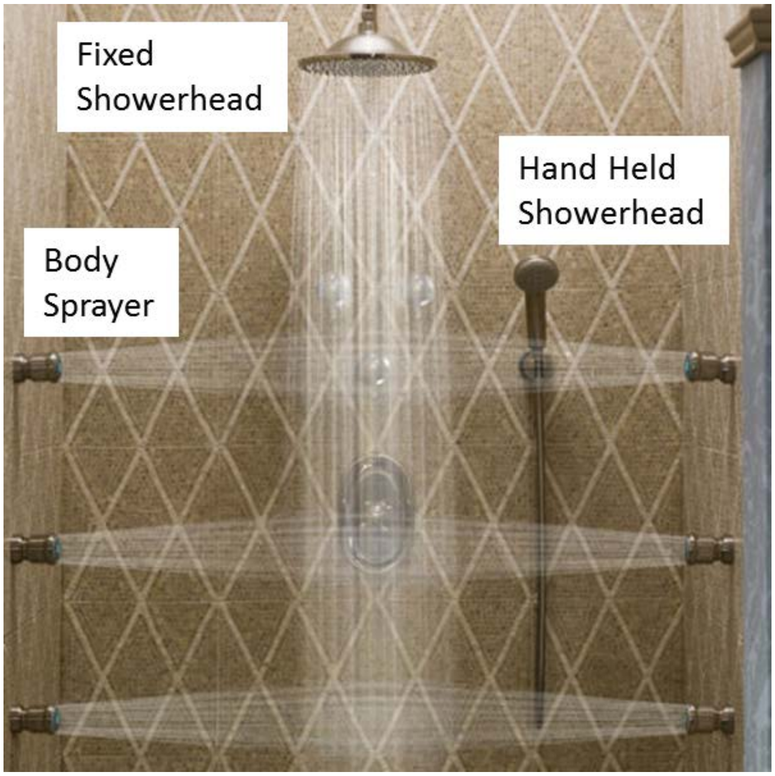

Photo Credit: American Standard

Showerheads can be used in both residential and commercial or industrial applications, such as hotels, prisons, and hospitals.

CHAPTER 5: Regulatory Approaches

Historical Approach

In 1978, the Energy Commission set the appliance standard for showerheads to a maximum flow rate of 2.75 GPM. Prior to the regulation, showerheads had flow rates between 5 and 8 GPM. The Commission later updated the standard to a max flow rate of 2.5 GPM.[13] In 1994, Congress passed the first federal standard for showerheads in the Energy Policy Act of 1992 (EPAct 1992). These standards took effect in 1994 and set a nationwide maximum flow rate for showerheads at 2.5 GPM.[14]

Federal Regulations

The U.S. Department of Energy (DOE) adopted the EPAct 1992 standards into the Code of Federal Regulations in 1992. These standards have remained unchanged since then, and DOE has not indicated any intent to amend these standards.

On December 22, 2010, DOE waived federal preemption for energy conservation standards with respect to any state regulation concerning the water use or water efficiency of faucets, showerheads, toilets, and urinals.[15] This waiver allows states to set their own standards for the relevant plumbing products as long as the state standard is more stringent than the federal standard.

DOE recently updated its test procedures for showerheads and faucets.[16] The final rule incorporates by reference the updated *American Society of Mechanical Engineers (ASME) Standard A112.18.1–2012* test procedure for faucets and showerheads. The DOE stated that these changes will not affect measured water use of these products. Instead, they will primarily clarify the manner in which to test for compliance with the current water conservation standards. DOE's test procedures for water efficiency or water consumption preempt nonidentical test procedures adopted by states, but states may adopt additional performance test procedures unrelated to water efficiency or consumption.

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13 California Energy Commission. Appliance Efficiency Regulations for Refrigerators and Freezers, Room Air Conditioners, Central Air Conditioners, Gas Space Heaters, Water Heaters, Plumbing Fittings, Fluorescent Lamp Ballasts, Luminaires, Gas Cooking Appliances, and Gas Pool Heaters. September 1992, pg. 44 http://www.energy.ca.gov/appliances/appl_regs_1976-1992/1992_09_00_Appl_Regs.pdf

14 Energy Policy Act of 1992, Pub. L. 102-486, § 123(f)(2) (Oct. 24, 1992).

15 75 Fed. Reg. 245 (Dec. 22, 2010).

16 78 Fed. Reg. 62970 (Oct. 23, 2013).

California Approach

The current standard and test procedure in the *Appliance Efficiency Regulations* mirror the federal standard and test procedure for showerheads.[17]

In 2009, the California Legislature enacted Senate Bill 407 (SB 407, Padilla, Chapter 587, Statutes of 2009) and implemented in Civil Code sections 1101.3-1101.5, requiring that residential and commercial buildings built on or before 1994 be retrofitted with more efficient plumbing fittings and fixtures by 2014 for single-family homes undergoing a retrofit, by 2017 for all single-family homes, and by 2019 for multifamily and commercial buildings.[18] Specifically, SB 407 requires that, by the applicable effective date, all showerheads with a flow rate greater than 2.5 GPM be replaced with a showerhead meeting the current building standards, and that building sellers disclose to the prospective buyer whether the building has noncompliant plumbing fixtures and fittings. While this is a significant step for California, SB 407 lacks an enforcement mechanism to ensure that building owners in fact replace their inefficient plumbing fittings for efficient ones.

The *2013 California Green Building Code* (*CALGreen 2013)* included mandatory water efficiency standards for showerheads in new and renovated buildings.[19] Effective January 1, 2014, *CALGreen 2013* mandates that:

- Single showerheads shall have a maximum flow rate of not more than 2.0 gallons per minute at 80 psi. Showerheads shall be certified to the performance criteria of the U.S. EPA WaterSense Specification for Showerheads.[20]
- Multiple showerheads serving one shower shall have a combined flow rate of all shower heads and /or other shower outlets controlled by a single valve not to exceed 2.0 gallons per minute at 80 psi, or the shower shall be designed to allow only one shower outlet to operate at a time.

The *2013 California Plumbing Code* sets the same efficiency standards set by *CALGreen 2013*.[21]

As building codes, the *California Plumbing Code* and *CALGreen* establish standards for products installed during new construction, but they do not regulate products *sold or offered for sale* in California. SB 407 is also enforced only at the point of installation, when a permit is issued, and not at the point of sale of the appliance.

