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STAFF ANALYSIS OF WATER EFFICIENCY STANDARDS FOR TOILETS, URINALS, AND FAUCETS

California Energy Commission
2015 Appliance Efficiency Rulemaking

Docket Number 15-AAER-1

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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 goal of pre-rulemaking was to develop the proposed appliance efficiency standards and measures to realize these energy savings opportunities.

On March 25, 2013, the Energy Commission released an "invitation to participate" to provide interested parties with the opportunity to inform the Energy Commission about the product, market, and industry characteristics of the appliances identified in the OIR. The Energy Commission reviewed the information and data received in the docket and hosted staff workshops from May 28 through 31, 2013, to vet this information publicly.

On June 13, 2013, the Energy Commission released an "invitation to submit proposals" to seek proposals for standards, test procedures, labeling requirements, and other measures to improve the efficiency and reduce the energy or water consumption of the appliances identified in the OIR.

On April 22, 2014, the Energy Commission released the *Staff Analysis of Toilets, Urinals, and Faucets* report and held a workshop on May 6, 2014, to solicit comments from stakeholders and interested parties on the draft proposed efficiency standards for these appliances.

The Energy Commission reviewed all information received at and after the workshop and will proceed with formal rulemaking for toilets, urinals, and faucets. The proposed regulation will establish better water efficiency standards for toilets, urinals, and faucets.

ABSTRACT

This staff report proposes updates to the toilet, urinal, and faucet standards in the *Appliance Efficiency Regulations* (California Code of Regulations, Title 20, Sections 1601 to 1608). California Energy Commission staff analyzed the cost-effectiveness and technical feasibility of proposed efficiency standards for toilets, urinals, and faucets. 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.

Through the enactment of Assembly Bill 715 (Laird, Chapter 499, Statutes of 2007), water efficiency standards for toilets and urinals that exceed the federal efficiency requirements became effective January 1, 2014. However, these statutory standards have not been incorporated into Title 20, which dictates the allowable water consumption values for products for sale or offered for sale in California and provides a means for enforcement of those standards. The proposed updates to Title 20 would go beyond AB 715 to set the efficiency level for toilets at 1.28 gallons per flush, 0.5 gallons per flush for floor mounted urinals, and 0.125 gallons per flush for wall mounted urinals.

California has also adopted water efficiency standards for the installation of indoor faucets through Senate Bill 407 (Padilla, Chapter 587, Statutes of 2009). The proposed updates to Title 20 would go beyond SB 407 to set maximum water consumption levels of 1.5 gallons per minute for lavatory faucets, 1.8 gallons per minute for kitchen faucets, and 0.5 gallons per minute for public lavatory faucets.

The proposed update to the standards for toilets, urinals, and faucets would save about 8.4 billion gallons of water, 24.6 million therms (Mtherm) of natural gas, and 171 gigawatt hours (GWh) per year the first year the standard is in effect.

In addition, the proposed standards would reduce greenhouse gas emissions by 1.9 million tons of carbon dioxide equivalent annually.

Keywords: Appliance Efficiency Regulations, appliance regulations, water efficiency, energy efficiency, toilets, water closets, urinals, faucets

Singh, Harinder, Ken Rider, and Tuan Ngo. 2015. *Staff Analysis of Water Efficiency Standards for Toilets, Urinals, and Faucets.* California Energy Commission. Publication Number: CEC-400-2015-008-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 proposed standards to reduce water consumption for toilets, urinals, and faucets. If adopted, the regulation would require that water-related appliances for sale or offered for sale in California meet the following standards.

- All toilets, except those designed for prisons or mental health facilities, shall not consume more than 1.28 gallons per flush and shall have a maximum performance (MaP) score of no fewer than 350 grams.
- Wall mounted urinals, except trough-type and those designed for prisons or mental health facilities, shall not consume more than 0.125 gallon per flush.
- Floor mounted urinals shall not consume more than 0.5 gallon per flush.
- All residential lavatory faucets shall not exceed 1.5 gallons per minute flow rate with pipe pressure at 60 pounds per square inch and shall have a minimum flow rate of 0.8 gallon per minute at 20 pounds per square inch.
- All kitchen faucets shall not exceed 1.8 gallons per minute flow rate and may have capability to increase to 2.2 gallons per minute momentarily for filling pots and pans.
- All public lavatory faucets shall not exceed 0.5 gallon per minute flow rate at 60 pounds per square inch.

The regulations, once fully in effect by 2039, would result in a combined annual savings of about 88.6 billion gallons of water, 223 million therms (Mtherm) of natural gas, and 1,677 gigawatt-hours (GWh) of electricity while causing no adverse impact to the environment. This equates to roughly $1.13 billion in savings to California businesses and individuals.

In addition, the proposed standards would reduce greenhouse gas emissions by 1.9 million tons of carbon dioxide equivalent (CO_2e) annually.

CHAPTER 1:
Legislative Criteria

Section 25402 (c)(1), of the Public Resources Code[1] 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.

In determining cost-effectiveness, 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. The Energy Commission also considers other relevant factors including, but not limited to, 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.

1 Warren-Alquist State Energy Resources Conservation and Development Act, Division 15 of the Public Resources Code, § 25000 et seq. Retrieved from http://www.energy.ca.gov/2014publications/CEC-140-2014-001/CEC-140-2014-001.pdf.

CHAPTER 2: Efficiency Policy

The Warren Alquist Act[2] establishes the California 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[3] alone, resulting in about $5.24 billion in savings to California consumers in 2012 from these regulations.[4] 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.[5] The Energy Commission's recently adopted appliance standards for battery chargers are expected to save 2,200 GWh annually, which is enough energy to power 350,000 California households each year.[6] Still, there remains a huge potential for additional savings by increasing the energy efficiency and improving the use of appliances.

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2 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

3 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.

4 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. This estimate does not incorporate any costs associated with developing or complying with appliance standards.

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

6 *Staff Analysis of Battery Chargers and Self-Contained Lighting Controls*, available at http://www.energy.ca.gov/2011publications/CEC-400-2011-001/CEC-400-2011-001-SF.pdf, page iii; California Energy Commission, *Energy Efficiency Standards for Battery Charger Systems Frequently Asked Questions*, January 2012, available at http://www.energy.ca.gov/appliances/battery_chargers/documents/Chargers_FAQ.pdf.

Reducing Electrical Energy Consumption to Address Climate Change

Appliance energy efficiency is identified as a key to achieving the greenhouse gas (GHG) emission reduction goals of Assembly Bill 32 (Núñez, Chapter 488, Statutes of 2006)[7] (AB 32), as well as the recommendations contained in the California Air Resources Board's *Climate Change Scoping Plan*.[8] Energy efficiency regulations are also identified as key components in reducing electrical energy consumption in the Energy Commission's *2013 Integrated Energy Policy Report (IEPR)*[9] and the California Public Utilities Commission's (CPUC) 2011 update to its *Energy Efficiency Strategic Plan*.[10]

Loading Order for Meeting the State's Energy Needs

California's loading order places energy efficiency as the top priority for meeting the state's energy needs. The *Energy Action Plan II* continues the strong support for the loading order, which describes the priority sequence of actions to address increasing energy needs. The loading order identifies energy efficiency and demand response as the state's preferred means of meeting growing energy needs.[11]

For the past 30 years, while per capita electricity consumption in the United States has increased by nearly 50 percent, California electricity use per capita has been nearly flat. Continued progress in cost-effective building and appliance standards and ongoing enhancements to efficiency programs implemented by investor-owned utilities (IOUs), customer-owned utilities, and other entities have significantly contributed to this achievement.[12]

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7 Assembly Bill 32, California Global Warming Solutions Act of 2006, available at http://www.leginfo.ca.gov/pub/05-06/bill/asm/ab_0001-0050/ab_32_bill_20060927_chaptered.html.
8 California Air Resources Board, *Climate Change Scoping Plan*, December 2008, *available at* http://www.arb.ca.gov/cc/scopingplan/document/adopted_scoping_plan.pdf.
9 California Energy Commission, *2013 Integrated Energy Policy Report*, January 2014, available at http://www.energy.ca.gov/2013publications/CEC-100-2013-001/CEC-100-2013-001-CMF.pdf.
10 California Public Utilities Commission, *Energy Efficiency Strategic Plan*, updated January 2011, available at http://www.cpuc.ca.gov/NR/rdonlyres/A54B59C2-D571-440D-9477-3363726F573A/0/CAEnergyEfficiencyStrategicPlan_Jan2011.pdf.
11 *Energy Action Plan II*, available at http://www.energy.ca.gov/energy_action_plan/2005-09-21_EAP2_FINAL.PDF, page 2.
12 *Energy Action Plan II*, available at http://www.energy.ca.gov/energy_action_plan/2005-09-21_EAP2_FINAL.PDF, page 3.

Zero-Net-Energy Goals

The *California Long-Term Energy Efficiency Strategic Plan*,[13] adopted in 2008 by the CPUC and developed with the Energy Commission, the California Air Resources Board, the state's utilities, and other key stakeholders, is California's roadmap to achieving maximum energy savings in the state between 2009 and 2020, and beyond. It includes four "big, bold strategies" as cornerstones for significant energy savings with widespread benefit for all Californians:[14]

- All new residential construction in California will be zero-net energy by 2020.
- All new commercial construction in California will be zero-net energy by 2030.
- Heating, ventilation, and air conditioning (HVAC) will be transformed to ensure that the energy performance is optimal for California's climate.
- All eligible low-income customers will be given the opportunity to participate in the low-income energy efficiency program by 2020.

These strategies were selected based on the ability to achieve significant energy efficiency savings and bring energy-efficient technologies and products into the market.

On April 25, 2012, Governor Edmund G. Brown Jr. further targeted zero-net-energy consumption for state-owned buildings. Executive Order B-18-12[15] requires zero-net-energy consumption for 50 percent of the square footage of existing state-owned buildings by 2025 and zero-net energy consumption from all new or renovated state buildings beginning design after 2025.

To achieve these zero-net-energy goals, the Energy Commission has committed to adopting and implementing building and appliance regulations that reduce wasteful power and water consumption. The *Long-Term Energy Efficiency Strategic Plan* calls on the Energy Commission to develop a phased and accelerated "top-down" approach to more stringent codes and

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13 California Energy Commission and California Public Utilities Commission, *Long-Term Energy Efficiency Strategic Plan,* updated January 2011, available at http://www.cpuc.ca.gov/NR/rdonlyres/A54B59C2-D571-440D-9477-3363726F573A/0/CAEnergyEfficiencyStrategicPlan_Jan2011.pdf.

14 California Energy Commission and California Public Utilities Commission, *Long-Term Energy Efficiency Strategic Plan*, available at http://www.cpuc.ca.gov/NR/rdonlyres/14D34133-4741-4EBC-85EA-8AE8CF69D36F/0/EESP_onepager.pdf, page 1.

15 Office of Governor Edmund G. Brown Jr., Executive Order B-18-12, April 25, 2012, available at http://gov.ca.gov/news.php?id=17506.

standards.[16] It also calls for expanding the scope of appliance standards to plug loads, process loads, and water use. The Energy Commission adopted its detailed plan for fulfilling these zero-net-energy objectives in its 2013 *Integrated Energy Policy Report* IEPR.[17]

Governor's Clean Energy Jobs Plan

On June 15, 2010, Governor Brown proposed a *Clean Energy Jobs Plan*,[18] which called on the Energy Commission to strengthen appliance efficiency standards for lighting, consumer electronics, and other products. Governor Brown noted that energy efficiency is the cheapest, fastest, and most reliable way to create jobs, save consumers money, and cut pollution from the power sector. He stated that California's efficiency standards and programs have triggered innovation and creativity in the marketplace. Today's appliances are not only more efficient, but they are cheaper and more versatile than ever.

