CALGREEN CODES AND STANDARDS ENHANCEMENT INITIATIVE

Indoor Domestic Water Use Efficiency

2016 CALIFORNIA GREEN BUILDING STANDARDS (CALGREEN)

California Utilities Statewide Codes and Standards Team May 18, 2015

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This report was prepared by the California Statewide Codes and Standards Enhancement (CASE) Program that is funded, in part, by California utility customers under the auspices of the California Public Utilities Commission.

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Document Information

Category: Codes and Standards

Keywords: Statewide Utility Codes and Standards Team, Statewide C&S Team, Codes and Standards Enhancements, Title 24, 2016, Part 11, CALGreen, water efficiency, indoor plumbing, water closets, faucets, pint urinals, toilets, compact distribution design, demand recirculation systems with manual controls.

1. EXECUTIVE SUMMARY

Introduction

This report presents proposals to support the California Department of Housing and Community Development (HCD) and the California Building Standards Commission (BSC) in their efforts to update California's Green Building Standards (CALGreen or Part 11 of Title 24) to include new requirements and amend existing requirements. The goal of this report is to prepare and submit proposals that will result in cost-effective enhancements to water efficiency in buildings. The four California Investor Owned Utilities (IOUs) – Pacific Gas and Electric Company (PG&E), San Diego Gas and Electric (SDG&E), Southern California Edison (SCE) and Southern California Gas Company (SoCalGas) – and Los Angeles Department of Water and Power (LADWP) sponsored this effort. These companies are collectively referred to in this report as the Utility Codes and Standards (C&S) Team. This report and the code change proposal presented herein are a part of Utility C&S Team efforts to develop technical and cost-effectiveness information for proposed code changes.

Summary of Proposed Code Changes

Residential Lavatory Faucet Efficiency

The proposed code change would update the existing mandatory efficiency requirements for lavatory faucets in residential buildings. The existing mandatory CALGreen standard requires a maximum flow rate of 1.5 gallons per minute (gpm) at 60 pounds per square inch (psi) and a minimum flow rate of 0.8 gpm at 20 psi. The proposed requirement is a maximum flow rate of 1.0 gpm at 60 psi for faucets installed in new buildings, and 1.2 gpm at 60 psi for faucets in additions and alterations. As documented in this report, the Utility C&S Team believes that the 1.0 gpm standard is appropriate for new construction, additions, and alterations. However, as a compromise to stakeholders that are concerned about installing 1.0 gpm faucets in existing buildings, the Utility C&S Team has proposed language that allows less efficient fixtures to be installed in additions and alterations. Marked up code language for each proposed change is provided in Section 8 of this report.

Urinal Efficiency

The proposed code change would update the existing mandatory efficiency requirements for urinals in residential and nonresidential buildings. The existing mandatory CALGreen standard requires a maximum flush volume of 0.5 gallons per flush (gpf). The proposed requirement would require a maximum flush volume of 0.125 gpf, and would apply to new construction, additions, and alterations.

On April 8, 2015, the California Energy Commission (CEC) adopted revisions to the California Appliance Efficiency Regulations (Title 20) to limit wall-mounted urinals sold or offered for sale in California after January 1, 2016 to a maximum flush volume of 0.125 gpf (CEC 2015d, CEC2015e). The requirements in CALGreen should be updated so they are consistent with newly revised Title 20 standards. The City of Los Angeles has had an ordinance in place since 2010 that requires urinals installed in both new and existing buildings to have a maximum flush volume of 0.125 gpf (City of Los Angeles 2009).

Premium Efficiency Toilets

The proposed code change would add a new voluntary requirement for premium efficiency water closets in residential buildings. The proposed voluntary standard would require an effective flush volume of 1.06 gpf, compliance with the toilet performance requirements specified in the 2013 version of American Society of Mechanical Engineers (ASME) / Canadian Standards Association (CSA) Standard for Ceramic Plumbing Fixtures (ASME A112.19.2-2013 / CSA B45.1-13), and a waste extraction performance rating of 600 grams or higher to ensure customer satisfaction. This requirement would apply to new construction, additions, and alterations.

Compact Hot Water Distribution Design

The proposed code change would add a new voluntary requirement that will reduce the amount of water wasted when waiting for hot water to arrive the point of use (shower, faucet, etc.). This change will also results in shorter wait times for hot water to arrive. The proposed change would provide builders with two compliance options. The first option is to meet proposed maximum pipe length requirements and have a California Home Energy Rating System (HERS) Rater complete a field-verification of compliance. The first option, compact hot water distribution design, is addressed in detail in this report. The second option, demand recirculation system with manual controls, was added as a compliance option in response to stakeholder comments and is not discussed in detail in this report.

Summary of Cost/Benefit Analysis

This report presents the annual savings from all installations that occur during the first year the standard is in effect (2017). The report also presents the annual water and energy savings for the year in which products installed in 2017 will come to the end of their lifecycle known as the "full deployment" year. At that point, new product deployments that are regulated by the standards will roughly equal existing product replacements and thus this level of savings will continue indefinitely (and potentially increase, due to market growth and the potential for consumers to replace retired products with products that have equal savings). Since a building's plumbing system will last for the entire lifespan of the building, the life of compact hot water distribution design is the same as the life of the building. Although savings from compact design will persist for much longer than 30 years, this report accounts for the savings for the first 30 years.

The proposed changes will result in significant cost-effective water and energy savings. Table 1 presents the first year statewide water and energy savings of the proposed requirements for faucets, urinals, toilets, and compact hot water distribution design. The Utility C&S Team estimates that during the first year the proposed requirements will result in 191 million gallons of water savings, which has an associated embedded energy savings of 1.9 GWh/yr. The proposed standards will also result in an annual natural gas savings of 0.7 million therms and 623 MWh from reduced water heating demand during the first year.

The Utility C&S Team also estimates that when standards are fully deployed, annual water savings will exceed 3.3 billion gallons, which has an associated embedded energy savings of over 33 GWh/yr. Annual natural gas and electricity savings from reduced hot water use are estimated to exceed 13 million therms and 6.7 GWh, respectively (see Table 2).

The per unit lifecycle cost savings for the proposed standards are presented in Table 3. All of the proposed standards are cost effective, and will result in cost savings to the consumer.

Table 1: Summary of First Year Water and Energy Savings

	Water Savings (Million Gallons/yr)	Natural Gas Savings from Water Heating (Million Therms/yr)	Electricity Savings from Water Heating (MWh/yr)	Embedded Electricity Savings (MWh/yr)
Lavatory Faucets	119	0.4	623	1,199
Urinals	9	N/A	N/A	93
Premium Efficiency Toilets	24	N/A	N/A	241
Compact Hot Water Distribution Design	39	0.3	was not calculated	390
TOTAL	**191**	**0.7**	**623**	**1,923**

Table 2: Summary of Water and Energy Savings at Full Deployment

Measure Name and Date of Full Deployment	Water Savings (Million Gallons/yr)	Natural Gas Savings from Water Heating (Million Therms/yr)	Electricity Savings from Water Heating (MWh/yr)	Embedded Electricity Savings (MWh/yr)
Lavatory Faucets (full deployment year: 2026)	1,285	4.3	6,706	12,903
Urinals (full deployment year: 2028)	116	N/A	N/A	1,164
Premium Efficiency Toilets (full deployment year : 2041)	731	N/A	N/A	7,344
Compact Hot Water Distribution Design (full deployment year: 2041)	1,199	9.3	Was not calculated	12,045