17 Cal. Code Regs., tit. 20, § 1605.1(i).

18 California Senate Bill 407 (Padilla, Chapter 587, Statutes of 2009).

19 Cal. Code Regs., tit. 24, pt. 11, §§ 4.303, 5.303 (2013).

20 EPA, WaterSense® Specification for Showerheads, Version 1.0 pg. 1

21 California Code of Regulations (CCR), Title 24, Part 5. December 7, 2013.

Local Regulations

In 2009, the City of Los Angeles passed an ordinance that established water efficiency requirements for newly constructed buildings and renovations of existing buildings. Among the provisions, the code requires all showerheads must be low-flow with a maximum flow rate that does not exceed 2.0 gallons per minute.[22]

Regulations in Other States

In 2010, New York City adopted a municipal code provision to revise the water efficiency standards in the local plumbing code. Local Law 57 sets the maximum flow rate for showerheads at 2.0 GPM.[23]

WaterSense®

WaterSense®, a partnership program by the U.S. Environmental Protection Agency (EPA), collaborates with stakeholders to establish voluntary specifications for high-efficiency water-consuming appliances, such as toilets, urinals, lavatory faucets, and showerheads. Manufacturers certify and label their products according to standards developed by EPA-licensed laboratories. The WaterSense label means the products:

- Perform as well or better than less efficient counterparts.
- Are 20 percent more water-efficient than average products.
- Realize water savings on a national level.
- Provide measurable water savings results.
- Achieve water efficiency through several technology options.

WaterSense labels make it easy for consumers to find and select water-efficient products.

WaterSense last updated the specification for water-efficient showerheads in 2010. WaterSense-labeled showerhead must not exceed 2.0 GPM at 80 psi, and the showerhead must be able to deliver a minimum flow rate of 60 percent of the maximum flow at 20 psi and deliver a minimum flow rate of 75 percent of the maximum flow rate at 45 psi. These minimum flow rates are included "to ensure performance and user satisfaction under a variety of household conditions."[24] WaterSense showerheads must also meet certain spray coverage and spray force performance criteria.

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22 City of Los Angeles, California. 2009a. Water Efficiency Requirements for New Development and Renovations of Existing Buildings. Ordinance Number 180822.
23 City of New York, New York. "Local Law No. 57. To amend the administrative code of the city of New York, in relation to enhanced water efficiency standards." 2010.
24 EPA, WaterSense® Specification for Showerheads Supporting Statement (Mar. 4, 2010), at p. 3.

Consideration of Alternative Proposals

Staff has analyzed the staff proposal to determine whether it meets the legislative criteria for the Energy Commission's prescription of appliance efficiency standards. Staff also reviewed and analyzed the federal (including standards suggested by WaterSense), state, and local standards. Staff will continue to analyze and consider alternative proposals as they are provided to the Energy Commission.

Alternative 1: Maintaining Current Title 20

Staff does not believe current Title 20 standards of 2.5 GPM is adequate because the current standards reflect product feasibility and costs in existence in 1993 and are inconsistent with current legislative intent regarding improving water efficiency. Moreover, there are available appliances in the market that perform satisfactorily while saving significant water and energy.

Alternative 2: More Stringent Standard

Staff considered adopting a lower flow rate than 2.0 GPM as the maximum flow rate for showerheads. Staff would like additional information on the effect to consumer efficacy of a lower flow-rate showerhead, whether there are any technical feasibility concerns associated with lower-flow showerheads, whether there are health concerns associated with lower-flow showerheads, and whether there are sufficient models available on the market with a lower-flow that can meet consumer demand.

Alternative 3: Change in Effective Date

Staff has considered extending the effective date to comply with the proposed standards for either longer or shorter periods. Making the effective date sooner has the advantage of providing near-immediate water savings in a time of dire drought. However, staff also recognizes that manufacturers and retailers may need time to ramp up production and distribution of showerheads that meet the proposed standard to respond to consumer demand. Staff's proposed effective date is designed to strike a balance between the two approaches.

CHAPTER 6: Staff Proposal for Showerhead Regulations

Energy Commission staff has analyzed the 2.0 GPM maximum flow rate for showerheads and compared the approach to what has been done at the federal, state, and local level. Staff has evaluated the cost-effectiveness and technical feasibility of the 2.0 GPM maximum flow rate for California consumers. Staff has determined that the savings resulting from reduced water and energy consumption under the proposed standard are significant, while imparting no incremental cost to consumers. In addition, staff has found that the proposed standard is attainable through products currently available in the market.

Staff's proposed standard for all showerheads manufactured on or after January 1, 2016, is the following:

- All showerheads shall not exceed 2.0 GPM maximum flow rate with pipe pressure at 80 psi.
- All showerheads shall have a minimum flow rate of 60 percent of the maximum flow rate at 20 psi.
- All showerheads shall have a minimum flow rate of 75 percent of the maximum flow rate at 45 psi.

The regulation will require showerheads to meet performance requirements at three pressures. The 80 psi maximum flow rate requirement controls water consumption and will lead to water savings over the current standard. The 20 psi and 45 psi performance requirements control minimum water flow at low water pressure to ensure consumer safety and satisfaction.

Based on its independent analysis of the best available data, including those from the Department of Water Resources (DWR) 2011 report, *California Single Family Water Use Efficiency Study*,[25] staff has concluded that the proposed regulations are both cost-effective and technically feasible. Staff assumptions and calculation methods are provided in Appendix A.

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25 *California Single Family Water Use Efficiency Study*, Aquacraft, DeOreo, William B and Peter W. Mayer, 2011, available at http://www.energy.ca.gov/appliances/2013rulemaking/documents/responses/Water_Appliances_12-AAER-2C/California_IOU_Response_to_CEC_Invitation_to_Participate-Water_Meters_REFERENCE/DeOreo_2011_California_Single-Family_Water_Use_Efficiency_Study.pdf

CHAPTER 7: Savings and Cost Analysis

The proposed standard for showerheads would significantly reduce water and energy consumption. Table 1 details the potential water and energy savings. Water and energy savings are further separated into first-year savings and stock savings. *First-year savings* mean the annual reduction of water and energy associated with annual sales one year after the standard takes effect. *Annual existing and incremental stock savings* mean the annual water and energy reductions achieved after all existing stock complies with the proposed standard.