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[19] 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 implements Governor Brown's call for all Californians to conserve water in every way possible.

16 California Energy Commission and California Public Utilities Commission, *Long-Term Energy Efficiency Strategic Plan*, p. 64.
17 California Energy Commission, *2013 IEPR*, pp. 21-26.
18 Office of Edmund G. Brown Jr., *Clean Energy Jobs Plan,* available at http://gov.ca.gov/docs/Clean_Energy_Plan.pdf.
[19] 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.

CHAPTER 3: Background

Water – A Scarce Resource

The Energy Commission staff estimated that California consumes about 443.8 billion gallons of water per year for flushing toilets and urinals, and running faucets.[20] Proposed water standards when all existing stock is replaced would reduce this consumption by 88.6 billion gallons. In California, water is a scarce resource which 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. The snow survey taken on February 27, 2014, showed that the water content of the snowpack was about 25 percent of average.[21] This raised serious concerns over the state's water supply, and on January 17, 2014, Governor Brown proclaimed a state of emergency and directed officials to take all necessary measures to prepare for drought conditions.[22]

In 2012, the Commission identified in its Order Instituting Rulemaking that toilets, urinals, and faucets contribute to significant water and energy consumption in California homes.[23] The California investor-owned utilities (IOUs) subsequently submitted information through their Codes and Standards Enhancement (CASE) initiative, in coordination with the Natural Resources Defense Council (NRDC). This information indicated that California consumes about 2.9 trillion gallons of water per year for residential indoor, outdoor, commercial, and industrial uses.[24] Water usage for toilets, urinals and faucets is a significant component of urban indoor water use. Thus, reducing the water consumption by establishing minimum efficiency

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20 Table B-3, Appendix A, page A-5.

21 California Natural Resources Agency Weekly Drought Update March 24, 2014; available at http://ca.gov/drought/Weekly-Drought-Update.pdf.

22 Office of Governor Edmund G. Brown Jr., "Governor Brown Declares Drought State of Emergency," available at http://gov.ca.gov/news.php?id=18379.

23 California Energy Commission, Order Instituting Rulemaking Proceeding, Order No. 12-0314-16 (Mar. 14, 2012), available at http://www.energy.ca.gov/appliances/2012rulemaking/notices/prerulemaking/2012-03-14_Appliance_Efficiency_OIR.pdf.

24 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.

standards for them is a key component of California's overall water and embedded energy use strategy.

CHAPTER 4: Product Description

Toilets

Toilets (also known as water closets) and urinals are sanitation fixtures used to dispose of human waste. In urban areas, toilets and urinals discharge to sewage lines, which carry waste from the toilet to a wastewater treatment facility. In rural areas that do not have sewage collection systems and centralized wastewater treatment facilities, toilets and urinals discharge to a septic system[25].

There are two types of toilets: siphoning and blowout. As the name implies, a *siphoning toilet* uses a siphon action to remove the waste, and a blowout toilet uses high-pressure, high-volume water to flush the waste out of the bowl. Siphoning toilets are most common in homes, offices, and commercial facilities, while blowout toilets are used primarily in locations subject to high use, such as airports, stadiums, and prisons, due to their durability. Siphoning toilets are further classified as tank-type (gravity-flush, pressure-assisted, or vacuum-assisted) or valve-type, according to the method used to deliver water to the bowl. Blowout toilets commonly use a flushing valve to deliver water for flushing instead of a water tank.[26]

Gravity-Flush Tank-Type

Gravity-flush tank-type toilets account for the majority of toilets, as well as a small percentage of commercial toilets. When toilets are flushed, a portion of the water flows to the toilet bowl rim to rinse the sides of the bowl, and a portion flows into a siphon hole to initiate the siphoning. This siphon action pulls and pushes water and waste out of the toilet bowl to the sewer line. In the meantime, as the water in the tank empties, a flapper valve at the bottom of the tank falls back onto the drain tube, which stops the water to the toilet bowl. The water tank refills through a ballcock or fill valve, which closes when the water reaches the proper level, as controlled by a float ball. As the tank refills, a portion of the refill water is diverted through a tube to refill the toilet bowl.

Vacuum-Assisted or Pressure-Assisted Tank-Type

To improve waste removal in toilets that consume less water, manufacturers have employed pressure-assisted systems and vacuum-assisted systems. In a pressure-assisted system, an

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25 CASE Report, *Toilets & Urinals Water Efficiency* (July 29, 2013), at pp.6 - 10.
26 eHowNow. Water Closet Types, available at http://www.ehow.com/facts_5836318_water-closet-types.html.

airtight enclosure is inserted into the tank. Water fills from the bottom of the enclosure and pressurizes the air space above, providing additional pressure to the flushing water for proper flushing. Vacuum-assisted systems use specialized double-S trap toilet bowls connected to a built-in sealed chamber by a vacuum tube. When the toilet is flushed, the draining water seals the air vent in the trapway. At the same time, water draining from the vacuum-sealed chamber creates a vacuum that is transmitted to the airspace in the trapway. This modest vacuum force combines with the inherent siphonic action of the toilet bowl to enhance the "pull" on the toilet bowl contents for an effective boost in the flush.

Dual-Flush

An increasing number of toilets are becoming available that provide dual-flush capability in a pressure-assisted design, using different flush volumes to flush solid or liquid waste. Some dual-flush toilets have two buttons, while others have a single lever that the user can push up or down to deliver different amounts of water for flushing solid or liquid waste. Dual-flush toilets sold in North America deliver up to 1.6 gallons with the high-volume flush, which is used for solid waste and between 0.8 to 1.1 gallons with the low-volume flush. Thus, on the average of two reduced flushes and one full flush, the effective flush volume is about 1.28 gallons per flush (gpf).[27]

Valve-Type (Flushometer)

Valve-type toilets, also known as *flushometer valve toilets*, are common in medium- to high-usage commercial and industrial buildings. The actual flush of a valve-type toilet is similar to a tank-type, except that the flushometer valve delivers the water and necessary flushing force using pipe pressure. Fairly high water pressure is required for this type of toilet, and it usually has to be supplied by a 1" plumbing line. It provides a quick flush and rapid recovery, but it is also quite noisy.

Blowout Toilets

A *blowout toilet* is a special type of toilet that uses a flushometer valve instead of a tank for flushing. Blowout toilets have two different characteristics than the more commonly seen residential toilet. It is typically made of stainless steel and is connected to the sewer system by bracketing it through the wall to a sewer connection (usually located about 10 to 12 inches above the floor) instead of through the floor. Blowout toilets rely exclusively on pipe pressure to deliver the necessary water volume to flush the waste.

27 Plumbing Manufacturers International, PMI Issues - CEC Docket No. 12-AAER-2C, February 13, 2014.

There is a special type of blowout toilet that is designed for use in prisons or mental health facilities. These toilets are designed to withstand between 2,000 and 5,000 pounds of force and are typically bracketed to the wall to prevent vandalism or suicide. They also feature components with round edges that cannot be removed from the primary device through normal means. These toilets have a large trapway diameter so that large pieces of debris can easily pass into the sewer to prevent intentional blockage. They are noisy, but more sanitary, due to their near-instant flush capability that leaves little, if any, residue behind.[28] Because these types of toilets are used with special safety intention, staff recommends that they be exempt from the proposed standards.

Urinals

Urinals are fixtures designed for male users to dispose of liquid waste and are mostly found in commercial buildings. Urinals can be for one or more users (for example, trough-type urinals) and commonly use a valve-type flushing system, which uses pipe water pressure to flush.[29] Flushing of urinals can be manual or automatic, although trough-type urinal models employ constant drips.[30] Urinals do not employ siphoning action and generally maintain enough water in the trapway to prevent odor escape.

Similar to blowout toilets, the blowout urinals use pipe pressure to flush. They have a hole on the inlet of the trapway that flushes the entire amount of liquid in the urinal. However, the water jet action is used at a higher velocity and creates a better and more certain evacuation of all liquid and debris in the urinal. Blowout urinals are particularly well-suited for high-usage commercial applications in stadiums and/or prisons.[31]

Also similar to blowout toilets, blowout urinals that are installed at prisons or mental health facilities are specially designed with safety in mind; therefore, staff recommends that they be exempted from proposed standard.

Urinals that use less than 0.125 gpf have been in the market for more than 20 years,[32] and manufacturers have several models certified by the EPA WaterSense®.[33] Some other urinal models do not use water at all (waterless).

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28 XPB Lockers. Industrial Lavatories & Sinks. Retrieved from http://www.xpblocker.com/industriallavatoriesandsinks-t-24_72.html.

29 CASE Report, *Toilets & Urinals Water Efficiency* (July 29, 2013), at p.10 to 12.

30 Plumbing Manufacturers International, PMI Issues - CEC Docket No. 12-AAER-2C, February 13, 2014.

31 XPB Lockers. Retrieved from http://www.xpblocker.com/industriallavatoriesandsinks-t-24_72.html

32 Koeller, Hohn, P.E. "High-Efficiency Toilets Answer Questions," *Contractor.* September 1, 2006. Retrieved from http://contractormag.com/bathkitchen/cm_newsarticle_987

Flushometer Valves

As mentioned earlier, water delivered to a toilet bowl or urinal can be from a tank or a valve, or flushometer valve. These valves use building water pressure to flush and can be manually operated (by pushing a lever) or automatically activated by using an electronic sensor. The amount of water delivered by the valve is mostly factory preset; therefore, if toilet or urinal water consumption is reduced, the valve must also be replaced.

Faucets

Faucets and accessories are devices that deliver a controlled amount of water at a desired pressure to users. Faucets direct the flow of water, and their accessories regulate the water pressure and flow rate.[34]

Faucets are generally designed for a particular application, such as a lavatory or kitchen. Both types of faucets are designed to deliver a mix of hot and cold water to the user, but the water volume flow rate of a kitchen faucet is higher to ensure quick washing of vegetables or dishes or quick filling of pots and pans.

There are four categories of faucet accessories: a restrictor to regulate the water flow rate, a pressure compensator to maintain the constant flow of water, an aerator to allow mixing of air to the flowing water to produce softer and adequate volume sensation, and a sprayer to produce several directional water streams to cover the full washing area. Some newer faucets employ dual-flow capability, which delivers a lower flow volume in normal mode and a higher volume through a built-in switch, to allow quick filling of pots and pans in response to customers' desires.