Table 3: Summary of Per Unit Lifecycle Cost Savings and Benefit/Cost Ratios

	Lifecycle Cost	Lifecycle Benefit	Net Lifecycle Cost Savings	Benefit / Cost Ratio
Faucets (natural gas water heating)	$5	$47	$42	9.4
Faucets (electric water heating)	$5	$84	$79	16.8
Urinals	$0	$156	$156	No costs
Premium Efficiency Toilets	$50	$81	$31	1.6
Compact Hot Water Distribution Design	$318	$670	$352	2.1

2. INTRODUCTION

2.1 Purpose of Report

This report presents recommendations to support the California Department of Housing and Community Development (HCD) and the California Building Standards Commission (BSC) in their efforts to add and amend water efficiency requirements in California's Green Building Standards (CALGreen or Part 11 of Title 24). The four California Investor Owned Utilities (IOUs) – Pacific Gas and Electric Company (PG&E), San Diego Gas and Electric (SDG&E), Southern California Edison (SCE) and Southern California Gas Company (SoCalGas) – and Los Angeles Department of Water and Power sponsored this report. This report and the code change proposals presented herein are part of the effort to develop technical and cost-effectiveness information for proposed regulations on water efficient building design practices, products and technologies.

This report proposes voluntary and mandatory requirements to improve domestic water use efficiency in residential and nonresidential buildings. The report contains pertinent information that justifies the code change proposal including:

- Executive Summary (Section 1)
- Measure description and rationale (Section 2);
- Relationship to other standards and model codes (Section 3);
- Market analysis, including a description of the market structure for specific technologies, and market availability (Section 4);
- Results of water and energy impacts analysis, cost-effectiveness analysis, and environmental impacts analysis (Section 5);
- Compliance and enforcement considerations (Section 6);
- Summary of stakeholder consultation to develop measures and responses to stakeholder feedback (Section 7); and
- Proposed code change language (Section 8).

When proposing changes to CALGreen, HCD and BSC are required to provide specific information about the impacts of the proposed standards in the Initial Statement of Reasons (ISOR),[1] and the Economic and Fiscal Impacts Statement (Form 399),[2] required by the Department of Finance. This report contains information that is responsive to the ISOR and Form 399 (see Appendix A). In addition, HCD and BSC are required to provide a "Nine-point

1 The template for the ISOR is available on BSC's website: http://www.documents.dgs.ca.gov/bsc/proc_rsltn/documents/templates/BSC-TP-106-ISOR-Template.doc.

2 The blank Form 399 worksheet is available on BSC's website: http://www.documents.dgs.ca.gov/bsc/proc_rsltn/2009/STD-399-EconomicandFiscalImpactStatement.pdf.

checklist."[3] This report provides information that is responsive to each relevant section of the checklist.

2.2 Measure Description

2.2.1 Summary of Proposed Changes to Mandatory CALGreen Requirements

Residential Lavatory Faucet Efficiency

The proposed code change would update the existing mandatory efficiency requirements for lavatory faucets in residential buildings. The existing mandatory CALGreen standard requires a maximum flow rate of 1.5 gallons per minute (gpm) at 60 pounds per square inch (psi) and a minimum flow rate of 0.8 gpm at 20 psi. The proposed requirement is a maximum flow rate of 1.0 gpm at 60 psi for faucets installed in new buildings, and 1.2 gpm at 60 psi for faucets in additions and alterations. As documented in this report, the Utility C&S Team believes that the 1.0 gpm standard is appropriate for new construction, additions, and alterations. However, as a compromise to stakeholders that are concerned about installing 1.0 gpm faucets in existing buildings, the Utility C&S Team has proposed language that allows less efficient fixtures to be installed in additions and alterations. Marked up code language for each proposed change is provided in Section 8 of this report.

Urinal Efficiency

The proposed code change would update the existing mandatory efficiency requirements for urinals in residential and nonresidential buildings. The existing mandatory CALGreen standard requires a maximum flush volume of 0.5 gallons per flush (gpf). The proposed requirement would require a maximum flush volume of 0.125 gpf, and would apply to new construction, additions, and alterations.

On April 8, 2015, the California Energy Commission (CEC) adopted revisions to the California Appliance Efficiency Regulations (Title 20) so wall-mounted urinals sold or offered for sale in California after January 1, 2016 have a maximum flush volume of 0.125 gpf (CEC 2015d, CEC2015e).[4] The requirements in CALGreen should be updated so they are consistent with newly revised Title 20 standards. The City of Los Angeles has had an ordinance in place since 2010 that requires urinals installed in both new and existing buildings to have a maximum flush volume of 0.125 gpf (City of Los Angeles 2009).

2.2.2 Summary of Proposed Changes to Voluntary CALGreen Requirements

Premium Efficiency Toilets

The proposed code change would add a new voluntary requirement for premium efficiency water closets in residential buildings. The proposed voluntary standard would require an

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[3] The Nine Points Criteria is available on BSC's website: http://www.documents.dgs.ca.gov/bsc/proc_rsltn/documents/templates/BSC-TP-109-Nine-Point-Criteria-Analysis-Template.doc.

[4] The maximum flush volume of other urinals (e.g., floor-mounted urinals) is 0.5 gpf.

effective flush volume[5] of 1.06 gpf, compliance with the toilet performance requirements specified in the 2013 version of American Society of Mechanical Engineers (ASME) / Canadian Standards Association (CSA) Standard for Ceramic Plumbing Fixtures (ASME A112.19.2-2013 / CSA B45.1-13),[6] and a waste extraction performance rating of 600 grams or higher to ensure customer satisfaction. This requirement would apply to new construction, additions, and alterations.

Compact Hot Water Distribution Design

The proposed code change would add a new voluntary requirement that will reduce the amount of water wasted when waiting for hot water to arrive the point of use (shower, faucet, etc.). This change will also results in shorter wait times for hot water to arrive. The proposed change would provide builders with two compliance options. The first option is to meet proposed maximum pipe length requirements and have a California Home Energy Rating System (HERS) Rater complete a field-verification of compliance. The second option is to install a demand recirculation system with manual controls.

2.3 Rationale for Proposed Code Changes

2.3.1 State Policy Goals

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

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

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[5] The effective flush volume is the composite average of two reduced-volume flushes and one full-volume flush.

[6] See Section 4.4.3 of this report for a description of these requirements.

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

Water Resources,[8] and CEC[9] have either adopted or plan to soon adopt "emergency" or "expedited" water saving regulations.

Finally, the CPUC has also directed the IOUs to pursue water efficiency activities such as rebate programs and codes and standards advocacy as part of their energy management portfolios. As discussed in Section 2.3.4, a significant amount of energy is used to fulfill California's water supply needs. CPUC has directed the energy utilities to pursue initiatives that aim to reduce the amount of energy associated with water use, including pursuing water efficiency measures.

2.3.2 Problem Statement – California's Drought Emergency

As of April 2015, 99.86 percent of California is in a drought, ranging from "severe drought" in 93 percent of the state (3 on a scale of 1 to 5, with 5 being the worst or "exceptional drought") to "exceptional drought" in 47 percent of the state. See Figure 1 below for drought map. The Department of Water Resources' snowpack survey readings from February 2015 measured water levels in the state's snowpack at 19 percent of normal (DWR 2015). This is of grave concern, since snowpack provides a third of the water for farms and cities. Furthermore, California's major reservoirs are at less than 40 percent of total capacity on average and less than 60 percent of historical average. The U.S. Geological Survey reports that 50 percent of its 220 stream flow gauges in California record either "below normal" or "much below normal" flows (USGS 2015).