Staff's calculations and assumptions used to estimate the first year savings and the stock change savings are provided in Appendix A. As provided in Table 1, staff estimated that if all residential showerheads complied with the proposed standard (annual existing and incremental stock savings), Californians would save 24 billion gallons of water, 127 million therms of natural gas, and 829 GWh of energy per year. Using a residential rate of $0.16 per kWh of electricity and $0.99 per therm of natural gas, staff estimated that implementation of the proposed standard for showerheads would achieve roughly $440 million a year in reduced utility costs after full implementation.

Staff has calculated the peak power reduction to be 829 GWh/8,760 hours, which equals to about 95 MW. This calculation is based on the simplified assumption that the load profile for showerheads is completely flat and energy would be evenly generated over the entire year to provide electricity for transporting and treating water used by showerheads.

The showerhead regulation will apply to both residential and commercial showerheads. The cost and energy-saving calculations include only residential use. Total savings estimates would be greater if commercial showerhead water and energy uses were considered in the analysis.

Table 1: Statewide Annual Water and Energy Savings

	First-Year Savings				Annual Existing and Incremental Stock Savings			
	Water (Mgal)	Nat.Gas (Mthm)	Electricity (GWh)	Savings (M$)	Water (Mgal)	Nat.Gas (Mthm)	Electricity (GWh)	Savings (M$)
Showerheads	2,433	13	83	44	24,326	127	829	440

Source: DWR 2011 reports, as modified by staff (see Appendix A for assumptions).
a. Energy savings include embedded electricity (energy used to supply the water) and heating energy (electric-heated water).

To determine cost-effectiveness, staff conducted a market price search of showerheads from three major retail sites: Amazon, Home Depot, and Lowe's. Table 2 summarizes the unit cost-effectiveness of the proposed standards based upon an aggregated version of Appendix A.

Table 2: Unit Water and Energy Savings and Cost-Effectiveness

	Design Life (years)	Water Savings (gal/yr)	Nat. Gas Savings (therms)	Heating Electricity Savings (kWh/yr)	Embedded Electricity Savings (kWh/yr)	Incre-mental Cost ($)	Average Annual Savings ($)	Life-Cycle Benefit ($)
Shower heads	10	2251	11.7	54.1	22.6	0	$20.25	$202.50

Source: Staff calculation with information from DWR 2011 report (see Appendix A for assumptions).

The values shown in Table 2 are sales and compliance averages for showerheads. The design life, incremental cost, and savings, in 2015 dollars, were incorporated into this table by averaging the annual sales of showerheads. The incremental cost for showerheads is zero because there is no cost premium for a compliant product (meaning that an efficient product and an inefficient product cost the same, all other variables constant).[26] Consumers should immediately see savings on their utility bill upon installing a compliant product. Thus, the average annual savings are the savings that consumers should receive once the product is installed. The *life-cycle benefit* represents the savings the consumer should receive over the life of the appliance and is simply the product of the average annual savings multiplied by the average design life of the unit.

The savings estimates compare the baseline water and energy consumption of the showerhead with the respective water and energy consumption under the proposed standard. For statewide estimates, these savings are multiplied by sales for the first-year figure and by California annual existing and incremental stock for the stock figure. The details of these calculations are available in Appendix A.

In conclusion, the proposed standard is clearly cost-effective as a compliant product carries no premium cost. Thus, ratepayers can enjoy immediate water, energy, and monetary savings and continue reaping those savings over the life of the product.

26 CASE Report, *Multi-Head Showers and Lower-Flow Shower Heads* (Sept. 2011), pp. 19-20, available at: http://www.energy.ca.gov/title24/2013standards/prerulemaking/documents/current/Reports/Residential/Water_Heating/2013_CASE_R_Shower_Heads_Sept_2011.pdf.

CHAPTER 8:
Showerhead Regulations: Technical Feasibility

Showerhead Technology

Showerheads control the water flow rate, water direction, spray area, and spray force. A typical showerhead will use an aerator to control the water flow rate. The aerator restricts the water flow rate while mixing air into the water to supply a spray force and coverage creating the perception of a higher flow rate to the shower user. The aerator is a key piece of technology that allows showerheads to meet user expectations for both user feel as well as providing water in a manner to make bathing easier.[27]

As of June 2015, the Energy Commission Appliance Database listed 4,398 showerhead models for sale. The database shows that 1,351 (31 percent) of the showerhead models would comply with the proposed 2.0 GPM maximum flow rate standard. The quantity and variety of high-efficiency showerheads available for sale indicate that qualifying products are technically feasible and readily available in California.

Staff reviewed information provided in the *Codes and Standards Enhancement (CASE) Initiative,* 2011 report, *Multi-Head Showers and Lower Flow Shower Heads,* [28] and WaterSense regarding consumer satisfaction and thermal shock phenomenon as the maximum flow rate is varied to assess the proposed standard's impact on consumer efficacy.

Consumer Satisfaction

Manufacturers and researchers have studied the factors that influence customer satisfaction with showerhead performance. Several studies have examined what effect flow rate has on the user's experience with various showerhead models and a variety of flow rates between 1.0 GPM and 2.5 GPM. A 2010 Energy Commission Public Interest Energy Research (PIER)-funded study[29] measured consumer satisfaction of showerhead performance at various flow levels, including 2.0 GPM. The study found that although consumers generally preferred a higher flow showerhead, consumers also rated showerheads based upon noise and time to rinse a small amount of conditioner from hair when ranking their satisfaction among showerheads.

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27 Appropedia: The sustainability wiki, 1.6 GPM or less low-flow shower heads (June 26, 2015) http://www.appropedia.org/1.6_GPM_or_less_low-flow_shower_heads

28 Codes and Standards Enhancement Initiative (CASE), *Multi-Head Showers and Lower Flow Shower Heads*, September 2011.

29 Mowris, Robert, Brian Woody. (Robert Mowris & Associates). 2010. *Development of New Testing Protocols for Measuring the Performance of Showerheads*. California Energy Commission. Publication number: CEC-500-2013-130.

The EPA partnered with industry to develop the WaterSense standard to ensure efficient water use with a high level of user satisfaction and showerhead performance.[30] The test requirements include spray force and spray coverage in addition to flow rate to measure the overall showerhead performance. While the Energy Commission regulation does not contain the additional WaterSense showerhead performance requirements, the WaterSense standard shows that industry can design a showerhead that ensures consumer satisfaction at the 2.0 GPM flow rate and below by evaluation of shower spray force and shower coverage.