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33 WaterSense, WaterSense Specification for Flushing Urinals. Retrieved from http://www.epa.gov/watersense/partners/urinals_final.html

34 CASE Report, Faucets (July 29, 2013), at pp.6 to 7.

CHAPTER 5:
Regulatory Approaches

Historical Approach

Before 1970, most toilets consumed 6 gpf or more, and some faucets used as much as 7 gallons per minute (gpm). Since January 1, 1978, California regulations required all toilets to consume no more than 3.5 gpf and all faucets to consume no more than 2.75 gpm.[35] In the 1980s and early 1990s, several states, including California, had established water efficiency standards for toilets and urinals.[36] Congress used these state-level standards as the basis for the first federal standards for these appliances, passed in the Energy Policy Act of 1992 (EPAct 1992). These standards took effect in 1994 and set the maximum flush volumes at 1.6 gpf for toilets, 1.0 gpf for urinals, and maximum allowable flow rate for lavatory and kitchen faucets at 2.2 gpm.[37]

Federal Regulations

The U.S. Department of Energy (DOE) adopted the EPAct 1992 standards into the Code of Federal Regulations in 1998.[38] 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.[39] 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, faucets, toilets, urinals, and commercial prerinse spray valves.[40] 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, and ASME A112.19.2–2008 test procedure for water closets and urinals. The DOE stated that these changes will not affect measured water use of these

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35 California Energy Commission. 1978. Conservation Division Regulations for Appliance Efficiency Standards, (including requirements for Intermittent Ignition Devices). Amended, July 19, 1978.

36 California Senate Bill 1224, (Killea, Chapter 2, Status of 1992). Can be retrieved from http://water.ca.gov/urbanwatermanagement/UWMPFAQs/

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

38 63 Fed. Reg. 13308 (Mar. 18, 1998).

39 75 Fed. Reg. 245 (December 22, 2010).

40 78 Fed. Reg. 62970 (Oct. 23, 2013).

products. Instead, they will primarily clarify the manner in which to test for compliance with the current water conservation standards.

California Regulations

The current standards in the *Appliance Efficiency Regulations*, adopted August 19, 2003, mirror the federal standards for toilets, faucets, and urinals.[41]

In 2007, the California Legislature enacted Assembly Bill 715 (AB 715), which set a schedule for manufacturers to meet water conservation standards for toilets and urinals sold or installed in the state such that after January 1, 2014, toilets cannot use more than 1.28 gpf and urinals cannot use more than 0.5 gpf.[42] AB 715 required the California Building Standards Commission to incorporate these standards into the California Building Code, which it did in adopting the 2013 California Plumbing Code (§ 401.2).

In 2009, the California Legislature enacted Senate Bill 407 (SB 407), which requires that residential and commercial buildings built on or before 1994 be retrofitted with more efficient plumbing fittings and fixtures by 2014 for single-family buildings undergoing a retrofit, by 2017 for all single-family buildings, and by 2019 for multifamily and commercial buildings.[43] Specifically, SB 407 requires that, by the effective date, all noncompliant fixtures be replaced with toilets that use no more than 1.6 gpf, urinals that use no more than 1.0 gpf, and faucets that use no more than 2.2 gpm.

The *2013 California Green Building Code* (*CALGreen 2013)* included mandatory water efficiency standards for toilets, urinals, and faucets in new and renovated buildings.[44] Effective January 1, 2014, *CALGreen 2013* mandates that:

- Toilets must use 1.28 gpf or less per flush.
- Urinals must use 0.5 gpf or less per flush.
- Lavatory faucets must have a maximum flow rate of 1.5 gpm at 60 psi and a minimum flow rate of 0.8 gpm at 20 psi.
- Kitchen faucets must have a maximum flow rate of 1.8 gpm measure at 60 psi. They may temporarily increase flow to 2.2 gpm measure at 60 psi, but must default back to a maximum flow rate of 1.8 gpm measure at 60 psi.

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

42 California Assembly Bill 715 (Laird, Chapter 499, Statutes of 2007).

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

44 Cal. Code Regs., tit. 24, pt. 11 (2013).

The *2013 California Plumbing Code* sets the same efficiency standards set by *CALGreen 2013*. In addition, it requires that faucets in common or public use area in homes shall not exceed 0.5 gpm.[45]

As building codes, the *California Plumbing Code* and *CALGreen* establish standards for products installed during new construction or alterations, 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. While AB 715 specifies that the standards apply at both sale and installation, it does not specify how to enforce the standards at the point of sale.

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 toilets installed in new buildings or during retrofits to have an effective flush[46] volume of 1.28 gpf or less. The maximum flush volume for urinals installed after October 1, 2010, cannot exceed 0.125 gpf.[47]

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 flush volumes of 1.28 gpf for toilets and 0.5 gpf for urinals, and 1.5 gpm for faucets.[48]

Two states have enacted statutes regulating the water efficiency of toilets and urinals. In June 2009, Texas enacted standards that would require toilets and urinals sold or offered for sale to achieve 1.28 gpf and 0.5 gpf, respectively.[49] In March 2010, Georgia enacted standards that required toilets and urinals installed in newly constructed buildings to achieve 1.28 gpf and 0.5 gpf, respectively.[50]

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45 California Code of Regulations (CCR), Title 24, Part 5. December 7, 2013.
46 *Effective flush* means a water flush volume of a dual flush toilets averaging of two reduced and a full flush.
47 City of Los Angeles, California. 2009a. Water Efficiency Requirements for New Development and Renovations of Existing Buildings. Ordinance Number 180822.
2009b. "Water Efficiency Requirements for New Development and Renovations of Existing Buildings." Municipal Code § 125 (2009).
48 City of New York, New York. "Local Law No. 54. To amend the administrative code of the city of New York, in relation to enhanced water efficiency standards." 2010.
49 Texas House Bill 2667. House Member Hinojosa. 2009 Regular Legislative Session.
50 Georgia Senate Bill 370. State Senator Ross Tolleson. 2009 – 2010 Regular Session.

Two other states are considering efficiency standards for toilets and urinals. In 2013, Oregon's legislature introduced Senate Bills 692 and 840 that would require toilets and urinals sold in Oregon to achieve 1.28 gpf and 0.125 gpf, respectively.[51] Washington's legislature is considering House Bill 1017, which would require water consumption of toilets and urinals sold in Washington to be no more than 1.28 gpf and 0.5 gpf, respectively.[52]

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, and lavatory faucets. Manufacturers certify and label their products according to standards developed by EPA-licensed laboratories. WaterSense labels mean the products:

- Perform as well or better than their less efficient counterparts.
- Are 20 percent more water-efficient than average products in that category.
- 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-labeled toilets and urinals must not exceed 1.28 gpf and 0.5 gpf, respectively. WaterSense-labeled faucets must not exceed 1.5 gpm, and the faucet must be able to deliver a minimum flow rate of 0.8 gpm at 20 pounds per square inch (psi).

The CASE Report

In July 2013, the IOUs and NRDC submitted a Codes and Standards Enhancement (CASE) report[53] to the Energy Commission in response to the Commission's invitation to submit

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51 Oregon Senate Bill 692. Committee on Environment and Natural Resources. 2013. http://gov.oregonlive.com/bill/2013/SB692/.
Oregon Senate Bill 840. Committee on Environment and Natural Resources. 2013.http://gov.oregonlive.com/bill/2013/SB840/.

52 Washington House Bill 1017. 2013.

53 CASE Report, Toilets & Urinals Water Efficiency (July 29, 2013), and Faucets (July 29, 2013). Retrieved from http://www.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, and http://www.energy.ca.gov/appliances/2013rulemaking/documents/proposals/12-AAER-2C_Water_Appliances/California_IOUs_and_Natural_Resources_defense_Councils_Response_to_the_Invitation_for_Standards_Proposals_for_Faucets_-_Updated_2013-08-05_TN-71810.pdf.

proposals. The CASE report recommends water efficiency standards of 1.28 gpf for toilets, 0.125 gpf for wall-mounted urinals, a maximum flow rate of 1.0 gpm at 60 pounds per square inch (psi) and a minimum flow rate of 0.5 gpm at 20 psi for residential lavatory faucets, and a 1.8 gpm flow rate with optional 2.2 gpm (for filling pots and pans) for kitchen faucets. The CASE report estimates that implementing these recommended measures would result in a reduction of about 55.3 billion gallons of water, 790 gigawatt-hours (GWh) of electricity, and 149 million therms (Mtherms) of natural gas each year after full-stock turnover.

In February 2014, the IOUs and NRDC submitted two addenda to their July 2013 CASE report. The first addendum adds information to support a 0.125 gpf standard for urinals.[54] The second addendum recommends a maximum performance, or MaP score for toilets of no fewer than 600 gram (g). Maximum performance or MaP indicates the toilet ability to flush solid waste. A higher score means the toilet is more effective to remove solid waste with a same volume of water.

On June 6, 2014, the IOUs submitted comments on the Energy Commission staff's proposed regulations, which were presented at the May 6, 2014, workshop for toilets, urinals, and faucets.[55] The IOUs commented that the proposed standards should impose water efficiency standards suggested in previously submitted CASE reports and a subsequent addendum. As an alternative, the IOUs suggested staff should consider three-tiered standards for toilets, urinals, and faucets.

- Tier 1 would be the standards currently suggested by staff with an effective date of one year after adoption.
- Tier 2 would contain all standards in Tier 1 plus a MaP score of 600 grams minimum for all toilets, an effective 1.06 gpf for dual-flush toilets, 0.125 gpf for urinals, and 1 gpm flowrate with a minimum 0.5 gpm for lavatory faucets.
- Tier 3 would contain all standards in Tiers 1 and 2, and 1.06 gpf for all tank-type toilets.

The Sierra Club California Chapter (SCC), Appliance Standards Awareness Project (ASAP), Southwest Energy Efficiency Project (SWEEP), and Northeast Energy Efficiency Partnerships (NCEE) jointly commented in support of the IOUs' suggested changes to staff's proposed regulations.

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54 http://www.energy.ca.gov/appliances/2013rulemaking/documents/proposals/12-AAER-2C_Water_Appliances/The_California_Statewide_IOU_Codes_and_Standards_Team_Addendum_2_to_the_Toilets_and_Urinals_CASE_Report_2014-02-21_TN-72713.pdf.

55 http://www.energy.ca.gov/appliances/2014-AAER-01/prerulemaking/comments/14-AAER-01_CA_IOUs_Comments_Regarding_Draft_Regulations_Faucets_Toilets_and_Urinals_2014-06-10_TN-73180.pdf.

On June 16, 2014, NRDC commented that staff's proposed regulations should impose stricter water consumption standards for wall-mounted urinals and residential lavatory faucets.[56]

Industry Proposals

Plumbing Manufacturers International (PMI), which represents many plumbing-fixture manufacturers, submitted a proposal that identifies water efficiency levels equal to those specified in AB 715 for toilets and urinals. The proposal also identifies water efficiency levels for faucets, proposing a flow-rate restriction of 1.5 gpm forresidential lavatory faucets, 1.8 gpm with optional 2.2 gpm (for filling pots and pans) for kitchen faucets and 0.5 gpm for public lavatory faucets, and 0.2 gallons per cycle for metered public lavatory faucets.[57] These proposed efficiency levels are identical to those set in the *2013 California Plumbing Code* and *CalGreen 2013*, effective January 1, 2014.[58]

Fluidmaster, Kohler, and Moen Incorporated submitted proposals making the same recommendations as PMI.

On June 6, 2014, PMI submitted comments on staff's proposed regulations, which were presented at the May 6, 2014, workshop for toilets, urinals, and faucets.[59] In summary, PMI supports all of staff's proposed recommendations for toilets, urinals, and faucets, except standards for replacement valves for toilets and urinals. PMI also urged against setting a restriction standard of 1.28 gpf full flush for dual-flush toilets, an MaP score of 600 grams for all toilets, 0.125 gpf for wall-mounted urinals, and 1 gpm flowrate for residential lavatory faucets.