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

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

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

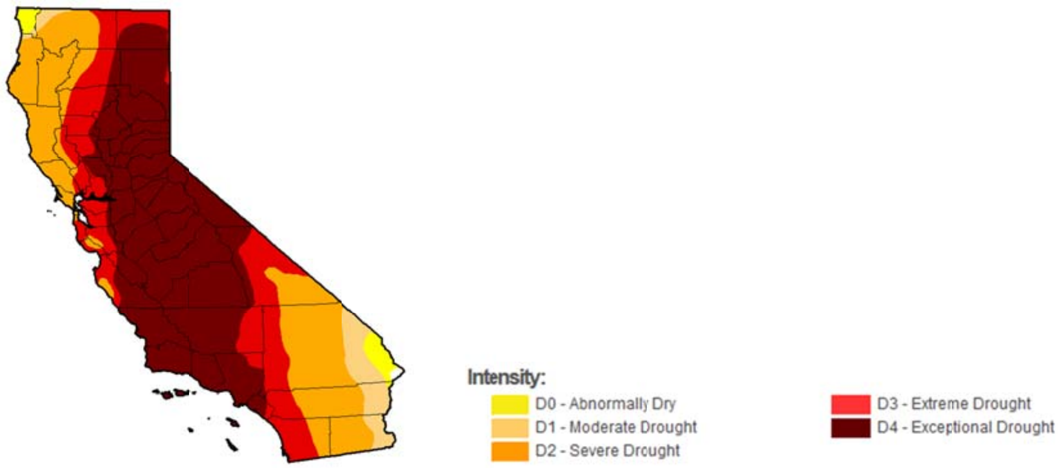

Figure 1: California Drought Classification by Region

Source: United States Drought Monitor (Updated April 21, 2015)

The installation of water-saving devices in residential, commercial, and industrial applications is crucial for addressing California's water resource needs during the drought. Water use efficiency and conservation protects the future of our state's water supply for communities, businesses, industry, and the environment. Water use efficiency decreases the need to invest in costly, large-scale infrastructure projects (e.g., dams, canals, reservoirs) as noted further below, while also reducing operating costs for water utilities (e.g., pumping and treatment) (U.S. EPA 2013).

HCD and BSC have an opportunity to respond to the Governor's directives to take all necessary actions to prepare and respond to drought conditions by prioritizing the proposed changes to CALGreen and achieving significant water savings standards.

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

Establishing more stringent water efficiency standards is a cost-effective intervention for reducing California's water demand. It may be the most cost-effective intervention when compared to solutions that aim to increase and maintain reliable water supplies. For instance, projects such as desalination, dams, or new water conveyance projects cost billions of dollars.[10] The water efficiency standards presented in this report, on the other hand, will reduce Californians' expenditures on water and energy bills while supporting manufacturers and builders that offer high efficiency fixtures and hot water distribution design practices. In

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

addition, in contrast to large-scale water supply projects, efficient water use is expected to result in significant environmental benefits as discussed in Section 5.

2.3.4 Water-Energy Nexus

The relationship between water use and energy use helps to justify additional water efficiency standards. Nearly twenty percent of the electricity and thirty percent of non-power plant-related natural gas use in California is associated with meeting California's water supply needs (CEC 2006).[11] California consumes about 2.9 trillion gallons of water per year for urban uses (Christian-Smith, Heberger & Luch 2012).[12] These 2.9 trillion gallons of water correspond to approximately 26.4 terawatt hours (TWh) of embedded electricity. Figure 2 presents the embedded energy associated with various water end uses. More than 9.1 TWh of electricity is used every year to supply and treat potable water that is used inside residential buildings.

Conversely, water is required to produce electricity; if electricity demand increases so does the demand for water (California Sustainability Alliance 2013).

The California Global Warming Action Plan recognizes this water-energy nexus. The plan calls for the establishment of indoor and outdoor water efficiency standards, and water recycling initiatives to help achieve California's greenhouse gas (GHG) reduction goals.[13]

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[11] Water-related energy uses include energy consumed by water agencies for water collection, extraction, conveyance, treatment prior to use (e.g., potable), treatment and disposal after use (e.g., wastewater), and for distribution to end-users. It also includes energy used by the end-user after the water agency has delivered water, such as energy used to pump and heat water on-site.

[12] Urban uses include outdoor and indoor residential water use; water used in commercial, institutional, and industrial applications; and unreported water use, which is primarily attributed to leaks.

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

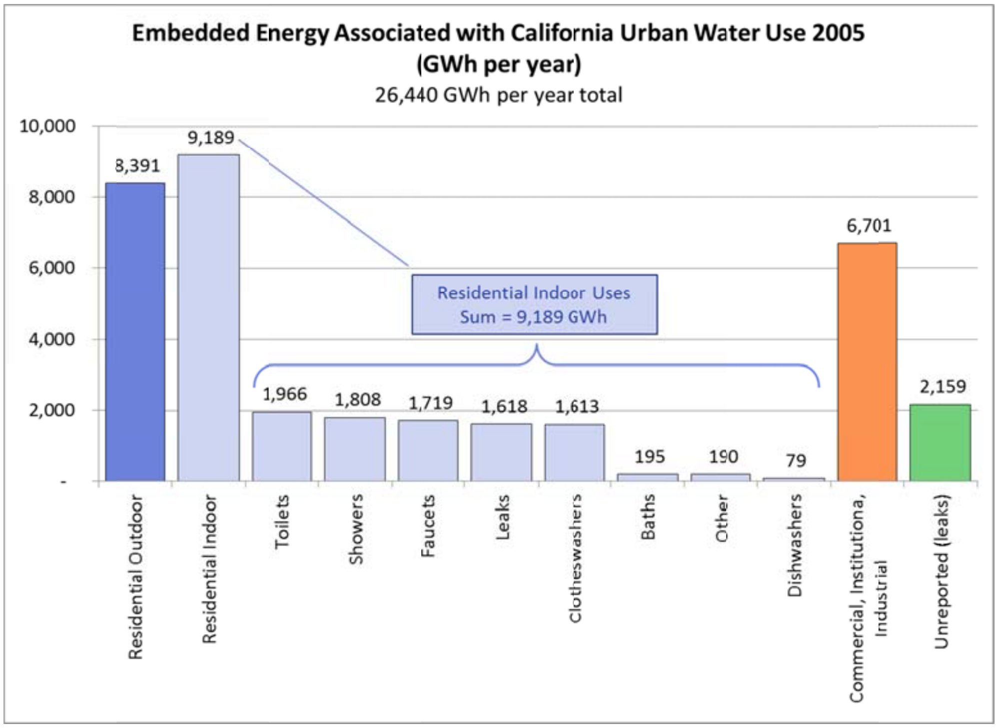

Figure 2: Embedded Energy Associated with California Urban Water Uses (2005)

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

3. Relationship to Other Standards and Model Codes

3.1 HCD and BSC Jurisdiction

Responsibility for developing CALGreen codes related to water efficiency is divided among agencies. Codes developed by HCD address residential buildings regulated by the CALGreen Code Division 4 and Appendix A4 and include apartments, one- and two-family dwellings, motels, and hotels. Codes developed by BSC address nonresidential buildings regulated by CALGreen Code Division 5 and Appendix A5 including privately owned buildings used for retail, office and medical services and others purposes (BSC 2014).