Thermal Shock

Shower water temperature may rise or fall if the plumbing system experiences a change in water pressure. A change in pressure typically occurs when another water appliance draws water. The change in shower water temperature is called "thermal shock." In some situations, thermal shock may present a risk to the shower user of scalding if the temperature of the water rises above a safe temperature. WaterSense and the CASE 2011 report[31] conclude that showerhead flow rate is not the sole determining factor for the thermal shock risk. Shower automatic compensating valves contain an internal mechanism to maintain shower temperature as water pressure fluctuates. Shower automatic compensating mixing valves, plumbing design, and hot water heater design contribute to the overall possibility of the shower water exceeding a safe temperature during a pressure change. Both reports discuss how a mismatch between automatic compensating valve design flow rate and showerhead design flow rate may increase the sensitivity of the entire system to changes in temperature from changes in pressure. Older buildings are more likely to contain mixing valves that are not designed for flow rates as low as the proposed 2.0 GPM standard. Thermal shock, however, can occur in all buildings, including new construction, as the plumbing code does not require mixing valves to be rated for low-flow showerheads.

Staff proposes a minimum flow rate requirement for showerheads at the 20 and 45 psi water pressure levels to partially reduce the risk of thermal shock by establishing minimum flow requirements at lower water pressure conditions. The WaterSense supporting statement suggests harmonizing the auto-compensating mixing valve standard with the showerhead standard to further lower the risk. These requirements will also allow builders to properly match the mixing valves with the lower-flow showerheads to provide additional protection against the risk of thermal shock.[32]

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30 *WaterSense Specification for Showerheads Supporting Statement*, March 10, 2010, Version 1.0.

31 Codes and Standards Enhancement Initiative (CASE), *Multi-Head Showers and Lower Flow Shower Heads*, September 2011.

32 *WaterSense Specification for Showerheads Supporting Statement*, March 10, 2010, Version 1.0. pg. 7

Figure 3: Plumbing System

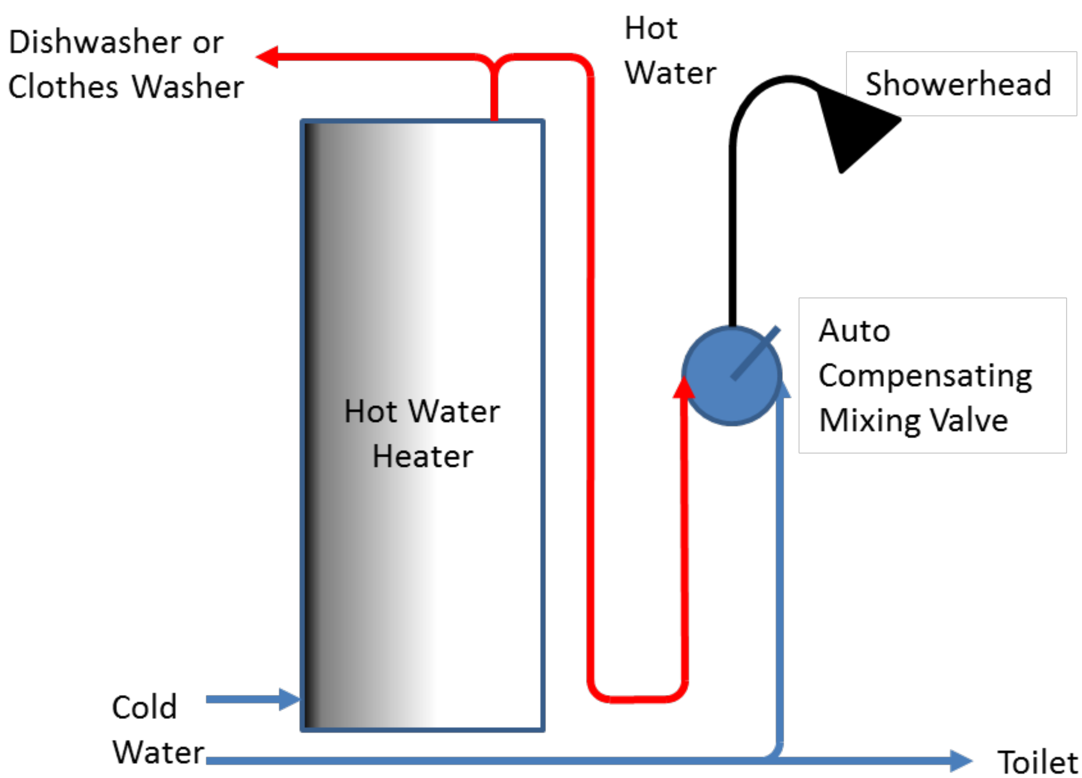

Illustration Credit: Energy Commission staff

CHAPTER 9: Environmental Impacts and Benefits

Impacts

Showerheads are usually replaced when they are at the end of the useful lives; therefore, replacement of these appliances would present no additional impact to the environment beyond the natural cycle. SB 407 may require showerheads to be replaced sooner than the end of the useful life. Energy and water utility rebate and direct install programs encourage the early replacement of showerheads. The environmental effects of SB 407 and the utility programs are not a result of the proposed regulation.

Showerhead water efficiency improvements may cause additional stress to some older sewer collection systems because of the reduced volume of water for carrying solid waste through the sewage pipes. However, not all sewage systems are affected by the reduced water flow; only antiquated combined sewer systems[33] may be susceptible to this issue, especially in dry weather. One widely cited example of wastewater collection problems is from San Francisco.[34] In 2009, San Francisco experienced an odor issue, and a few media articles claimed the odor was caused by low-flush toilets. The San Francisco Public Utilities Commission (SFPUC) refuted this claim in a letter submitted to the Energy Commission in June 2013.[35]

Although the Energy Commission staff recognizes that there is some controversy about the cause of sewage clogging has reviewed available evidence including the Alliance for Water Efficiency Report (2011), *The Impacts of High-Efficiency Toilets on Plumbing Drain Lines and*

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33 A *combined sewer* is a sewer system that collects sewage and storm water runoff in a single pipe. This design carries two differences from a conventional sewage collection system: (1) the combined sewer systems contain weirs to prevent solid waste from entering the public waterway, and (2) the pipe diameter is several times larger than a conventional sewage collection system. During dry periods, wastewater trickles inside the pipe, and the flow direction is dictated by the placement of the weirs. During rainy periods, wastewater and storm water flow in the big pipe, solid waste is be caught in the weirs and goes to the sewage treatment plant, and the storm water flows over the weirs to a public waterway. Because of this arrangement, combined sewers can cause serious water pollution problems due to combined sewer overflows. This design is not used in new communities, but many older cities continue to operate combined sewers.
34 "Low-Flow Toilets Cause a Stink in SF," *SFGate*. Retrieved from http://www.sfgate.com/bayarea/matier-ross/article/Low-flow-toilets-cause-a-stink-in-SF-2457645.php.
35 San Francisco Public Utilities Commission. "Letter to California Energy Commission Appliance Efficiency Standard Staff Regarding 2013 Appliance Efficiency Rulemaking for Water Appliances." Docket 12-AAER-2C. June 3, 2013.
http://www.energy.ca.gov/appliances/2013rulemaking/documents/responses/Water_Appliances_12-AAER-2C/San_Francisco_Water_Power_Sewers_Comments_2013-06-03_TN-71110.pdf.