Manufacturers such as American Standards, SLOAN, TOTO, and Kohler jointly commented in support of PMI's comments regarding the staff-proposed regulations.

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56 http://www.energy.ca.gov/appliances/2014-AAER-01/prerulemaking/comments/14-AAER-01_NRDC_T_Quinn_Comments_on_Appliance_Efficiency_Pre_Rulemaking_2014-06-16_TN-73213.pdf .
57 http://energy.ca.gov/appliances/2013rulemaking/documents/proposals/12-AAER-2C_Water_Appliances/PMI_Comments_re_Invitation_to_Submit_Proposals_2012-2013_Appliance_Efficiency_Rulemaking_Water_Appliances_2013-07-26_TN-71717.pdf; http://www.energy.ca.gov/appliances/2013rulemaking/documents/proposals/12-AAER-2C_Water_Appliances/PMI_Comments_re_the_CEC_Current_Rulemaking_on_Water_Closets_Urinals_and_Faucets_2013-10-28_TN-72309.pdf.
58 California Code of Regulations (CCR), Title 24, Part 5. December 7, 2013.
59 http://www.energy.ca.gov/appliances/2014-AAER-01/prerulemaking/comments/14-AAER-01_PMI_Letter_Comments_to_CEC_in_its_Current_Rulemaking_on_Water_Closets_Urinals_and_Faucets_Staff_Analysis_2014-06-06_TN-73159.pdf, and http://www.energy.ca.gov/appliances/2014-AAER-01/prerulemaking/comments/14-AAER-01_PMI_Comments_to_the_California_Energy_Commission_2014-06-06_TN-73120.pdf.

Geberit, a European market of sanitary and piping systems, submitted comments to support the staff-proposed standards.[60] It also suggested that water consumption of toilets, urinals, and faucets that are lower than the staff-proposed standards could negatively affect the balance of the current plumbing system. The result may trigger the incorrect use of appliances by the consumers, which can severely affect the efficacy of toilets, urinals, and faucets.

Waterless, a manufacturer of nonwater urinals, submitted comments to support the staff-proposed standards for toilets and urinals.[61]

Other Comments

On June 2 and 3, 2014, the American Society of Plumbing Engineers (ASPE), its San Diego chapter, and some of its members submitted comments in support of the staff-proposed standards. Their comments opposed the IOUs' suggested standards for full flush level of dual-flush toilets, wall-mounted urinals, MaP score, and residential lavatory faucets (mentioned above in PMI comments).

On June 6, 2014, East Bay Municipal Utility District (EBMUD), Municipal Water District of Orange County (MWDOC), Irvine Ranch Water District (IRWD), Inland Empire Utilities Agency (IEUA), and Alliance for Water Efficiency (AWE) submitted comments to support the staff-proposed standards.[62] Similar to comments from PMI (above), they also argued against the IOUs' proposed stricter standards for MaP score, wall-mounted urinals, and residential lavatory faucets.

The California Building Industry Association (CBIA) and California Business Properties Association (CBPA) submitted comments to support the staff-proposed standards.[63] Similar to comments from PMI (above), they also opposed the IOUs' proposed stricter standards for full flush level of dual- flush toilets, MaP score, wall-mounted urinals, and residential lavatory faucets.

60 http://www.energy.ca.gov/appliances/2014-AAER-01/prerulemaking/comments/14-AAER-01_Geberit_Comments_and_Response_Related_to_Water_Appliance_Efficiency_2014-06-04_TN-73098.pdf.

61 http://www.energy.ca.gov/appliances/2014-AAER-01/prerulemaking/comments/14-AAER-01_Waterless_Letter_re_Water_Efficiency_and_Urge_the_Commission_not_to_Adopt_a_Flushing_Urinal_Requirement_that_goes_below_0_2014-06-05_TN-73108.pdf.

62 http://www.energy.ca.gov/appliances/2014-AAER-01/prerulemaking/comments/index.html.

63 http://www.energy.ca.gov/appliances/2014-AAER-01/prerulemaking/comments/14-AAER-01_CBIA_Comments_and_Recommendations_for_Outlined_Staff_Analysis_of_Toliets_Urinals_and_Faucets__20-06-0617_TN-73150.pdf.

On June 2, 2014, the State Department of Housing and Community Development (HCD) submitted comments opposing revised standards for replacement valves for toilets and urinals, and MaP score testing, as these provisions conflict with current building standards.[64]

On June 4, 2014, the Pacific Hearth, Patio and Barbecue Association (HPBA) submitted comments citing difficulties with implementing provisions of SB 407, and suggesting that the Energy Commission consider impacts on small business for its rulemakings.[65]

Alternatives Consideration

Staff has analyzed the proposal in the CASE report 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, and stakeholders' proposals, for three alternatives scenarios: maintaining current Title 20 standards, revising Title 20 to incorporate the suggestions of the CASE report (most restrictive), or revising Title 20 to incorporate PMI's suggested measures.

Alternative 1: Maintaining Current Title 20

Staff does not believe current Title 20 standards are 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 as expressed in AB 715. Moreover, there are available appliances in the market that perform satisfactorily while saving significant water and energy.

Alternative 2: CASE Report Proposals

The CASE report proposes standards for toilets and urinals that are similar to AB 715, except the CASE report also proposes to restrict maximum flush volume of dual-flush toilets to 1.28 gpf, to require all toilets to have a minimum MaP score of 600, and to restrict water consumption of wall-mounted urinals to no more than 0.125 gpf. In summary, the CASE report proposed:

- Tier 1: Effective one year after the adoption date,
    - All toilets, except those designed for prisons or mental health facilities, shall not consume more than 1.28 gpf and shall have a MaP score of no less than 350 grams.

64 http://www.energy.ca.gov/appliances/2014-AAER-01/prerulemaking/comments/14-AAER-01_CEC_to_Consider_Comments_and_Amend_or_Withdraw_as_Appropriate_2014-06-06_TN-73109.pdf.
65 http://www.energy.ca.gov/appliances/2014-AAER-01/prerulemaking/comments/14-AAER-01_HPBA_Letter_Re_Legislation_that_Affects_Building_Permits_2014-06-04_TN-73102.pdf.

- All urinals, except trough-type and those designed for prisons or mental health facilities, shall not consume more than 0.125 gpf.
- All residential lavatory faucets shall not exceed 1.5 gpm flow rate with pipe pressure at 60 pounds per square inch (psi) and shall have a minimum flow rate of 0.8 gpm at 20 psi.
- All kitchen faucets shall not exceed 1.8 gpm flow rate and may have capability to increase to 2.2 gpm momentarily for filling pots and pans.

- Tier 2: Effective three years after the adoption date, toilets, urinals, and faucets shall meet all standards specified in Tier 1 plus:

  - A MaP score of 600 grams minimum for all toilets.
  - An effective flush volume of 1.06 gpf for all dual-flush toilets.
  - 0.125 gpf for urinals.
  - 1 gpm flowrate with a minimum 0.5 gpm for lavatory faucets.

- Tier 3: Effective four years after the adoption date, all toilets, urinals, and faucets shall meet all standards specified in Tiers 1 and 2, and a flush volume of 1.06 gpf for all tank-type toilets.

Alternative 3: Industry Proposals

PMI, with the support of other manufacturers, submitted a proposal to restrict water consumption of toilets and urinals to the levels specified in AB 715. These levels are 1.28 gpf for toilets and 0.5 gpf for urinals. PMI also suggested restricting flow for residential lavatory faucets at 1.5 gpm and 0.8 gpm minimum flow, kitchen faucets at 1.8 gpm with optional temporary flow of 2.2 gpm (for filling pots and pans), public lavatory faucets at 0.5 gpm, and metered public lavatory faucets at 0.2 gallon per cycle (gpc). Overall, the industry proposal contains efficiency levels set by California Plumbing Code.

CHAPTER 6: Staff Proposal for Toilets, Urinals, and Faucets Regulations

Energy Commission staff has analyzed the approaches proposed in the CASE report and by the plumbing industry and evaluated comments from stakeholders, approaches federally and in other states, and the cost-effectiveness and technical feasibility of each approach for California consumers. Staff has determined that the savings resulting from reduced water and energy consumption under the proposed standards are significant, while imparting no incremental cost to consumers. In addition, staff has found that the proposed standards are attainable through products available in the market.

Staff's proposed standards for all toilets, urinals, and faucets, which would take effect one year after adoption by the Energy Commission, are the following:

- All toilets, except those designed for prisons or mental health facilities, shall not consume more than an effective 1.28 gpf and shall have a MaP score of no fewer than 350 grams.
- All wall mounted urinals, except trough-type and those designed for prisons or mental health facilities, shall not consume more than 0.125 gpf.
- All floor mounted urinals shall not consume more than 0.5 gpf.
- All residential lavatory faucets shall not exceed 1.5 gpm flow rate with pipe pressure at 60 pounds per square inch (psi) and shall have a minimum flow rate of 0.8 gpm at 20 psi.
- All kitchen faucets shall not exceed 1.8 gpm flow rate and may have capability to increase to 2.2 gpm momentarily for filling pots and pans.
- All public lavatory faucets shall not exceed 0.5 gpm flow rate at 60 psi.

Based on its independent analysis of the best available data, including those from the CASE report and information provided by plumbing manufacturers, staff has concluded that the proposed regulations are both cost-effective and technically feasible. Staff assumptions and calculation methods are provided in Appendix A.

Staff-proposed standards would result in significant water and energy savings, and many efficient products are already available to consumers.

CHAPTER 7: Savings and Cost Analysis

The proposed standards for toilets, urinals, and faucets 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 standards take effect. *Annual existing and incremental stock savings* mean the annual water and energy reductions achieved after all existing stock complies with the proposed standards.

Staff's calculations and assumptions used to estimate first year savings and stock change savings are provided in the Appendix. As provided in Table 1, staff estimated that if all toilets, urinals, and faucets complied with the proposed standards (annual existing and incremental stock savings), California would save 88.6 billion gallons of water, 223 million therms of natural gas, and 1,677 GWh of energy per year. Of these numbers, about 19 billion gallons of water and 190 GWh of embedded energy savings are the direct result of standards set forth in AB 715. Using a residential rate of $0.16 per kWh of electricity and $0.99 per therm of natural gas, a commercial rate of $0.14 per kWh of electricity, and $0.75 per therm of natural gas, staff estimated that implementation of the proposed standards for toilets, urinals, and faucets would achieve roughly $1.13 billion a year in reduced utility costs after full implementation.

Staff has calculated the peak power reduction to be 1,677 GWh/8,760 hours, which equals to about 191 MW. This calculation is based on the simplified assumption that the load profile for toilets, urinals, and faucets is completely flat and energy would be evenly generated over the entire year to provide electricity for transporting and treating water used by toilets, urinals, and faucets.