The goals of CALGreen include: (1) reducing GHG emissions from buildings; (2) promoting environmentally responsible, cost-effective, healthier places to live and work; and (3) reducing energy and water consumption.

CALGreen includes sections (such as Divisions 4 and 5) that are mandatory state wide as well as voluntary sections. The voluntary sections of the codes (Appendix A4 and A5 for instance) include measures that are voluntary unless a local jurisdiction chooses to require compliance with the voluntary sections of the code. The voluntary requirements can include either one or two Tiers. In the latter case, a Tier 2 standard would achieve greater water savings than a Tier 1 standard (BSC 2014).

3.2 Relationship to Federal Regulations

On December 22, 2010, the United States (U.S.) Department of Energy (DOE) waived federal preemption for energy and water conservation standards with respect to any state regulation concerning the water use or water efficiency of faucets, showerheads, and urinals (75 Fed. Reg.245, 22 December 2010). This waiver allows states to set their own standards for the relevant plumbing products as long as the state standard is as stringent as the federal standard.

3.3 Relationship to Existing State Regulations

3.3.1 Existing CALGreen Standards (Part 11 of Title 24)

The 2013 version of CALGreen (effective July 1, 2015) includes mandatory requirements for toilets, urinals, faucets (residential lavatory faucets, lavatory faucets in common and public use areas, metering faucets, kitchen faucets) in all buildings (Sections 4.303 and 5.303.3).

3.3.2 Existing Requirements in Part 6 of Title 24

California's Building Energy Efficiency Standards (Title 24, Part 6) include a provision that allows buildings to account for the energy benefits of compact hot water distribution design when using the performance approach for code compliance. If claiming the compact distribution design compliance credits, the hot water distribution system must meet the requirements in Section 3.6.5 of the Residential Appendix (CEC 2012a).[14]

3.3.3 California Plumbing Code Standards (Part 5 of Title 24)

The 2013 California Plumbing Code (§401.2) includes efficiency requirements for faucets, urinals and toilets. The California Plumbing Code is based on the Uniform Plumbing Code (UPC), a model code developed by the International Association of Plumbing and Mechanical Officials (IAPMO) using the American National Standards Institute's process for developing voluntary standards. The UPC serves as a model code for a number of states, including states that have plentiful water supplies. However, California's water supply constraints necessitate more aggressive water efficiency measures than are necessary elsewhere in the country. As such, California's mandatory water efficiency standards for newly constructed buildings have been more stringent than the water efficiency standards in the UPC for quite some time.

Proposing more efficient water efficiency standards through CALGreen is a means to vet the more stringent water efficiency standards through a public rulemaking process. Stakeholders engage in the process to establish building standards that result in water savings. For this

[14] For the 2016 version of Title 24, Part 6, the California Energy Commission (CEC) is proposing modifications that would allow compact hot water distribution to be used in conjunction with other measures (i.e., storage water heaters and quality insulation inspection) as an alternative compliance option for the prescriptive water heating requirements (CEC 2015b, Section 150.1(c)8A).

reason, efficiency standards for plumbing fixtures and fittings have appeared in CALGreen (Part 11 of Title 24) and the California Plumbing Code (Part 5 of Title 24) since CALGreen was added to the building code. The requirements in CALGreen and the California Plumbing Code should be—and typically are—consistent, in cases where they address the same product.

The Utility C&S Team recognizes that including efficiency standards for plumbing products that are relevant to both Part 5 and Part 11 of Title 24 will require coordination. For instance, informational notations in Part 5 can indicate plumbing-related water efficiency measures in Part 11, and vice versa. Agencies could also choose to replicate standards in both parts.

3.3.4 California Appliance Efficiency Standards (Title 20)

California's Appliance Efficiency Standards (Title 20) include requirements for faucets, urinals and toilets. On April 8, 2015, the CEC adopted revisions to the Title 20 requirements for these products (CEC 2015d, CEC2015e). The updated efficiency standards, which apply to products sold or offered for sale in California after January 1, 2016, are as follows:

- Lavatory faucets and aerators: maximum flow rate of 1.2 gpm at 60 psi.
- Kitchen faucets and aerators: maximum flow rate of 1.8 gpm with optional temporary flow of 2.2 gpm at 60 psi.
- Public lavatory faucets: maximum flow rate of 0.5 gpm at 60 psi.
- All water closets: maximum effective flush volume of 1.28 gpf and waste extraction performance of 350 grams or higher.
- Wall-mounted urinals: maximum flush volume of 0.125 gpf.
- Other urinals (e.g., floor-mounted urinals): maximum flush volume of 0.5 gpf.

The Utility C&S Team has been participating in CEC's rulemaking to update the Title 20 standards since 2012.[15] The Utility C&S Team recommended that CEC adopt a 1.0 gpm standard for lavatory faucets and faucet accessories, a 0.125 gpf standard for urinals, and a 1.28 gpf standard for toilets which would apply to all products sold in the state, whether the product is being installed in a new building or an existing building (CA IOUs 2013a, 2013b).

The requirements in CALGreen should be updated so they are, at minimum, consistent with newly revised Title 20 standards. However, the Utility C&S Team recommends that HCD go beyond the Title 20 requirements and adopt a mandatory requirement that residential lavatory faucets use no more than 1.0 gpm in new construction and a voluntary requirement that toilets installed in residential buildings use no more than 1.06 gpf and achieve a waste extraction score of 600 grams or higher.

[15] CEC's Appliance Efficiency Rulemakings: http://www.energy.ca.gov/appliances/rulemaking.html.

3.4 Relationship to Existing State Legislation

3.4.1 California Senate Bill 407

In 2009, the California Legislature enacted Senate Bill 407 (California SB 407 2009). This bill requires plumbing fixtures installed in residential and commercial buildings constructed before 1994 to be replaced with water-conserving plumbing fixtures by 2017 (single-family buildings) or 2019 (multi-family and commercial buildings). Toilets, urinals, showerheads, and faucets are the plumbing fixtures subject to SB 407. In practice, this law is difficult to enforce for existing buildings, thus some local jurisdictions are requiring that non-compliant fixtures be replaced when certain building permits are issued. Using this enforcement approach, it is unlikely that the 2017 and 2019 deadlines for fixture replacement will be met. Therefore, it is likely that non-compliant fixtures will continue to be replaced well beyond the 2019 timeframe.

The bill states "'Water-conserving plumbing fixture' means any fixture that is in compliance with current building standards applicable to a newly constructed real property of the same type." Updating the efficiency standards for urinals in CALGreen from 0.5 gpf to 0.125 gpf would presumably have the effect of requiring noncompliant (1.0 gpf) urinals to be replaced with 0.125 gpf urinals as opposed to 0.5 gpf urinals. As noted above however, the practical effect is likely to be limited to projects where building permits are issued for building alterations rather than fixture replacements that do not require building permits.

3.4.2 California Assembly Bill 715

In 2007, the California Legislature enacted Assembly Bill 715 (Laird, 2007), which established modified minimum efficiency standards for toilets and urinals sold or installed in California. By 2014, new toilets must have an effective flush volume of 1.28 gpf or less and new urinals must have an effective flush volume of 0.5 gpf or less. AB715 does not preempt more stringent CALGreen standards.