*Sewer*s,[36] and concludes the showerhead standard will not adversely impact sewage system performance. In addition, the U.S EPA has stated no evidence exists to show that waste transport problems occur because of low-flow toilets.[37] Staff also believes that evaluation of the systematic impacts of water conservation, wastewater collection and treatment systems, and development of a strategy to achieve water conservation goals without compromising the reliability of wastewater collection and treatment systems should be considered statewide.

Benefits

For homes and workplaces, reducing water consumption would reduce the demand for available and shrinking water supplies, which will help decrease the need of future investment to costly, large-scale infrastructure projects such as dams, canals, and reservoirs. It will also result in reduced operating costs for water utilities as it takes a significant amount of energy to get water to the showerheads at a home or business. Energy is needed to extract water from the source; to treat, distribute, and use it; and to collect and treat wastewater for release back into the environment.

Furthermore, reducing water consumption would improve water quality and help the state maintain higher water levels in lakes, rivers, and reservoirs. On the demand side, reducing water consumption will improve air quality by reducing greenhouse gases emitted in the production of energy used to transport, treat, and heat California's water.

Staff estimates that the proposed standards will result in reductions of criteria air pollutants[38] and greenhouse gas emissions due to the reduced amount of energy used to heat and transport water to the users. Staff tabulated the criteria air pollutant and greenhouse gas emissions reductions in Table 3. Staff calculated the greenhouse emission reductions using the estimated energy savings and the Commission's *Energy Aware Planning Guide*s suggested emission factor of 690 pounds (lbs) CO_2e per MWh for electricity and 11.65 lbs CO_2e per therm (lb/th) for natural gas.[39]

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36 Alliance for Water Efficiency Report (2011), *The Impacts of High-Efficiency Toilets on Plumbing Drainlines and Sewer*s available at:
http://www.allianceforwaterefficiency.org/uploadedFiles/Resource_Center/Library/residential/toilets/AWE-Drainline-Article-July-2011.pdf
37 U.S. Environmental Protection Agency Website, available at
http://www.epa.gov/watersense/fq_toilets.html#problems
38 *Criteria air pollutants* are those for which a state or federal standard has been established. They include nitrogen dioxide (NO_2), sulfur dioxide (SO_2), carbon monoxide (CO), ozone (O_3) and related precursors, oxides of nitrogen (NOx) and volatile organic compounds (VOC), particulate matter less than 2.5 microns ($PM_{2.5}$) and less than 10 microns in diameter (PM_{10}), and lead (Pb).
39 *Energy Aware Planning Guide*, February 2011, available at
http://www.energy.ca.gov/2009publications/CEC-600-2009-013/CEC-600-2009-013.pdf.

For criteria air pollutants, staff used the California Air Resources Board-suggested emission factors used to estimate cost-effectiveness of emission reductions:[40]

- Oxides of nitrogen (NO_x) = 0.07 lb per MWh
- Sulfur dioxide (SO_2) = 0.01 lb per MWh
- Carbon monoxide (CO) = 0.1 lb per MWh
- Particulate matters ($PM_{2.5}$) = 0.03 lb per MWh

Table 3: Criteria and Greenhouse Gas Emissions Reductions After Full Stock Turnover

Appliance Type	Avoided Emissions (tons)				
	Oxides of Nitrogen (NO_x)	Sulfur Dioxide (SO_x)	Carbon Monoxide (CO)	Particulate Matter ($PM_{2.5}$)	Greenhouse Gas (eCO_2)
Showerheads	29.02	4.15	41.45	12.44	1,023,536

Source: Energy Commission staff

As seen in Table 3, 87 tons of criteria air contaminants and about 1.0 million tons of greenhouse gas equivalent would be avoided annually after full stock turnover due to the savings from the proposed standard in embedded energy and the natural gas and electricity used to heat water. This is almost equal to the emissions from a 250 MW conventional combined-cycle, natural gas-fueled power plant.

The proposed standard would also save significant amounts of water, estimated at 24 billion gallons annually, after full-stock turnover. The decrease in water consumption will result in increased availability of water to other users, decreased need for diversions, decreased associated environmental impacts to riparian and wetland habitats from those diversions, and decreased drought impacts on California.

40 *California Air Resources Board Economic Analysis Assumptions*, available at http://www.arb.ca.gov/regact/2010/res2010/res10d.pdf.

CHAPTER 10: Proposed Regulatory 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 substance of the regulations that exists between the proposed language and current language.

Summary of Proposed Standards

The recommended code change will:

1. Remove duplicative showerhead definition
2. Update the maximum allowable flow rate for all showerheads.
3. Establish minimum flow rate requirements for showerheads at 20 and 45 psi
4. Correct inadvertent omission of a reference to Federally required test method (430.23 [t])

The efficiency standards for showerheads would apply to products manufactured on or after January 1, 2016.

The proposed standard modifies Section 1604(h)(4), Test Methods for Specific Appliances; Section 1605.1(h)(1) and (6), Federal and State Standards for Federally Regulated Appliances, and Section 1605.3(h)(3), State Standards for non-Federally Regulated Appliances.

Proposed Changes to the Title 20 Code Language

Section 1602. Definitions.

(h) Plumbing Fittings.

…

"Showerhead" means a device through which water is discharged for a shower bath. Showerhead means any showerhead (including a hand held showerhead), except a safety showerhead.

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

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 is:

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

(B) Minimum flow rate test, ASME A112.18.1 / CSA B125.1-2012, Section 5.13

~~(2)~~ (3) The test method for other plumbing fittings is 10 C.F.R. section 430.23(s) and (t) (Appendix S to Subpart B of part 430).

~~(3)~~ (4) Showerhead-tub spout diverter combinations shall have both the showerhead and tub spout diverter tested individually.