Table 1: Statewide Annual Water and Energy Savings

	First-Year Savings				Annual Existing and Incremental Stock Savings			
	Water (Mgal)	**Nat.Gas (Mthm)**	**Energy[b] (GWh)**	**Savings (M$)**	**Water (Mgal)**	**Nat.Gas (Mthm)**	**Energy[b] (GWh)**	**Savings (M$)**
Residential toilets	808	N/A	8.11	7.35	15,880	N/A	160	145
Commercial toilets	96.6	N/A	0.97	0.86	1,110	N/A	11.2	9.73
Urinals	308	N/A	3.10	2.31	3,550	N/A	35.6	26.6
Residential lavatory faucets	2,450	8.04	61.8	36.2	22,070	72.4	557	326
Kitchen faucets	3,290	10.78	82.9	48.56	29,700	97.4	749	439
Public lavatory faucets	1,420	5.81	14.2	16.95	16,280	53.4	164	184
Total	**8,370**	**24.6**	**171**	**112**	**88,590**	**223**	**1,677**	**1,130**

Source: CASE reports, as modified by staff (see Appendix A for assumptions)
a. The first year and stock savings are totals of product categories in Appendix A.
b. Energy savings include embedded energy (energy used to supply the water) and heating energy (electric-heated water).

The CASE report for toilets, urinals, and faucets shows that the proposed standards are cost-effective as the cost per unit of compliant appliances is the same as the cost per unit of noncompliant appliances, indicating that there is no incremental cost to improve the efficiency of the appliance. Staff conducted a market price search of toilets, urinals, and faucets from three major retail sites, Amazon, Home Depot, and Lowe’s, to confirm the price results from the CASE report. 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

Individual Appliance Savings								
	Design Life (years)	Water Savings (gal/yr)	Nat. Gas Savings (therms)	Heating Energy Savings (kWh/yr)	Embedded Energy Savings (kWh/yr)	Incre-mental Cost ($)	Average Annual Savings ($)	Life-Cycle Benefit ($)
Residential Toilets	25	646	N/A	N/A	6	0	1.82	45.5
Commercial Toilets	12	245	N/A	N/A	2	0	1.82	22.8
Urinals	12	3,112	N/A	N/A	31	0	23.31	280
Residential Lavatory Faucets	10	823	3	12	8	0	7.21	72.1
Kitchen Faucets	10	2,154	7	33	22	0	18.28	183
Public Faucets	3	3,598	12	None	36	0	40.74	122

Source: CASE reports, as modified by staff (see Appendix A for assumptions)

The values shown in Table 2 are sales and compliance averages for each type of appliance. The design life, incremental cost, and savings, in 2013 dollars, were incorporated into this table by averaging the annual sales of each product. The incremental cost for each product category 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). Consumers will immediately see savings on their utility bill upon installing a compliant product. Thus, the average annual savings are the savings that consumers will receive once the product is installed. The *life-cycle benefit* represents the savings the consumer will 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 consumptions for each product with the respective water and energy consumptions under the proposed standards. For statewide estimates, these savings are multiplied by sales for first-year figures and by California annual existing and incremental stock for stock figures. The details of these calculations are available in Appendix A.

In conclusion, the proposed standards are 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.

CHAPTER 8:
Toilets, Urinals, and Faucets Regulations: Technical Feasibility

Toilets

Manufacturers use a variety of approaches to achieve good performance with 1.28 gallons of water or less. These technologies are described below.

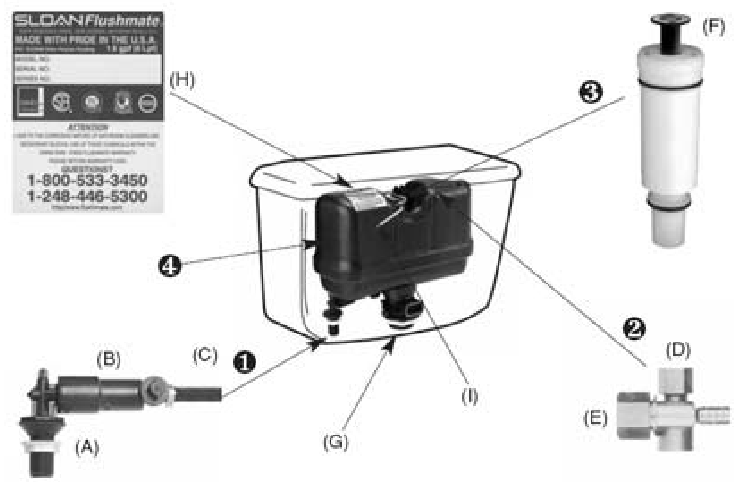
Better Gravity-Flush Tank-Type Toilets

Manufacturers redesigned the toilet bowls and trapways (the S-shaped pipe through which the toilet bowl drains) using advanced computer modeling to achieve better waste removal. They also introduced a better flapper such that in most 1.28 gpf toilets, the flapper closes before the tank is completely drained; thus, only about half the water in the tank empties during a flush. By only partially emptying the tank, the full vertical static pressure of a larger tank is available for flushing force, resulting in lower water consumption. This also minimizes tank sweating (condensation outside the tank) because entering cold water is mixed with the existing water in the tank.

Pressure-Assisted Flushometer Tank

A pressure-assisted toilet uses a separate, airtight flushometer tank inside the conventional tank to provide the pressure necessary to start the siphonic action in the bowl. Compressed air above the water inside the flushometer tank provides the additional pressure. After flushing, the water fills the tank from below, and because the tank is airtight, the incoming water compresses the air inside the tank to aid in flushing.

Figure 1: Pressure-Assisted Flushometer Tank



Source: http://www.flushmaterepairparts.com/troubleshooting

Redesigned Flush Valve

Enlarging the size of the flush valve ensures rapid flow of water to the toilet bowl, which shortens the flush duration while increasing the siphonic action, resulting in an effective flush.

Flapperless Gravity Flush

This type of toilet uses a trough inside the tank to collect water, and the tank itself does not have a flapper. It does not rely on water pressure or static head in the tank to flush; instead, it relies on fast release of a measured load of water to the tank by the water collection trough. Because the tank has no flapper, water is flowing rapidly to the bowl, which initiates an effective flush.

Figure 2: Flapperless Gravity Flush Tank

Source: http://www.niagaraconservation.com/water_conservation/products/toilets/detail?object=8664

Vacuum-Assisted Toilet

Instead of using gravity or pressure to push water through a toilet to induce the flush, a vacuum-assisted toilet uses a vacuum to help pull the waste out of the toilet bowl. Two approaches are typical with vacuum-assisted toilets: the more common self-contained or passive vacuum, and the less common centrally located vacuum.

Self-contained or *passive vacuum-assisted* toilets use the water to induce a vacuum in a specially designed and interconnected trapway and water bowl. When flushing is initiated, water flows down to both the toilet bowl (to start siphonic action) and the vacuum trapway. When the vacuum trapway is filled, it starts draining and creates a vacuum, which helps pull the waste from the toilet bowl.

The less common *vacuum-assisted toilets*, designed for airplanes or ships, connect to a centrally located waste collection vacuum tank. When flushing starts, a valve opens, and the waste is pulled from the toilet bowl. This type of system is less common because it is expensive and not suitable for homes or small businesses, although it uses very little water. Toilets on airplanes consume about a cup of water per flush.

Dual-Flush Toilets

An increasing number of toilets rely on two flush volumes, an approach that is very popular in Europe and Australia. Dual-flush action can be initiated in a conventional gravity feed or a pressure-assisted toilet, where the consumer selects which flush to engage. There is also a dual-flush retrofit device for conventional high-flush toilets.

Dual-flush toilets use as much as 1.6 gpf for removal of solid wastes (full flush) and up to 0.8 gpf for removal of liquid wastes (reduced flush). Thus, on average of two small flushes and a full flush (2:1 ratio), the effective flush volume is about 1.28 gallon. The CASE report cited seven studies documenting a concern that the 2:1 ratio used to estimate the effective flush volume of dual-flush toilets is not accurate, which, in effect, could underestimate actual water consumption.

Staff has decided not to recommend maximum 1.28 gpf flush volume for dual-flush toilets because:

- Drain line clogging is not a concern for toilets with an effective flush volume of 1.28 gpf.[66]
- All but one of the studies cited by the IOU shows that the actual water consumption of the studied dual-flush toilets is near or less than 1.28 gpf.[67]
- One study shows that higher effective flushing volume for dual-flush toilets are attributed to installation at a public female restroom.[68] This is a specific users' behavior in which females tend to use much more paper for sanitary protection at a public place. Because of the excessive amount of paper used, a higher volume of water is needed for proper flushing without additional stress to the existing plumbing system.[69]

Early Clogging Issues With Low-Volume Toilets

Although early low-volume flushing toilets performed well in the lab, they clogged up easily and needed to be double-flushed, plunged, or even snaked, upon field installation. This was a major cause of complaints from consumers in the early stage of low-volume flushing toilets. The most significant issue was that none of the early test methods addressed the likelihood of blockages. In response, more than a dozen municipalities and utility companies in Canada and the United States funded an exhaustive investigation to follow the National Association of Home Builders Research Center study *Maximum Performance Testing of Popular Toilet Models*.

Maximum performance (MaP)[70] testing identifies and ranks how well toilet models remove bulk waste using a realistic test media. A soybean paste having similar physical properties (density, moisture content) to human waste is used in combination with toilet paper as the test media. All toilet samples are adjusted, where possible, to the rated flush volume (typically 1.6 gallons) before testing to ensure a level playing field.

The testing protocol requires the soybean paste to be extruded through a 7/8-inch (22-mm) die and cut into 50-gram (50g) specimens (each specimen about 100 mm or 4 inches in length).

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66 WaterSense Notice of Intent to Develop a Draft Specification for Flushometer Valve Toilets. August 8, 2013. p.2. Retrieved from: http://www.epa.gov/watersense/docs/final-flushometer-valve-noi-508.pdf.
67 Code and Standard Enhancement (CASE) report. Appendix E. Retrieved from http://www.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.
68 Ibid.
69 http://www.energy.ca.gov/appliances/2014-AAER-01/prerulemaking/comments/14-AAER-01_Geberit_Comments_and_Response_Related_to_Water_Appliance_Efficiency_2014-06-04_TN-73098.pdf.
70 Maximum Performance Testing. *Maximum Performance (MaP) Testing Toilet Fixture Performance Testing Protocol: Version 5*. March 2013. http://www.map-testing.com/maximum-performance/background.html.

Toilet models are subjected to progressively larger loadings (in 50-gram increments) until the unit fails to clear the bowl completely in two of three attempts, or to fully restore a minimum 50mm (2-in.) trap seal, essentially a "test to failure."

The U.S. Environmental Protection Agency (EPA) has adopted 350g of uncased MaP media (soybean paste) as the minimum performance threshold for high-efficiency toilets in its WaterSense program. Many water utilities with toilet replacement rebate and installation programs also apply a MaP of 350g.

Since the use of the MaP test, early problems of frequent clogging have been alleviated, and low-volume toilets now receive favorable reviews from users.

The CASE report proposals recommend that toilets should be required to have a higher MaP score of 600 grams as there are products available, and that better solid removal performance could eliminate potential double flushing from persons with heavy bowel movements.

Staff has decided not to recommend a 600 grams MaP score for toilets because:

- The suggested 600 grams MaP score was based on a conceptual theory (evolved from a study of 10 persons) that 20 percent of the male population would double flush at least once in every 12 to 16 days because of their heavy loads. There is no evidence thus far to support that theory. Map Testing, Koeller & Company suggests four primary causes for double flushing:[71]

    - Unable to remove solid bulk matter
    - Unable to remove bowl marking
    - Unable to remove paper adhered to the side of the bowl
    - Unable to remove slurry waste at the end of flushing cycle.