3.5 Relationship with Model Codes and Standards

A number of government and non-government entities have made substantial progress establishing model building codes and voluntary standards that address water efficiency. Many of these existing codes and standards have been developed through rigorous public vetting processes in which key industry stakeholders participated. In some cases the water efficiency requirements in these existing standards are more robust than the mandatory and voluntary requirements in CALGreen. As such, these existing codes and standards can serve as a model for updates to the CALGreen water efficiency standards. The requirements in the IAPMO Green Plumbing and Mechanical Code Supplement (GPMCS) are particularly noteworthy as the GPMCS serves as the reach code for the UPC, which California uses as the basis of California's Plumbing Code (Part 5 of Title 24). Some of the model building codes and voluntary standards that the report authors evaluated when considering recommended code changes for CALGreen are listed below:

- 2012 Green Plumbing and Mechanical Code Supplement For Use with all Codes (IAPMO GPMCS)

- International Green Construction Code
- Leadership in Energy and Environmental Design (LEED) Building Design and Construction Rating System, Version 4
- WaterSense® Specifications

3.6 Relationship to Existing Local Requirements

In 2009, the City of Los Angeles passed an ordinance that established water efficiency requirements for newly constructed buildings and renovations of existing buildings (City of Los Angeles 2009). The ordinance added Article V to Chapter XII of the City's Municipal Code. The code now requires all urinals installed in new buildings or during retrofits after October 1, 2010, to have a maximum flush volume of 0.125 gpf (City of Los Angeles 2009).

4. Product and Market Description

The Utility C&S Team performed a market analysis with the goals of identifying current technology availability, current product availability, and market trends. The Utility C&S Team considered how the proposed standard would impact the market in general and individual market participants. Estimates of market size and measure applicability were identified through research and outreach with key stakeholders, as explained in Section 7 of this report. Appendix B includes additional information about market size.

4.1 Product Description

4.1.1 Product Description: Lavatory Faucets

Faucets and faucet accessories work together to control the flow of water delivered to the end user. The faucet tap mechanism controls the amount of water entering the faucet from the building's main water supply, whereas the faucet accessory controls the flow rate of water that is discharged from the faucet. Figure 3 illustrates the relationship between the faucet tap mechanism and the faucet accessory for standard lavatory faucets.

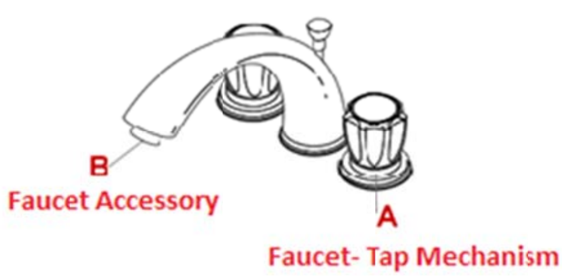

Figure 3: Basic Lavatory Faucet Diagram: A) Faucet Tap Mechanism which controls the main water flow and B) Faucet Accessory for further restriction of water flow

Source: Delta Faucet, 2013.

Faucet accessories are typically the primary flow control mechanisms. There are two categories of faucet accessories: restricting devices and regulating devices. A restricting device regulates flow by physically narrowing the opening through which water exits the faucet. A regulating device, or pressure compensating device, adapts the size of the opening based on fluctuations in water pressure to maintain a constant flow rate. Common faucet accessories include aerators, laminar flow devices, and spray devices – each produces water flows with unique characteristics (see Figure 4). Aerators, laminar flow devices, and spray devices are all available as regulating or pressure compensating.

	**Aerators** — air is added to the water to produce softer feeling water that offers the sensation of a stronger flow.
	**Laminar Flow Devices** — water is forced through a small opening creating a more uniform flow.
	**Spray Devices** — similar to a laminar flow device, water is forced through several small openings creating several parallel water streams providing full coverage of wash area.

Figure 4: Classifications of Faucet Restricting and Regulating Devices

Source: Neoperl 2013

4.1.2 Product Description: Urinals

Urinals are fixtures designed for male users to dispose of liquid waste. Urinals are most commonly found in public buildings, but on occasion they can be found at private residences. The urinal can be flushed by pressurized water that comes directly from the water line or water that comes from a storage tank. Most urinals are wall-mounted, though floor-mounted urinals are also available. Tank-type urinals, which utilize gravity to create water pressure, are less common.

The ceramic portion of a urinal (also referred to as the fixture) and the flushing device (also referred to as the valve) can be sold as separate products, and consumers can combine fixtures and valves from different manufacturers. Some manufacturers sell fixture-valve systems together at a packaged price.

Flushing urinals can flush either manually or automatically. Most major manufacturers offer waterless urinals as well as flushing urinals that use only 0.125 gpf. While this report does not focus on waterless urinals, the emergence of waterless urinals is helping to push the market towards higher-efficiency products.

4.1.3 Product Description: Premium Efficiency Water Closets

For the purpose of this report, premium efficiency water closets achieve an effective flush volume of no more than 1.06 gpf, adhere to the requirements for toilets in ASME A112.19.2-2013 / CSA B45.1-13, and achieve a waste extraction performance rating of 600 grams or higher to ensure customer satisfaction and avoid potential double-flushing.

4.1.4 Measure Description: Compact Hot Water Distribution Design

Domestic hot water (DHW) distribution systems in single family homes are often complicated by layouts that place bathrooms and kitchens far from the water heater. This practice, in turn, leads to unnecessarily long and oversized diameter pipes to connect the water heater and hot water fixtures.

A 2012 CEC study evaluated hot water distribution systems in 97 homes (CEC 2012b). It found that the average 2,000 square foot home built in 2011 held one gallon of water in the pipes between the hot water source and the point of use (consistent with findings from a survey completed in 2006). While the 2012 CEC study was not a comprehensive review of all plumbing systems in existing buildings in California, the results are representative of buildings that have been built in the past decade.

The goal of the compact hot water distribution design measure is to minimize the volume of water entrained within the pipes, between the point of use and the hot water source (usually the water heater, but potentially also a recirculation loop). This design practice has many benefits including: minimizing hot water wait time, minimizing the amount of cold water that is wasted when waiting for hot water to arrive, minimizing energy losses by reducing the surface area available for conductive heat losses, reducing material costs and labor costs, and reducing the number of pipe connections thereby reducing chances of leakages.

Hot water recirculation systems are another option for plumbing systems that reduce wait times and wasted water. These systems can reduce the amount of potable water wasted when waiting for hot water to arrive at the fixture because they reduce the volume of water that must be purged from the pipes before hot water arrives. Recirculation systems have the advantage of providing potential reduction in water waste without requiring modifications to the building's floorplans that minimize the distance between the water heater and the point of use (e.g., shower, faucet). On the other hand, recirculation systems require a pump to circulate water, resulting in additional electricity usage. See additional information about recirculation systems in Section 7.2.7.