. . .

The American Society for Mechanical Engineers (ASME)

ASME A112.19.2/CSA B45.1-2013	Ceramic Plumbing Fixtures
ASME A112.18.1/CSA B125.1-2012	Plumbing Supply Fittings
Copies available from:	ASME Headquarters Two Park Avenue New York, NY 10016-5990 www.asme.org Phone: 800-843-2763 (U.S/Canada) 001-800-843-2763 (Mexico) 973-882-1170 (outside North America) Email: CustomerCare@asme.org

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 preset 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 preset 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]).

. . .

(6) Showerheads. See Section 1605.3(h) for water efficiency standards for showerheads.

. . .

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

. . .

(h) Plumbing Fittings.

. . .

(4) Showerheads. The flow rate of showerheads shall not be greater than the applicable values shown in Table H-4. Showerheads shall also meet the requirements of ASME/ANSI Standard A112.18.1-2012.

Table H-4

Standards for Showerheads

Appliance	***Maximum Flow Rate***	
	Manufactured on or after January 1, 1994	**Manufactured on or after January 1, 2016**
Showerheads	2.5 gpm at 80 psi	2.0 gpm at 80 psi[1,2,3]

[1] The maximum flow rate shall be the highest value obtained through testing at flowing pressures of 20, 45, and 80 ± 1 psi and shall not exceed the maximum flow rate in Table H-4.

[2] **Minimum flow rate.** 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 in Table H-4. 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 in Table H-4.

[3] **Showerheads with multiple nozzles.** 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.

~~(4)~~ (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.

(a) Filing of Statements.

…

Table X Continued – Data Submittal Requirements

	Appliance	Required Information	Permissible Answers
H	Plumbing Fittings	*Type	Showerhead, lavatory faucet (independent or collective), public lavatory faucet, kitchen faucet, metering faucet (independent or collective), lavatory replacement aerator, kitchen replacement aerator, wash fountain, lift-type tub spout diverter, turn-type tub spout diverter, pull-type tub spout diverter, push-type tub spout diverter
		Flow Rate	
		Pulsating (for showerheads only)	Yes, no
		Minimum Flow Rate 45 psi (for showerheads only)	
		Minimum Flow Rate 20 psi (for showerheads only)	
		Rim Space(for wash fountains only)	
		Tub Spout Leakage Rate When New	
		Tub Spout Leakage Rate After 15,000 Cycles	

APPENDIX A: Staff Assumptions and Calculation Methods

Appendix A discusses the information and calculations used to characterize showerheads in California, the current water and energy use, and potential savings. The source of much of the information for these tables is the DWR 2011 report.[41] Staff altered some of the figures as appropriate to fit staff's approach to water and energy consumption and savings.

Table B-1 lists estimated annual sales of showerheads, the total stock, and the appliance lifetimes from the DWR 2011 report.

Table B-1: Stock, Sales, and Design Life

Product	2016 sales	2016 Stock	Lifetime (yrs)
Showerheads	1,801,266	18,012,658	10

Source: Energy Commision staff calculations, applying updated population statistics to the DWR 2011 report

Compliance Rates, Duty Cycle, and Baseline Water Consumption

Table B-2 lists the estimated or reported compliance rates and duty cycle and the estimated baseline water consumption per use. A compliance rate percentage indicates the ratio of compliant appliances to the total current market or stock. Thus, a compliance rate of 40 percent means that 40 percent of that particular appliance already meets the proposed standard.

The *duty cycle* of an appliance is an estimate of consumer behavior for that particular appliance. In the context of this report, the duty cycle is the average daily usage of the appliance. For example, a duty cycle of 1.66 for a showerhead means that on the average, each showerhead provides 1.66 showers each day.

Staff calculated the baseline water consumption of showerheads shown in Table B-2. The baseline average water consumption represents the water consumption of the showerhead reflecting the number of compliant and noncompliant units in the market. The 17.1 gallons per shower value represents the weighted average of the total water consumed with both compliant and noncompliant showerheads during an 8.7-minute shower.

41 DeOreo, William B and Peter W. Mayer, Aquacraft, *California Single Family Water Use Efficiency Study*, 2011, available at http://www.energy.ca.gov/appliances/2013rulemaking/documents/responses/Water_Appliances_12-AAER-2C/California_IOU_Response_to_CEC_Invitation_to_Participate-Water_Meters_REFERENCE/DeOreo_2011_California_Single-Family_Water_Use_Efficiency_Study.pdf

Table B-2: Compliance Rates, Duty Cycle and Baseline Water Consumption

Product	Compliance (%)	Duty Cycle (Showers per Day)	Baseline Average Water Consumption (gal/shower)
Showerheads	40	1.66	17.1

Source: Energy Commission staff calculations

Assumptions:

Table B-3: Values and Assumptions for Calculations

Value	Units	Description	Source
2.62	Persons	Persons per household	DWR 2011/Staff Calculation
39,658,120	Persons	2017 CA Population	CA Dept. of Finance
18,012,658	Showerheads	Stock (showerheads)	Staff Calculation
1.97	Showers	Showers per household per day	DWR 2011
1.19	Showerheads	Showerheads/household	DWR 2011
8.7	Minutes	Minutes Average Shower duration	DWR 2011
2.0	Gallons per minute	Compliant Flow Rate GPM	Proposed Title 20 Maximum Flow Rate
0.854	None	Derating Factor	DWR 2011
2.5	Gallons per minute	Non-Compliant Flow Rate GPM	Current Title 20 Maximum Flow Rate
40	Percentage	Compliance products market share	Staff Estimate
0.0089	Therms/Gal	therms/gal to heat water from 60 to 124 F	Staff Calculation
0.731	None	ratio of hot to total water in showerhead	Seattle and EPA 2000[42]
0.80	None	Percent of households that use natural gas for heating	Staff Estimate
0.20	None	Percent of households that use electricity for water heating	Staff Estimate
$2.82	Dollars	Delivery charge per 1000 gallons of water	DWR 2011
$4.66	Dollars	Treatment charge per 1000 gallons of water	DWR 2011
$0.16	Dollars	$/kWh	U.S Energy Information Administration 2013[43]

42 Seattle Public Utility and United States Environmental Protection Agency. *Seattle Home Water Conservation Study: The Impacts of High Efficiency Plumbing Retrofits in Single-Family Homes*. December 2000. Prepared by Aquacraft, Inc. Water Engineering and Management.
43 Energy Information Administration – electricity prices for 2013 through December 2013 http://www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_5_6_b.