  The MaP score is a test mainly used to verify the solid waste removal; other issues such as bowl markings, paper adhering to the bowl, and slurry removal are not addressed by MaP testing.

  Flushing a toilet involves adequate distribution of water to the rim (for side cleaning), and to the bowl bottom (for initiating cyclonic action and filing of trapway) to enhance a minimum vacuum to add removal of solid waste. Thus, insisting on a higher MaP score on toilets to address a theoretical (heavy load) problem of a small population may force

71 http://www.energy.ca.gov/appliances/2014-AAER-01/prerulemaking/comments/14-AAER-01_MAP_Comments_Re_Flush_Performance_Threshold_for_Toilets_Sold_in_California_2014-06-06_TN-73118.pdf.

manufacturers to concentrate only on solid removal instead of overall performance of the entire flushing system and toilet. This focus would stifle innovation for future toilet performance and may actually result in a toilet that is not completely clean, which would necessitate double flushes and cause consumer backlash.

- There is no evidence suggesting that toilets with MaP score of 350 grams are not working properly and causing double flushes. Thus, insisting on a higher score to deal with a theoretical problem would cause significant economic effects to manufacturers by:
    - Forcing perfectly functioning toilets out of the market.
    - Increasing costs to manufacturers for retesting and recertification of products.
    - Increasing costs to manufacturers for new investment for possible redesign of toilets.

Tank-Type Toilets With a Maximum 1.06 Gpf

The CASE report proposed that four years after adoption, all tank-type toilets shall be restricted to a maximum flush volume of 1.06 gpf while still maintaining 600 grams MaP score. Staff conducted searches of WaterSense and MaP Testing Lab databases and found that 43 models of toilets comply with the aforementioned criteria. Of these models, only nine are available for sale in the United States. Other models were discontinued for sale in the United States.

Staff has decided not to recommend maximum 1.06 gpf for tank type toilets because:

- ✓ There is limited availability of products available for sale in California.
- ✓ Available research[72] indicated that the solid media in these low-volume flushing toilets tend to compress together to form large plugs in drain pipes, which can cause frequent backup of drainage.

Blowout Toilets and Urinals

Reducing water consumption of blowout toilets and urinals is accomplished by better distribution of water flow to the rim and maintaining the necessary pressure to flush. Thus, minimal change to the bowl or urinal is needed. The CASE report and the Energy Commission

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72 Plumbing Efficiency Research Coalition, *The Drainline Transport of Solid Waste in Buildings*, November 2012. p. 7. Retrieved from: http://www.allianceforwaterefficiency.org/uploadedFiles/PERC/PERC-Report_FINAL_Phase-One_Nov-2012.pdf.

Appliance Database indicate that there are compliant blowout toilets already on the market[73]. This market availability indicates that qualifying products are technically feasible and readily available in California.

As of July 2013, 292 WaterSense-labeled urinal models, with valves of various flushing systems (including blowout) from 19 brand names, complied with staff's proposed regulation. The quantity and variety of high-efficiency urinals available for sale indicate that compliant products are technically feasible and readily available in California.

Urinals

As a urinal is mainly used for disposing of liquid waste, it does not have as many problems with clogging or effective waste removal as a toilet; however, manufacturers have made important technological improvements in urinals to achieve better waste removal and lessen evaporation of liquid in the trap.

The issue of whether the standard for urinals should be set at 0.5 gpf or 0.125 gpf generated considerable discussion among stakeholders over the last year. Concerns were raised regarding lost opportunities for water savings as a urinal installed today will be operating for many years, locking in a certain level of water consumption. Given there are a number of 0.125 gpf urinals available on the market that are cost-effective, supporters of the lower standard argued for the Commission to be aggressive and to seize the opportunity for maximum water savings now, especially given the ongoing drought.

Others raised concerns with how existing piping systems will be affected with the use of low-flow urinals due to mineral buildup and pipe corrosion, and what type of maintenance and cleaning will be required.

Staff carefully considered all the information presented and all the discussion generated on the topic of urinal water use. While there is a possibility of some increase in mineral buildup in pipes, there is significant uncertainty of the frequency of such occurrence, while the water savings of a 0.125 gpf urinal is far more certain. In addition, as noted earlier, Los Angeles has required 0.125 gpf urinals in new buildings and retrofitted buildings since 2010, and Oregon is moving forward with a 0.125 gpf proposal.

It is possible a restroom with 0.125 gpf wall-mounted urinals may require additional or different maintenance than those with a flush volume of 0.5 gpf to avoid odor or mineral

73 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.

buildup.[74] But to this point, staff has been presented with only anecdotal information from the field about buildup and odors in real-world applications or speculation that it could be a problem, while the severe drought and cost-effective water savings of 0.125 gpf urinals are immediate concerns.

As of July 2013, there were 256 WaterSense-labeled urinal fixtures, valves, and systems from 19 brand names. Thirty-five percent of all WaterSense-labeled urinal fixtures, valves, and systems consume just 0.125 gpf or less. The quantity and variety of high-efficiency urinals available for sale indicate that compliant products are technically feasible and are readily available in California and throughout the United States. Therefore, given the water and economic savings, the availability of compliant models, and the level of speculation regarding effects to piping systems, staff recommends a standard of 0.125 gpf for wall-mounted urinals, and 0.5 gpf for floor mounted urinals.

Faucets

Controlling flow from faucets still relies on existing technology: restricting the flow area with a gasket and creating a feeling of adequate flow or coverage with an aerator (laminar flow or gentle spray). Because the technology has not changed, reducing the flow rate of kitchen or lavatory faucets is a matter of maintaining sanitation and users' acceptance.

As of August 2014, the Energy Commission Appliance Database listed 3,400 lavatory faucets and accessories, and 2,900 kitchen faucets and accessories for sale. The database shows that 41 percent of the lavatory faucets and 22 percent of kitchen faucets would comply with the proposed standard. The quantity and variety of high-efficiency kitchen and lavatory faucets available for sale indicate that qualifying products are technically feasible and readily available in California.

Residential Lavatory Faucets With a Maximum Flow of 1.0 gpm

The CASE report proposed that three years after adoption, all faucets shall be restricted to a maximum flow of 1.0 gpm at a pipe pressure of 60 psi, and a minimum flow of 0.5 gpm at a pipe pressure at 20 psi.

The issue of whether the standard for faucets should be set at 1.0 gpm generated considerable discussion among stakeholders over the last year. Concerns were raised regarding lost opportunities for water savings as a faucet installed today will be operating for many years,

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74 http://energy.ca.gov/appliances/2013rulemaking/documents/proposals/12-AAER-2C_Water_Appliances/TN 72842 03-26-14 T Ngo CEC Consideration of Urinal Flush Levels.pdf; http://www.energy.ca.gov/appliances/2013rulemaking/documents/proposals/12-AAER-2C.

locking in a certain level of water consumption. In addition, because the Energy Commission's regulatory process would not allow a new cycle of revision to the regulation until five years after the adoption date, supporters of the lower standard argued for the Commission to be aggressive and to seize the opportunity for maximum water savings now, especially given the ongoing drought.

Another stakeholder raised concerns with how existing plumbing systems will be affected with the use of these low-flow faucets as they would not provide enough water to clear waste in the plumbing system.

Other stakeholders raised serious concerns that faucets with low-flow volume create stagnant conditions, which may cause waterborne pathogens such as legionella to grow in the hot water pipes.[75] The same stakeholders also raised concerns that faucets with a low-flow volume can significantly increase the "waiting for hot water" time, thereby causing dissatisfaction with consumers.[76]

Staff carefully considered all the information presented to and all the discussion generated on the topic of faucet water use. Staff findings and reasons for not going forward with reducing the flow rate of faucets to 1.0 gpm are:

- As of August 2014, no faucet and accessories listed in the Energy Commission Appliance Database would comply with the 1.0 gpm at 60 psi and 0.5 gpm at 20 psi pipe pressure flow rate standard.
- At 1.0 gpm flow rate, consumers may experience a slower delivery of hot water to the faucet. Staff has estimated that the wait for hot water delivery can be as long as 63 seconds, which is almost twice as long as the current wait time of 37 seconds. (See calculations in Appendix A.) This longer delivery time would result in greater heat loss within the plumbing system and more water wasted.

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75 http://www.energy.ca.gov/appliances/2014-AAER-01/prerulemaking/comments/AWE-PMI_Letter_to_CEC_on_WRF_Research_with_Research_Report_2014-11-10_TN-74002.pdf.

http://www.energy.ca.gov/appliances/2014-AAER-01/prerulemaking/comments/Dr_Sturman_of_Montana_State_University_Additional_Comments_2014-10-09_TN-74004.pdf.

76 http://www.energy.ca.gov/appliances/2014-AAER-01/prerulemaking/comments/PMI-Unintended_Consequences_of_Lowering_Residential_Lavatory_Faucet_Flow_Rates_2014-10-24_TN-73861.pdf.

- PMI's sponsored study shows that the wait for hot water times could be even longer: up to 140 seconds for 60 psi pipe pressure and 215 seconds for 20 psi pipe pressure.[77]
- Low-pressure flow is the critical factor for consumer satisfaction, especially for residential buildings with wells and for aging buildings (in which the piping pressure will be low, that is, in the 20-40 psi range). There is risk of consumer dissatisfaction with the low flow, which can lead to removing the aerator. Doing this could make the faucet flow be as high as 5 gpm. Therefore, one tampered faucet could wipe out all savings from four other compliant faucets, and a 20 percent tampered rate would wipe out the entire expected savings for all faucets.
- Low- flow faucets would increase sediment buildup within the trap and drain lines, which can contribute to more frequent clogging.

Prospect of Waterborne Pathogen Illness Caused by Low-Flow Faucets

As mentioned above, stakeholders raised serious concerns that low-flow faucets could create stagnant conditions necessary for waterborne pathogen such as Legionella to grow in the hot water pipe. This is the pathogen that causes "Legionnaires' disease" and a milder "Pontiac fever," in which the patient experiences cough, shortness of breath, high fever, muscle aches, and headaches. Most healthy patients infected with legionella can be treated and will recover, but complications can result and may cause death, especially for the elderly, those who smoke, those with weak immune systems, and infants.[78]

Staff reviewed available literature and made inquiries to the California Department of Health Services (DHS) and the National Centers for Disease Control and Prevention (CDC) to find out whether there was evidence of any link between faucet flow rate restriction and the potential increase for waterborne pathogens. According to CDC publications, legionella pathogen grow best in warm water environments like those found in hot tubs, cooling towers, hot water tanks, large plumbing systems, and decorative fountains.[79]

A 1984 study conducted at John Hopkins Hospital[80] shows that Legionella cultures were found in hot water tanks under stagnant conditions, and that by reducing stagnation of the hot water tank (by continuous usage), Legionella colonies were reduced. This research also found that

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77 Ibid.

78 Center for Disease Control and Prevention. Legionella (Legionnaires' Disease and Pontiac Fever). Feb. 2013. available at: http://www.cdc.gov/legionella/about/index.html

79 Centers for Disease Control and Prevention. Legionella (Legionnaires' Disease and Pontiac Fever): Causes & Transmission. Feb. 2013. available at http://www.cdc.gov/legionella/about/causes-transmission.html.