4.2 Market Availability

4.2.1 Market Availability: Lavatory Faucets

DOE's Appliance Compliance Certification Database[16] lists accessory and faucet models available for sale in the United States. While the database does not indicate shipments of each product, it does provide a rough approximation of the type of products being sold. The database does not differentiate products based on their aesthetic (i.e., whether the design looks like it belongs in a nonresidential bathroom or a residential bathroom). The same technologies are used for all lavatory faucets whether they look like they belong in a public bathroom or a private bathroom. The DOE database lists the basic model number and unique model numbers. The individual model numbers are often slight variations on the basic model. The Utility C&S Team has provided information on the number of basic models and the number of unique models. Table 4 presents a summary of the number of accessories and faucet models in DOE's database by rated flow rate. Overall, the data show that the proposed standards are technically feasible and many manufacturers are already offering products for sale in the California market that would qualify under the proposed new CALGreen standards.

Lavatory Faucets Accessories (Aerators)

Faucet flow rate is adjusted with the faucet accessory (e.g., aerator, laminar flow device, etc.). Since flow rate is dictated by the accessory, the ability to meet the 1.0 gpm faucet standard is dependent on the availability of 1.0 gpm accessories. Faucet accessories that meet the proposed efficiency level of 1.0 gpm are available from a number of manufacturers. The products listed in the DOE database are available for sale as stand-alone products. There are additional products available to faucet manufacturers for use in faucet assemblies. There are 145 basic models in the DOE database – 63 (43 percent) of which have a flowrate of 1.0 gpm or less. There are 294 unique models, 153 (52 percent) of which have a flowrate of 1.0 gpm or less. The fact that there are over 50 percent of the lavatory faucet accessories available for purchase today would meet the proposed 1.0 gpm standard indicates that compliant products are readily available.

Lavatory Faucets

There are 1,957 Basic Models in the DOE database – 217 (14 percent) of which have a flowrate of 1.0 gpm or less (see Table 4). There are also 5,546 Unique Models, 1,224 (22 percent) of which have a flowrate of 1.0 gpm or less. The fact that there are over 1,000 lavatory faucets available for purchase today that would meet the proposed 1.0 gpm standards indicates that compliant products are readily available. There are 55 major brands that have products listed in DOE's database, 13 of which offer 1.0 gpm faucets today. Many of these brands use the same manufactures and identical parts. For example, Globe Union has eight of their own brands and manufacturers products for at least a dozen additional brands such as Toto, Delta Faucet Co., Ferguson Enterprises, Ikea, Lowes, etc. Similarly, NEOPERL flow restriction devices (aerators) can be found in a vast majority of faucets available on the market.

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[16] DOE's Appliance Compliance Certification Database is accessible here: http://www.regulations.doe.gov/certification-data/CCMS-41431717377.html.

Since many brands are sourcing parts and manufacturing services from the same companies, the industry is well positioned to increase supply of 1.0 gpm faucets, particularly because manufacturing a 1.0 gpm faucet does not require any changes to the manufacturing process.

Table 4: Summary of Lavatory Accessories and Faucets in DOE Database

Source: DOE Compliance Certification Database. Accessed March 19, 2015. Statewide Utility Codes and Standards Team Analysis

Accessory or Faucet	Basic Models			Unique Models		
	Number of Models that Use 2.2 gpm* or less	Number of Models that Use 1.5 gpm or less	Number of Models that Use 1.0 gpm or less	Number of Models that Use 2.2 gpm or less	Number of Models that Use 1.5 gpm or less	Number of Models that Use 1.0 gpm or less
Lavatory Faucet Accessories						
Models	1957	1505	217	5546	3810	1224
Percent of Total	100%	77%	11%	100%	69%	22%
Lavatory Faucets						
Models	145	115	63	294	247	153
Percent of Total	100%	79%	43%	100%	84%	52%

*gpm = gallons per minute

4.2.2 Market Availability: Urinals

As of November 22, 2014, there were 84 flushing urinal fixtures (ceramic bowls) that met WaterSense® requirements and were rated at 0.125 gpf. These pint flush urinal fixtures were available from 12 of the 19 brands that have products that comply with the WaterSense® standard. There were 46 urinal valves (flush devices) that were rated at 0.125 gpf. In addition, 8 of the 9 brands that have valves that meet the WaterSense® specification also provide 0.125 gpf valves. The quantity and variety of high-efficiency urinals available for sale is an indication that qualifying products are readily available in California (WaterSense 2014b).

4.2.3 Market Availability: Premium Efficiency Water Closets

As of November 22, 2014 there were 126 water closet models from 26 brands that were compliant with Maximum Performance (MaP) Premium requirements. MaP Premium water closet models must achieve an effective flush volume of 1.06 gpf, have a MaP solid waste extraction rating of 600 grams or higher, and meet the WaterSense® performance requirements (MaP 2014). The water efficiency and toilet performance requirements for MaP premium are the same as the proposed requirements for the voluntary toilet requirement for CALGreen. This data indicates that over 100 water closets that meet the proposed voluntary standard exist and are readily available today.

4.2.4 Market Availability: Compact Hot Water Distribution Design

Compact hot water distribution designs are technically feasible and cost effective, though they have not been commonly used by the building industry. The building industry, like the California Building Industry Association (CBIA), has expressed interest in learning more about compact distribution design in part because customers desire shorter hot water wait times. It will take some time for the market to fully understand the design principles. The Utility C&S

Team is recommending a voluntary standard to help encourage compact design. There may be opportunities for utilities or others to use the voluntary standard as an impetus to provide builders with education and financial incentives to pursue compact designs, thereby increasing the prevalence of compact design using market-driven approaches.

4.3 Market Structure

4.3.1 Market Structure: Faucets, Urinals and Toilets

Faucets, urinals, and toilets are distributed through four primary outlets:

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

Manufacturers sell directly to entities that can purchase a large volume of products such as homebuilders, commercial builders, or water utilities. Distributors have a limited (or non-existent) role in direct manufacturer to installer sales, so the distributor mark-ups are minimal or eliminated completely. The price of units sold through direct sales can be 20 to 50 percent lower than typical retail prices (D&R International 2005).

Retail sales are common for do-it-yourself remodels. Large retailers such as Lowes, Home Depot, and Sears process a majority of the retail sales. These large retailers have a significant influence on which products reach the mainstream retail market. Retailers cannot stock a wide variety of models due, in part, to limited shelf space. The models that are stocked have a distinct advantage over models that are not stocked. Typically, water efficiency is not the primary factor retailers consider when making decisions about which products to carry. Retailers tend to stock products that they have offered previously and products that have sold well in the past. It can be difficult to insert new products into retail spaces and educate consumers about the value of an efficient product in the absence of standards.

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

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

Overall, water efficiency is increasingly important for the building industry and for building owners and occupants. It is becoming more common for water efficient plumbing fixtures and fittings to be installed in new construction and building retrofits.

4.3.2 Market Structure: Compact Hot Water Distribution Design

The compact hot water distribution design does not change the existing market structure for the supply of pipes or pipe insulation. It may lead to increased training among building designers and builders and thus greater availability of expertise in the marketplace regarding compact hot water distribution design.

4.4 User Satisfaction

4.4.1 User Satisfaction: Lavatory Faucets

Three studies conducted by Aquacraft, Inc. Water Engineering Management suggest that users are satisfied with products that meet the proposed efficiency standard (Aquacraft 2000, Aquacraft 2003, Aquacraft 2004). In Tampa, Florida, 1.0 gpm faucets were installed, and 89 percent of study participants felt the high-efficiency faucets performed the same or better than their old fixtures. Based on this evidence that users are satisfied with faucets that consume less water, the Utility C&S Team does not expecting dissent from consumers regarding an updated California standard.