Value	Units	Description	Source
$0.99	Dollars	$/therm	U.S Energy Information Administration 2013
10045	kWh/Mgal	kWh/M gallon of water embedded energy	PIER Report 2006[44]
0.1644	kWh/gal	kWh/gal to heat water from 60 to 124 F	Staff Calculation
0.07	lb/MWh	Oxides of nitrogen emission factor	California Air Resources Board[45]
0.01	lb/MWh	Sulfur Dioxide emission factor	California Air Resources Board
0.10	lb/MWh	Carbon Monoxide emission factor	California Air Resources Board
0.03	lb/MWh	Particulate matters emission factor	California Air Resources Board
690	lbs/MWh	Carbon Dioxide emission factor	Energy Aware Planning Guide
11.65	lbs/therm	Carbon Dioxide emission factor	Energy Aware Planning Guide

Staff Sample Calculations

Stock Calculation

Stock data were calculated from data found in the DWR 2011 report

=California population (persons) x (showerheads per household)/(Persons per household)

=39,658,120 persons in California x 1.19 showerheads per household / 2.62 persons per household = 18,012,658 showerheads in California

Annual Sales Calculation

= Stock (showerheads)/design life

=18,012,658 showerheads/10 years = 1,801,266 showerheads per year

Compliance Rate

Compliance rate is the percentage of compliant units over the total stock units.

Compliance rate = (number of compliant units/total stock) x 100

Duty Cycle

Showerhead duty cycle = showers per household/showerheads per household

44 Navigant Consulting, Inc. 2006. *Refining Estimates of Water-Related Energy Use in California*. California Energy Commission, PIER Industrial/Agricultural/Water End Use Energy Efficiency Program. CEC-500-2006-118.

45 *California Air Resources Board Economic Analysis Assumptions*, available at http://www.arb.ca.gov/regact/2010/res2010/res10d.pdf.

= (1.97 showers per household per day)/(1.19 Showerheads per household) = 1.66 showers per showerhead per day

Baseline Average Water Consumption

The baseline average water consumption for each use of the appliance is the estimate of water consumed by the market representative ratio of compliant and noncompliant units.

The calculation used a usage factor to represent that some users do not operate the shower at the appliances maximum flow rate due to user choice or degradation due to mineralization of the shower outlet.

Thus, in the case of a showerhead, the baseline average water consumption per showerhead is:

= [(40 percent x 2.0 gpm flow rate) + (60 percent x 2.5 gpm flowrate)] x (0.854 utilization factor) x (8.7 min/shower) = 17.089 or approximately 17.1 gallons per shower

Baseline Water and Energy Use

Table B-4 lists the estimated water consumption, embedded electrical energy for transporting and treating of water, and electrical energy and natural gas used to heat hot water. Staff calculated the baseline water consumption for showerheads using the baseline average water consumption and duty cycle listed in Table B-2 and the estimated annual sales and stock listed in Table B-1. The product of annual sales in 2017 and baseline average water consumption and duty cycle yields the 2017 baseline water consumption for that appliance. Similarly, the product of stock, duty cycle, and baseline average water consumption yields the stock annual water consumption for that appliance.

Staff estimates the embedded energy using PIER 2006 Report information on embedded energy and the baseline water consumption. Staff also estimated the electricity and natural gas needed to heat water delivered to the showerhead using assumptions listed below.

Table B-4: Baseline Water and Energy Use

Baseline Annual Water, Electricity, and Natural Gas Consumption								
	Water Use (MM g/yr)		**Embedded Electricity (GWh/yr)**		**Hot Water Electricity (GWh/yr)**		**Hot Water Natural Gas (MMTherms/yr)**	
	2017	Stock	2017	Stock	2017	Stock	2017	Stock
Showerheads	18,650	186,502	187	1,873	448	4,483	97	971

Source: Energy Commision staff calculations

Assumptions:

- Embedded electrical energy is 10,045 kWh/MMgal water delivered.
- Water is heated from 60° to 124°F.
- Water heat capacity is 1 BTU/lb-°F.
- Density of water is 8.34 lb/gallon.
- Hot water flowing through showerhead is 73 percent of showerhead flow rate.
- Combined thermal efficiency to heat water is 60 percent for natural gas and 95 percent for electric.
- About 80 percent of households use natural gas to heat water; the rest used electric.
- Heat content for natural gas is 100,000 BTU/therm.

Staff Sample Calculations

Baseline Water Consumption

Baseline water consumption = baseline average water consumption per unit x duty cycle x annual operating days x stock quantity.

= (17.1 gal x 1.66/day x 365 day/year x 18,012,658 units)/1,000,000

= 186,502 MMgal/yr

Embedded Electrical Energy

Embedded electrical energy = baseline water consumption in MMgal/yr x 10,045 kWh/MMgal. Thus, for showerheads, the embedded energy is:

= 186,502 MMgal/day x 10,045 kWh/MMgal = 1,873,413,500 kWh or 1.873 GWh/yr

Baseline Heating Water Energy Consumption

The baseline energy consumption (to heat water by electricity or natural gas) is calculated from the energy needed to heat a gallon of water from 60° to 124°F multiplied by the baseline water consumption. To do this, staff used the following basic heating equation:

$Q = m\ Cp\ \Delta T$, where.
Q is the heat needed to heat a gallon of water from 60° to 124°F, in BTU/gal.
m is the weight of a gallon of water or 8.34 lb/gallon.
Cp is the water heat capacity, which is 1 BTU/lb-°F.
ΔT is the difference in temperature of the water from 60° to 124°F.

Using the assumed values listed in Table B-4, staff calculated that the heat needed to bring water from 60° to 124°F is 534 BTU/gal.

Using a 60 percent combined efficiency of heating water using natural gas, and 95 percent efficiency for heating water using electric, staff estimates that the heat needed to bring water from 60° to 124°F is:

= 534 BTU/gal/(100,000 BTU/therm x 0.6) = 0.0089 therm/gal, or

= 534 BTU/gal/(3,412 BTU/kWh x 0.95) = 0.1644 kWh/gal

The product of the energy (in kWh or BTU for natural gas) and the baseline hot water consumption yields the energy needed (by natural gas or electricity) to heat water that flow through showerheads. For example, for showerheads, the heating energy needed by using natural gas is:

(Therm needed/gal) x (stock water use/yr) x (ratio of hot water/total water) x ratio of gas customers = Therm needed/yr

0.0089 therm/gal x 186,502 MMgal/yr x 0.731 x 0.8 = 971 MMtherm/yr

Compliant Water and Energy Uses

Compliant water and energy uses, tabulated in Table B-5, were calculated using annual market sales and stock and the respective water consumption limits.