80 Ciesielski, C.A., M.J. Blaser, and W.L. Wang. 1984. "Role of Stagnation and Obstruction of Water Flow in Isolation of *Legionella Pneumophila* From Hospital Plumbing". *Applied and Environmental Microbiology.* Nov. 1984, p. 984-987. Available at http://www.ncbi.nlm.nih.gov/pmc/articles/PMC241662/pdf/aem00156-0084.pdf.

faucets aerators, by providing extra surface for colonization, can become secondary reservoirs for waterborne pathogens.

In 2003, the Association of Water Technologies (AWT) prepared a comprehensive collection of available information from various research's and environmental health organizations.[81] AWT issued a statement indicating that legionella growth is tied to:

- Stagnant water conditions and/or system design configurations that produce stagnation, such as side-arm and dead-leg piping in plumbing systems.
- Warm water temperatures between 20 and 50ºC (68 to 122ºF); optimal growth at temperatures between 35 and 45ºC (95 to 113ºF).
- Bulk water pH in the range of 5.0 to 8.5.
- Sediment, scale, deposits, and biofilm in plumbing system supporting not only legionella growth, but also microbiota as a nutrient and shelter source for legionella.

A 2006 study conducted at a hospital in Taiwan[82] shows legionella colonies were present in faucets with and without aerators. The flow rates are 3 gpm for faucets without aerator and 1.5 gpm for faucets with aerators.

Another 2006 study of 452 samples from hot water systems of randomly selected single-family residences in the suburbs of two German cities were analyzed for the occurrence of Legionella.[83] This study yields these findings:

- Plumbing systems with copper pipes were more frequently contaminated than those made of synthetic materials or galvanized steel.
- Newly constructed systems (<2 years) were not colonized.
- The type of hot water preparation had a marked influence on microbial growth. The data show convincingly that the temperature of the hot water is probably the most important or perhaps the only determinant factor for multiplication of Legionella.
- Water with a temperature below 46 °C (115 °F) was most frequently colonized and contained the highest concentrations of Legionella.

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81 Association of Water Technologies (AWT). 2003. *Legionella 2003: An Update and Statement by the Association of Water Technologies.* Rockville, MD [Online] Available at http://www.legionella.com/images/awtlegionella2003.pdf.
82 Wen-Kuei Huang, MS; Yusen Eason Lin, PhD, MBA. 2007. "A Controlled Study of Legionella Concentrations in Water From Faucets With Aerators or Laminar Water Flow Devices." *Infection Control and Hospital Epidemiology*, Volume 28, No 6, June 2007. Can be retrieved here: http://www.jstor.org/stable/10.1086/516797.
83 Mathys, W., Stanke, J., Harmuth, M., and Junge-Mathys, E. 2008. Occurrence of Legionella in Hot Water Systems of Single-Family Residences in Suburbs of Two German Cities With Special Reference to Solar and District Heating." *International Journal of Hygiene and Environmental Health,* Elsevier GmbH, Germany, 211(1), 179–185.

The results of a 2010 study of 10 separated household[84] water samples after overnight stagnation showed considerable microbial changes from household piping. This study also shows that a simple five-minute flushing diminished water microbial cells significantly; thus, flushing is an effective way to reduce waterborne growth in stagnant water.

Another 2011 study also conducted at Johns Hopkins Hospital[85] shows that nearly all faucets controlled by electronic eye sensors (95 percent) had legionella in at least one water sample, compared with less than half (45 percent) of manual faucets. The faucets that were equipped with electronic eye sensors were restricted to a flow of 0.5 gpm, while the manual faucets had a flow rate of at least 2.2 gpm, as they did not have aerators.

Based on the above information, staff's findings and conclusions are:

- Legionella growth is most prevalent in stagnant warm water between 95 and 113 °F.
- Older pipes provide a greater chance for microbial growth.
- Flushing of aging stagnated water in side-arms and dead-legs of pipes is an effective way to combat potential growth of legionella.
- There was insufficient evidence to conclude that a faucet standard reducing to 1.5 gpm flow rate in a home or 0.5 gpm flow rate for a public lavatory faucet would increase additional risk of Legionella growth, compared to the current faucet standard flow rate of 2.2 gpm.[86]

Public Lavatory Faucets

Because the technology used to reduce water flow from faucets are the same, and because there are well-performing public lavatory faucets available,[87] staff recommends that the flow restriction of 0.5 gpm apply to public lavatory faucets.

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84 Lautenschlager, K., N. Boon, Y. Wang, T. Egli, and F. Hammes. 2010. "Overnight Stagnation of Drinking Water in Household Taps Induces Microbial Growth and Changes in Community Composition." *Water Research*, 44(17):4868-4877.

85 Sydnor, E.R., G. Bova, A. Gimburg, S.E. Cosgrove, T.M. Perl, and L.L. Maragakis. 2012. "Electronic-Eye Faucets: Legionella Species Contamination in Healthcare Settings." *Infection Control and Hospital Epidemiology*, Volume 33, No 3, March 2012. Can be retrieved here: http://www.jstor.org/stable/pdfplus/10.1086/664047.pdf?acceptTC=true&jpdConfirm=true.

86 Current standard for faucet.

87 *Green Building Operation Manual*. p.198. Retrieved from http://www.greenseal.org/Portals/0/Documents/IG/PHA%20Manuals/Chapter10_Green_Building_OM_Manual_PHA.pdf.

CHAPTER 9: Environmental Impacts and Benefits

Impacts

Toilets, urinals, and faucets are replaced when they are at the end of their useful lives; therefore, replacement of these appliances would present no additional impact to the environment beyond the natural cycle.

Efficiency improvement of toilets, urinals, and faucets 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[88] may be susceptible to this issue, especially in dry weather. One widely cited example of wastewater collection problems due to low-flow fixtures is from San Francisco.[89] In 2009, the city of 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.[90]

Although the Energy Commission staff recognizes that there is some controversy about the cause of sewage clogging, staff believes the solution is not to slow down efforts to achieve water conservation and water efficiency goals. Staff also believes that evaluation of the systematic impacts of water conservation, wastewater collection and treatment systems, and development

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88 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: one, the combined sewer systems contain weirs to prevent solid waste from entering the public waterway; and two, 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.

89 "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.

90 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.

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 faucets or showerheads at a home or business. Energy is needed to extract water from the source, to treat, distribute, and use it, as well as to collect and treat wastewater for release back into the environment.

Furthermore, reducing water consumption would decrease the amount of waste, 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 through reduced energy requirements for pumping, and a reduction of 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[91] 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*suggested emission factor of 690 lbs CO_2e per MW for electricity and 11.65 pound CO_2e per therm (lb/th) for natural gas.[92]

For criteria air pollutants, staff used the California Air Resources Board-suggested emission factors used to estimate cost-effectiveness of emission reductions:[93]

- Oxides of nitrogen (NO_x) = 0.07 lb per MW,
- Sulfur dioxide (SO_2) = 0.01 lb per MW,

91 *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).

92 *Energy Aware Planning Guide*, February 2011, available at http://www.energy.ca.gov/2009publications/CEC-600-2009-013/CEC-600-2009-013.PDF.

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

- Carbon monoxide (CO) = 0.1 lb per MW,
- Particulate matters ($PM_{2.5}$) = 0.03 lb per MW.

Table 3: Criteria and Greenhouse Gas Emissions Reductions

Annual Reductions (tons)	Avoided Emissions (tons)				
	Oxides of Nitrogen (NO_x)	Sulfur Dioxide (SO_x)	Carbon Monoxide (CO)	Particulate Matter ($PM_{2.5}$)	Greenhouse Gas (eCO_2)
Toilets	5.97	0.85	8.53	2.56	58,880
Urinals	1.25	0.18	1.78	0.53	12,290
Faucets	52.6	7.51	75.1	22.5	1,807,370
Totals	**59.8**	**8.5**	**85.4**	**25.6**	**1,878,540**

Source: Staff calculated from appliance inventories in CASE report

As seen in Table 3, close to 180 tons of criteria air contaminants and close to 1.9 million tons of greenhouse gas equivalent would be avoided annually due to the savings from the proposed standards in embedded energy and the natural gas and electricity used to heat water. This is almost equal to emissions from a conventional combined-cycle, natural gas-fueled 500 MW power plant.

The proposed standards would also save significant amounts of water, estimated at 88.6 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.

APPENDIX A:
Staff Assumptions and Calculation Methods

Appendix A discusses the information and calculations used to characterize toilets, urinals, and faucets in California, the current water and energy use, and potential savings. The source of much of the information for these tables is the CASE report. 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 each appliance, the total stock of appliances for each category, and the appliance lifetimes for the CASE report. As the CASE report recommended standards for residential lavatory and kitchen faucets, it does not report the annual sale and stock for public lavatory faucets. By extrapolating requirements from the *California Plumbing Codes*, staff assumed that there are an equal number of faucets for each commercial toilet; therefore, the annual sale and stock numbers for public lavatory faucets are essentially the same for commercial toilets. Staff also assumed that the lifetimes of public lavatory faucets are three years due to heavy usage, because the duty cycle is about three times that of residential lavatory faucets.

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

Product	2013 sale	Stock	Lifetime (yrs)
Residential toilets	1,250,866	24,597,887	25
Commercial toilets	393,539	4,525,964	12
Urinals	99,073	1,139,411	12
Residential lavatory faucets	2,976,950	26,815,188	10
Kitchen faucets	1,526,368	13,792,553	10
Public lavatory faucets[a]	393,539	4,525,964	3[b]

Source: CASE reports

Notes: a. Staff assumes the same number of public lavatory faucets as commercial toilets.
b. Staff estimate for lifetime of public places' faucets.

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 21 percent means that 21 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 7.37 for a residentail toilet means that on the average, each toilet being flushed 7.37 times each day.

Staff calculated the baseline water consumption for each use of each appliance listed in **Table B-2**. The baseline average water consumption represents the water consumption of that appliance reflecting the number of compliant and noncompliant units in the market. For example, 0.79 value baseline average water consumption for a urinal means that each time the urinal is flushed, a market average water consumption of 0.79 gallon is consumed.

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

Product	**Compliance (%)**	**Duty Cycle**	**Baseline Average Water Consumption (gal/use)**
Residential toilets	21	7.37	1.53
Commercial toilets	51	5.87	1.44
Urinals	42	18.0	0.79
Residential lavatory faucets	43	13.8	0.78
Kitchen faucets	23	41.6	0.89 + 3 gal/day pots and pans filling
Public lavatory faucets	43	24.0	0.60

Source: CASE reports.

Assumptions:

- Census bureau data for California population 37.3 million people in 2010. Of these, 13.9 million are employed. Male and female ratios for employed sector are 0.55 for male and 0.45 for female.
- Survey data from the CASE report show:
    - A typical flushing of one for males and three for females for each working day.
    - Each person flushes about 4.76 times a day using residential toilets.
    - Each urinal is flushed about 18 times a day.
    - Commercial properties occupied usage is 260 days a year.
    - Each duration of faucet usage is about 37 seconds.

  - Numbers of compliant appliances and total stock.
  - A derating factor of 0.67 for all faucets. The *derating factor* means the correction factor to reflect actual flow of a faucet due to line pressure variation, incomplete opening of the valve of a faucet, and actual performance of flow restrictor gasket. Thus, a faucet rated at 2.2 gpm may actually deliver only 1.5 gpm (2.2 gpm x 0.67) on average.