Minimum Flow Rate of Low Flow Faucets

To help maintain high satisfaction with low flow faucets, the WaterSense® Specification for High-Efficiency Lavatory Faucet requires faucets to achieve a least 0.8 gpm at 20 psi (WaterSense 2007a). Although water pressure is higher than 20 psi in most buildings, this safeguard is in place to guarantee that users will be satisfied with the flow delivered by WaterSense® labeled faucets even if a building's water pressure is low (WaterSense 2007c). The existing CALGreen requirement for residential lavatory faucets includes minimum flow rate requirements for faucets.

The Utility C&S Team agrees with WaterSense® that a faucet's utility should be maintained as water efficiency improves. However, establishing a minimum flow rate requirement can have the unintended consequence of preventing people that want to install faucets that are more efficient than the minimum required by code from doing so. For example, lavatory faucets that are designed to use no more than 0.5 gpm at 60 psi are readily available. Many of the 0.5 gpm faucets use pressure compensating accessories (PCA) that effectively maintain the flow rate near 0.5 gpm even as pressure drops to 20 psi. If a homeowner wanted to install a 0.5 gpm faucet in their newly constructed home today, they would be in violation of the minimum flow rate requirement in CALGreen that states faucets must achieve a minimum flow rate of 0.8 gpm at 20 psi.

The Utility C&S Team recommends that HCD remove the minimum flow rate requirements for residential lavatory faucets to allow even lower flow products to be sold considering the urgency for responding to the extreme drought conditions. The removal of the minimum flow rate for residential lavatory faucets also aligns with the current CALGreen requirements for kitchen faucets, lavatory faucets in common and public use areas of residential buildings, and nonresidential lavatory faucets, as these products have no minimum flow rate requirement. CEC did not adopt a minimum flow rate requirement for the Title 20 Standards that were updated in April 2015. Another option is to establish a minimum flow rate requirement that is relative to the maximum flow rate requirement. The Utility C&S Team does not prefer this option as it adds complexity to the code, and since manufacturers are already offering products that meet user satisfaction expectations (e.g., by using PCAs that maintain flow rate across the likely range of water pressures in typical homes), the adding a complicated code requirement may not result in significant benefits to the customer.

4.4.2 User Satisfaction: Urinals

Low flow 0.125 gpf urinals, or “pint urinals,” have now been installed and provided satisfactory service at many locations for a period of several years, including all new construction in the City of Los Angeles, the University of Washington, the Seattle Public Utilities District, and California state government facilities. For instance, in 2009 the City of Los Angeles passed an ordinance that established water efficiency requirements for newly constructed buildings and renovations of existing buildings. The ordinance added Article V to Chapter XII of the City’s Municipal Code. Among other provisions, the code requires that the maximum flush volume for urinals installed after October 1, 2010 not exceed 0.125 gpf (City of Los Angeles 2009). LADWP and the City of Los Angeles have confirmed to the Utility C&S Team in personal communications that there have been no issues related to user satisfaction with the 0.125 gpf urinal standard.

In 2010, the Seattle Public Utilities Commission interviewed facility managers in buildings with high efficiency toilets and urinals to assess their experience with these high-performance fixtures. They found that maintenance requirements for 0.125 urinals were minimal and drainline clogging was not a significant problem (SPUC 2010).

4.4.3 User Satisfaction: Premium Efficiency Water Closets

In the early 1990s, several models of high-efficiency toilets did not perform as well as consumers had hoped. These poorly performing models marred public perception of high-efficiency toilets. Driven by the desire to provide products that meet performance expectations while achieving superior water efficiency, industry collaborated to develop a number of tests that measure toilet performance. The 2013 version of American Society of Mechanical Engineers (ASME) / Canadian Standards Association (CSA) Standard for Ceramic Plumbing Fixtures (ASME A112.19.2-2013 / CSA B45.1-13) includes a variety of tests to measure a toilet’s performance, including ability to evacuate waste of a range of densities, ability to wash the bowl, how waste travel in the drainline, leakage, etc. These tests are designed to help ensure user satisfaction.

The proposed requirement would require toilets to meet the minimum requirements of ASME A112.19.2-2013 and achieve a waste extraction performance rating of 600 grams, which is 250 grams higher than the minimum required by the ASME standard. The Utility C&S Team has documented the benefits of establishing a more stringent waste extraction performance rating in comments that were submitted to CEC’s pre-rulemaking docket for the proposed revisions to the Title 20 requirements (CA IOUs 2014). A more stringent waste extraction performance could lead to higher consumer satisfaction, particularly for the estimated 20 percent of males that have bowel movements that exceed 350 grams on a regular basis. If a toilet cannot clear the contents of the bowl in one flush, the user will flush the toilet again, which results in consumer dissatisfaction and wasted water.

It is estimated that nearly 1 percent of all solid waste events that occur statewide exceed 350 grams. One might contend that exceeding the 350 gram threshold less than 1 percent of the time is acceptable. However, Californians initiate about 14 billion solid waste flushes per year, which means Californians are flushing more than 350 grams more than 140 million times per year. If all toilets just met the minimum performance standard of 350 grams, toilets would be double-flushed 140 million times per year, resulting in 179 million gallons of wasted water. Fortunately, many toilets currently available on the market exceed the minimum performance threshold. In fact, 91 percent of the toilets in the MaP database, as of December 2013, met or exceeded 600 grams.

Finally, the Utility C&S Team recommends that tank-type toilets meet the appropriate requirements as specified in the WaterSense® Specification for Tank-Type Toilets – Version 1.2. Several stakeholders have argued that the toilet performance standard should be based on the WaterSense® Specification, which requires tank-type toilets to meet all of the performance requirements included in ASME A112.19.2-2013. The Utility C&S Team supports requiring tank-type toilets to meet the relevant performance requirements in the WaterSense Specification.

4.4.4 User Satisfaction: Compact Hot Water Distribution Design

Compact hot water distribution design has a number of benefits including minimizing hot water wait times and reducing initial construction costs by reducing. Building owners and occupants as well as builders are likely to be satisfied by the cost and functional benefits that compact design offers. On the other hand, compact design can impact the location of water fixtures and, therefore, building layouts. The Utility C&S Team believes that limitations of building layouts will be addressed as builders gain experience with the design practices.

For example, builders could explore opportunities to use recirculation systems to bring "hot enough" water closer to fixture outlets while still allowing for building layouts where the water heater is relatively far from the most distant outlets. Recirculation systems do have energy penalties because pumps are required to circulate water. However, Part 6 of Title 24 already includes requirements that aim to minimize the energy use from recirculation systems. Specifically, all pipes in recirculation systems must be insulated, regardless of pipe diameter (Section 150.0(j)2Aiv). If a builder chooses to comply with the Part 6 standards using the prescriptive approach, only Demand Recirculation Systems with manual control pumps are allowed in recirculation systems serving individual dwelling units (Section 150.1(c)(8)). Demand Recirculation Systems only circulate hot water when there is a demand for hot water at an outlet. When the Demand Recirculation Systems are controlled manually, the user provides feedback to the system to initiate the circulation of water so water is only circulated when it is needed.