The product of the above limits on water consumption of individual appliances and the respective annual sales and stock yields the annual or stock water consumption. These are listed in the first two columns of Table B-5. From the calculated water consumption, staff calculated the embedded electrical energy and hot water heating energy using procedures similar to calculations for the baseline water and energy use (explained in Table B-4). The results are tabulated in Table B-5.

Table B-5: Compliant Water and Energy Use

Compliant Annual Water, Electricity, and Natural Gas Consumption								
	Water Use (MM g/yr)		Embedded Electricity (GWh/yr)		Hot Water Electricity (GWh/yr)		Hot Water Natural Gas (MMTherms/yr)	
	2017	Stock	2017	Stock	2017	Stock	2017	Stock
Showerheads	16,218	162,176	163	1,629	390	3,898	84.4	844.1

Source: Energy Commission staff calculations

Costs and Savings

Table B-6 lists the annual water and energy savings for the first year the proposed standards become effective. It also lists the water, energy, and monetary savings upon complete stock turnover to products compliant with the proposed standards in 2026 for showerheads.

Staff estimated and tabulated statewide savings in Table B-6 using DWR 2011 report information, and results listed in tables B-4 and B-5. Staff assumptions, as well as sample calculations, are provided below.

Table B-6: Statewide Annual Water, Energy, and Monetary Savings

	First-Year Savings				Annual Existing and Incremental Stock Savings			
	Water (Mgal)	Nat.Gas (Mthm)	Electricity (GWh)	Savings (M$)	Water (Mgal)	Nat.Gas (Mthm)	Electricity (GWh)	Savings (M$)
Showerheads	2,433	13	83	44	24,326	127	829	440

Source: Energy Commission staff calculations

Assumptions

- The CASE Report 2013[46] provided costs of residential avoided water as \$2.82 for delivery and \$4.66 for treatment per 1000 gallons water and \$2.58 and \$4.84 per 1000 gallons water, respectively, for commercial rate, all in 2013 dollars.
- U.S. Energy Information Administration electricity prices (for 2013) of \$0.16/kWh for residential.[47]
- U.S. Energy Information Administration natural gas prices (for 2013) of \$0.99/therm for residential.[48]

Sample Calculations

First-Year Water and Energy Savings

First-year water and energy savings are the differences between the baseline water and energy consumptions and the respective compliant water and energy consumption. For example, the first-year energy saving for showerhead is

= (baseline water consumption for showerhead) – (compliant

water consumption for showerhead)

= 18650 Mgal/yr – 16218 Mgal/yr = 2,433 Mgal/yr

Stock Change Water and Energy and Monetary Savings

Similar to first-year savings, the stock change water and energy savings are the difference between baseline stock water and energy consumption, and compliant stock water and energy consumptions. Staff calculates the stock change monetary savings by multiplying the avoided cost of water delivered, the avoided cost of wastewater treatment, the savings from avoided

46 http://www.energy.ca.gov/appliances/2013rulemaking/documents/proposals/12-AAER 2C_Water_Appliances/The_California_Statewide_IOU_Codes_and_Standards_Team_Addendum_to_the_Toilets_and_Urinals_CASE_Report_2014-02-21_TN-72711.pdf.

47 Energy Information Administration – electricity prices for 2013 through December 2013 http://www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_5_6_b.

48 Energy Information Administration – natural gas prices for 2013 through December 2013. http://www.eia.gov/dnav/ng/ng_pri_sum_dcu_SCA_m.htm.

natural gas and electricity and the respective water and energy savings. The sum of all savings from avoided water and energy is the total monetary savings listed in the last column of Table B-6. For example, the stock change monetary saving of showerheads is:

= (stock water savings x ($2.82 + $4.66)/1000gal) + (stock natural gas savings x $0.99/therm) + (stock energy savings x $0.16/kWh)

= (24,326 Mgal x($2.82 + $4.66)/1000) + (127 Mth x $0.99/th) + (829 GWh x $0.16/kWh) = $440 million

Table B-7 lists the annual water and energy savings for showerheads once the proposed standard becomes effective. It also lists the design life, annual monetary savings, the incremental cost, and the life-cycle benefit of showerheads. Because the costs of a compliant unit and a noncompliant unit are the same, the incremental cost is zero; therefore, once a compliant unit is installed, cost savings are immediately realized and continue for the life of the appliance.

Staff estimated and tabulated annual water, energy, and monetary savings in Table B-7 using DWR 2011 report information, Table B-6 assumptions, and the results listed in Tables B-4 and B-5. Staff's additional assumptions, as well as sample calculations are provided below.

Table B-7 Annual Water, Energy, and Monetary Savings

	Design Life (years)	Water Savings (gal/yr)	Nat. Gas Savings (therms)	Heating Electricity Savings (kWh/yr)	Embedded Energy Savings (kWh/yr)	Incre-mental Cost ($)	Average Annual Savings ($)	Life-Cycle Benefit ($)
Shower heads	10	2251	11.7	54.1	22.6	0	$20.25	$202.50

Source: Energy Commission staff calculations

Assumptions

- Because most residential California ratepayers paid a monthly fixed rate for sewer services, the savings from avoided water treatment will not immediately benefit residential customers; therefore, the avoided water treatment savings are not factored into staff calculations for annual savings for residential service.
- Similarly, because water delivered to customers typically carries a fixed price, savings resulting from embedded electrical energy are not factored into staff calculations for monetary savings per unit.

Sample Calculation

Water and energy savings per unit is the difference between the baseline and compliant consumption calculated in previous steps. The average annual savings is calculated using the cost data assumptions listed in Table B-6. The life-cycle benefit is simply the product of the annual savings and life of each unit. For example, the annual savings and life-cycle benefit for showerheads is:

Annual savings = (water savings x ($2.82 + $4.66)/1000gal) + (natural gas savings x $0.99/therm) + (energy savings x $0.16/kW)

= 2,251 gal x ($2.82 + $4.66)/1,000gal + 11.7 therms x $0.99/therms + 54.1 kWh x $0.16/kW

= $ 20.25 per year

Life-cycle benefit = $20.25/yr x 10 yr = $202.50