- Compliance rates for residential and commercial toilets and urinals are estimated based on assumed compliance with the AB 715 compliance timeline. (See below.)
- Embedded energy cited in the CASE report is about 10,045 kWh/MM gallons of water delivered to customers.
- Duty cycles for residential and commercial toilets are estimated based on survey data and census population data. Duty cycles for urinals and all faucets are reported in CASE report.

Staff Sample Calculations

Compliance Rate

Compliance rate is the percentage of compliant units over the total stock units, or

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

Compliance rate for toilets = annual toilet turnover x number of years since AB 715 in effect / total stock, where

Annual toilets turnover = stock toilet / lifetime

For example:

Annual toilets turnover = 24,597,887 units / 25 yrs = 1MM units

AB 715 in effect since 2010 (5 years), therefore, the compliance rate =

= [(1MM units x 5 yrs) / 24.5MM units] x 100 = 21 percent

Duty Cycle

Residential toilet duty cycle = daily flushes per person x CA population / stock toilets, or

= (4.76 fpd x 37.3 MM person) / 24.1 MM units = 7.37 flushes per toilet per day

Commercial toilet duty cycle = sum of daily flushes for male and female / stock units

= [(0.55 male x 1f) +(0.45female x 3f)] x 13.9 MM = 24.6 MM flushes/day

Thus, daily flushes per commercial toilet is

= 24.6 MM f/d / 4.5 MM toilets = 5.87 flush per toilet 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.

Thus, in the case of a residential toilet, the baseline average water consumption per toilet is

= the sum of (percent complying unit x 1.28 gpf) and (percent of non-complying units x 1.6 gpf) / 100

= [(21 x 1.28 gpf) + (79 x 1.6 gpf)] / 100 = 1.53 gpf

And for the case of residential lavatory faucet, the baseline average water consumption per faucet is

= [(43 x 1.5 gpm) + (57 x 2.2 gpm)] x 0.67 x (37sec/use/60sec/min)/ 100 = 0.78 gallon each use

Baseline Water and Energy Use

Table B-3 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 each appliance type 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 2013 and baseline average water consumption and duty cycle yields the 2013 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 CASE report information on embedded energy and the baseline water consumption. Staff also estimated the electric and natural gas needed to heat water delivered to the faucet using assumptions listed below.

Table B-3: Baseline Water and Energy Use

Baseline Annual Water, Electricity, and Natural Gas Consumption								
	Water (MM g/yr)		**Embedded Electricity (GWh/yr)**		**Hot Water Electricity (GWh/yr)**		**Hot Water Natural Gas (MMTherms/yr)**	
	2013	Stock	2013	Stock	2013	Stock	2013	Stock
Residential toilets	5,115	100,577	51.4	1010	N/A	N/A	N/A	N/A
Commercial toilets	869	10,000	8.7	100	N/A	N/A	N/A	N/A
Urinals	366	4,213	3.7	42.3	N/A	N/A	N/A	N/A
Residential lavatory faucets	11,743	105,780	118	1063	178	1606	38.5	347
Kitchen faucets	22,252	201,073	224	2020	338	3052	73.0	660
Public lavatory faucets	1,923	22,118	19.3	222	N/A	N/A	7.9	72.6

Source: CASE reports

Assumptions:

- Embedded 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 faucet is 50 percent of faucet 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 day x number of unit. Thus, for urinals, the baseline water consumption is:

= (0.79 gal x 18/day x 260day/yr x 99,073 units)/1,000,000 = 366 MMgal/yr

And, in the case of residential lavatory faucets:

= (0.78 gal x 13.8/day x 365 day/year x 2,976,950 units) / 1,000,000

= 11,740 MMgal/yr

Embedded Energy

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

= 22,252 MMgal/day x 10,045 kWh/MMgal = 223,521,340 kWh or 224 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 a 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, and
ΔT is the difference in temperature of the water from 60 to 124°F.

Using the assumed values listed in Table B-3, staff calculated that the heat needed to bring water from 60 to 124°F is 492 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:

= 492 BTU/gal / (100,000 BTU/therm x 0.6) = 0.0082 therm/gal, or

= 492 BTU/gal / (3,412 BTU/kWh x 0.95) = 0.1518 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 faucets. For example, for residential lavatory faucets, the heating energy needed by using natural gas is:

= 0.0082 therm/gal x 11,743 MMgal/yr x 0.5 x 0.8 = 38.5 MMtherm

Compliant Water and Energy Uses

Compliant water and energy uses, tabulated in Table B-4, were calculated using annual market sale and stock and the respective water consumption limits, which are:

- 1.28 gpf for toilets,
- 0.5 gpf for urinals,
- 1.5 gpm for residential lavatory faucets,
- 1.8 gpm, with optional 2.2 gpm flow, for kitchen faucets, and
- 0.5 gpm for public faucets.

The product of the above limits water consumption of individual appliance and the respective annual sale and stock yields the annual or stock water consumption. These are listed in the first two columns of Table B-4. From the calculated water consumptions, staff calculated the embedded energy, and hot water heating energy using procedures similar to calculating the baseline hot water heating above (explained in Table B-3). The results are tabulated in Table B-4.

Table B-4: Compliant Water and Energy Use

Compliant Annual Water, Electricity, and Natural Gas Consumption								
	Water (MM g/yr)		**Embedded Electricity (Gwh/yr)**		**Hot Water Electricity (GWh/yr)**		**Hot Water Natural Gas (MMTherms/yr)**	
	2013	Stock	2013	Stock	2013	Stock	2013	Stock
Residential toilets	4,307	84,697	43.3	851	N/A	N/A	N/A	N/A
Commercial toilets	773	8,887	7.8	89.3	N/A	N/A	N/A	N/A
Urinals	58	667	0.6	6.7	N/A	N/A	N/A	N/A
Residential lavatory faucets	9,293	83,708	93	841	141	1606	30.5	275
Kitchen faucets	18,965	171,370	190	1,721	288	3052	62.2	562
Public lavatory faucets	507	5,834	5.1	58.6	N/A	N/A	2.1	19.1

Source: CASE reports

Costs and Savings

Table B-5 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; that is, 2040 for residential toilets, 2026 for commercial toilets and urinals, and 2025 for faucets.

Staff estimated and tabulated statewide savings in Table B-5 using CASE report information, and results listed in tables B-3 and B-4. Staff assumptions, as well as sample calculations, are provided below.

Table B-5: Statewide Annual Water, Energy, and Monetary Savings

	First-Year Savings				Annual Existing and Incremental Stock Savings			
	Water (Mgal)	Nat.Gas (Mthm)	Energy (GWh)	Savings (M$)	Water (Mgal)	Nat.Gas (Mthm)	Energy (GWh)	Savings (M$)
Residential toilets	808	N/A	8.11	7.35	15,880	N/A	160	145
Commercial toilets	96.6	N/A	0.97	0.86	1,110	N/A	11.2	9.73
Urinals	308	N/A	3.10	2.31	3,550	N/A	35.6	26.6
Residential lavatory faucets	2,450	8.04	61.8	36.20	22,070	72.4	557	326
Kitchen faucets	3,290	10.78	82.9	48.56	29,700	97.4	749	439
Public lavatory faucets	1,420	5.81	14.2	16.95	16,280	53.4	164	184
Total	**8,370**	**24.6**	**171**	**112**	**88,590**	**223**	**1,677**	**1,130**

Source: CASE reports

Assumptions

- The CASE report-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 and $0.14/kWh for commercial.[94]
- U.S. Energy Information Administration natural gas prices (for 2013) of $0.99/therm for residential and $0.75/therm for commercial.[95]

94 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.
95 Energy Information Administration – natural gas prices for 2013 through December 2013.

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 their respective compliant water and energy consumption. For example, the first-year energy saving for residential bathoom faucets is

= (baseline water consumptions for residential lavatory faucets) – (compliant water consumption for residential bathroom)

= 11,743 Mgal/yr – 9,293 Mgal/yr = 2,450 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 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-5. For example, the stock change monetary saving of public lavatory faucets 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)

= (22,070 Mgal x($2.82 + $4.66)/1000) + (72.4 Mth x $0.99/th) + (557 GWh x $0.16/kWh) = $326 million

Table B-6 lists the annual water and energy savings for each compliant product once the proposed standards become effective. It also lists the design life, annual monetary savings, the incremental cost and the life-cycle benefit of each compliant unit. Because the costs of a compliant unit and a noncompliant unit are the, the incremental cost would be 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-6 using CASE report information, Table B-5 assumptions, and the results listed in Tables B-3 and B-4. Staff's additional assumptions, as well as sample calculations are provided below.

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http://www.eia.gov/dnav/ng/ng_pri_sum_dcu_SCA_m.htm.

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

Individual Appliance Savings								
	Design Life (years)	Water Savings (gal/yr)	Nat. Gas Savings (therms)	Heating Energy Savings (kWh/yr)	Embedded Energy Savings (kWh/yr)	Incremental Cost ($)	Average Annual Savings ($)	Life-Cycle Benefit ($)
Residential Toilets	25	646	N/A	N/A	6	0	1.82	45.5
Commercial Toilets	12	245	N/A	N/A	2	0	1.82	22.8
Urinals	12	3,112	N/A	N/A	31	0	23.31	280
Residential Lavatory Faucets	10	823	3	12	8	0	7.21	72.1
Kitchen Faucets	10	2,154	7	33	22	0	18.28	183
Public Faucets	3	3,598	12	No	36	0	40.74	122

Source: CASE reports

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 energy is 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-5. 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 public lavatory faucets is following:

Annual savings = (water savings x ($2.58 + $4.84)/1000gal) + (natural gas savings x $0.75/therm) + (energy savings x $0.14/kW)

= 3,598 gal x ($2.58 + $4.84)/1,000gal + 12th x $0.75/th + 36 kWh x $0.14/kW

= $ 40.74 per year

Life-cycle benefit = $40.74/yr x 3 yr = $122

Faucet Hot Water Waiting Times

Assumptions:

- Survey data from CASE report show that :
  - Each duration of faucet usage is about 37 seconds.
  - The average water flow rate of lavatory faucets is 1.9 gpm.
  - All faucets have a derating factor of 0.67.
- Residential buildings have ½-inch water pipes.
- Staff estimated an average of 45 feet of pipe from water heater to faucet (measured from a typical 3 bedroom, 1 bath home).
- Staff estimated that hot water must clear an entrapment of one volume of pipe from water heater to faucet before useful warm water (to the users) starts to flow at the faucet.

Calculations:

Water entrapment volume = pipe length X pipe area

where pipe length is 45 feet, and pipe area is calculated from the pipe inside diameter (ID) using the equation $A = \Pi\,(I.D.)^2/4$

$= 3.14(0.569/12)^2/4 = 0.0018\ ft^2$

Water entrapment volume = 45 X 0.0018 = 0.081 ft^3 or 0.61 gallon

Thus, the time to clear the entrapment volume is

= 0.61 g / 1.9 gpm X 60sec/min = 28.7 seconds

And the time used for actual useful activities, such as hand washing, is

= 37 sec – 28.7 sec = 8.3 sec

Thus for a 1 gpm lavatory faucet, the time for actual warm water to appear at the faucet is

= 0.61 gal / 1gpm X 60 sec/min = 54.6 seconds

And the total faucet usage time is

= 54.6 + 8.3 = 62.9 seconds