4.5 Useful Life and Maintenance

4.5.1 Useful Life and Maintenance: Faucets

The design life of a residential faucet accessory – which is typically the primary flow control device as noted earlier – is 10 years. The faucet itself has a longer life – the design life of lavatory faucets are 20+ years, respectively – and the Utility C&S Team assumed that the faucet accessory may be replaced before the faucet is replaced (NAHB 2007). Additionally, Niagara Conservation®, one manufacturer of high efficiency water products, includes a 10 year limited warranty for aerators obtained through wholesale, municipalities, utilities, or other commercial channels (Niagara Conservation 2013). This warranty further supports the use of an assumed 10-year design life for faucet accessories.

4.5.2 Useful Life: Urinals and Toilets

The analysis presented in this report assumes that residential toilets have a lifetime of 25 years and urinals have a lifetime of 12 years. These lifetime estimates may be conservative, as there is evidence that toilets and urinals often last for significantly longer. For example, in 2011, Aquacraft, Inc. Water Engineering and Management published a study of water use trends in California single-family homes. The study found that 24 percent of all registered toilet flushes consumed 3.5 gallons or more. This data indicates that many toilets installed in California during the study period (2005-2010) were rated at 3.5 gpf or more. Considering the 1.6 gpf minimum efficiency standard took effect in 1978 and all toilets sold after that time had to be rated at 1.6 gpf or less, these 3.5 gpf toilets that were identified in the 2005-2010 time period (27 to 32 years after the 1.6 gpf standard took effect) were well over 25 years old (Aquacraft 2011).

D&R International developed a report for the U.S. EPA in 2005 that assumes a replacement rate of 8 percent for urinals. This corresponds to a product lifetime 12.5 years, respectively. Findings from the D&R International report were used in support of WaterSense® specifications for urinals (D&R International 2005).

4.5.3 Useful Life: Compact Distribution Design

Compact hot water distribution systems are expected to last as long as “standard” distribution systems. Plumbing systems within buildings are rarely, if ever, replaced. Design choices will impact the performance of the building for decades.

5. COST BENEFIT ANALYSIS

5.1 Cost and Benefits Methodology

5.1.1 Per Unit Incremental Cost Methodology

Faucets, Urinals and Toilets

The cost estimates for the proposed standards for faucets, urinals and toilets were derived primarily from online retailers and interviews with builders, contractors, manufacturers, and residential energy efficiency program implementers. Unless otherwise noted, cost estimates do not include the impact of rebates or other incentives. There are no increased maintenance costs expected from the proposed code changes.

Compact Hot Water Design

The methodology used to estimate costs from compact hot water distribution design are presented in the Single Family Water Heating Distribution System Improvements CASE Report that the California IOUs developed for the 2013 code change cycle for Title 24, Part 6 (CA IOUs 2012).

5.1.2 Per Unit Energy and Water Savings Methodology

Cost savings will be realized through lower water, electricity, and gas bills. Electricity and gas savings are due to a reduction in the amount of energy required to heat water for faucets and hot water distribution systems. To calculate the per unit lifecycle cost savings, the Utility C&S Team used the electricity, natural gas, and water rates presented in Appendix C to calculate the monetary value of avoided expenditures on water and energy. The cost savings associated with avoided embedded energy were not included in the cost savings analysis.

Faucets, Urinals and Toilets

The Utility C&S Team calculated annual water and energy savings per unit (faucet, urinal, or toilet) by determining the difference in water and energy use between the base case and the standards case scenarios. For the base case scenario, the Utility C&S Team used the efficiency of a product that meets the minimum efficiency requirements in 2013 CALGreen. For the standards case scenario, the Utility C&S Team used the proposed efficiency levels. The key assumptions used in the per unit water and energy impacts analysis are presented in Appendix B. Appendix B also details the calculation methods for each product and estimates of how many products will be installed in newly constructed buildings for a given year.

Compact Hot Water Design

Additional details on the methodology used to estimate water and energy savings of compact hot water distribution design are presented in the Single Family Water Heating Distribution System Improvements CASE Report. The CA IOUs developed for the 2013 code change cycle for the Building Energy Efficiency Standards (CA IOUs 2012).

5.1.3 Per Unit Lifecycle Cost Savings Methodology

The lifecycle cost analysis presents the costs and savings of the measure over a product's lifetime. The lifecycle Benefit to Cost (B/C) ratio is a key metric used to measure cost effectiveness. The B/C ratio is calculated by dividing the total present value cost savings (the benefit) by the present value of the total incremental cost (the cost). If the B/C ratio is 1.0 or greater (i.e., the present valued benefits are greater than the present valued costs), then the measure is cost effective. The measures presented in this report will provide savings to ratepayer greater than costs and all proposed measures are cost effective.

Cost savings will be realized through lower consumer water, electricity, and gas bills. Consumer electricity and gas savings are due to a reduction in the amount of energy required to heat water for faucets. The analysis assumes that there are no cost savings to the end user associated with embedded energy savings.

To calculate the per unit lifecycle cost savings for faucets, urinals, and toilets, the Utility C&S Team used the electricity, natural gas, and water rates (presented in Appendix C). The methodology and assumptions used to calculate per unit cost saving for compact hot water distribution design are presented in the CASE Report that the CA IOUs developed for the Building Energy Efficiency Standards 2013 code change cycle (CA IOUs 2012).

5.1.4 Statewide Energy and Water Savings Methodology

Statewide savings estimates were calculated by multiplying the per unit savings by estimates of the number of products that are projected to be installed in newly constructed buildings during the first year the standard is in effect (2017). This report also presents the annual water and energy savings for the year in which products installed in 2017 will come to the end of their lifecycle. At that point, new product deployments that are regulated by the standards will roughly equal existing product replacements and thus this level of savings will continue indefinitely (and potentially increase, due to market growth and the potential for consumers to replace retired products with products that have equal savings). Since a building's plumbing system will last for the entire lifespan of the building, the life of compact hot water distribution design is the same as the life of the building. Although savings from compact design will persist for much longer than 30 years, this report accounts for the savings for the first 30 years.

The Utility C&S Team did not count water or energy savings from buildings that are anticipated to install products that comply with the proposed efficiency levels under a baseline or "business as usual" case (i.e. regardless of whether the proposed standards are adopted). For mandatory measures, 100 percent compliance with the standards was assumed. The Utility C&S Team assumed that 1 percent of the newly constructed buildings statewide would comply with the voluntary requirement in the baseline condition and that 15 percent would comply if the proposed standards are adopted. This value represents the percent of jurisdictions that have reported adopting CALGreen water efficiency measures in the prior code cycle (based on a review of local codes for agencies that filed CALGreen amendments with BSC).[17]

5.2 Per Unit Incremental Cost

5.2.1 Per Unit Incremental Cost: Lavatory Faucets

There is very little price difference between higher and lower efficiency faucets and faucet accessories. There is no cost difference between non-qualifying (1.5 gpm) and qualifying faucet accessories (1.0 gpm) from wholesale accessory manufacturers. Basic faucet accessories cost about $1-2 dollars wholesale, and the most expensive accessories are less than $10 wholesale. It can be assumed that a 1.0 gpm faucet can cost the same as a 1.5 gpm faucet. Some manufacturers might choose to transition from using a non-PCA 1.5 gpm to a 1.0 gpm PCA (to increase flow rates at lower water pressure), which could add several dollars to the total faucet cost. While manufacturers could comply with the standard using a faucet accessory that has no cost premium relative to a base case accessory, the cost effectiveness analysis presented in this report conservatively assumes that the incremental cost of the proposed standard is $5 per unit to upgrade to a PCA. As presented in Section 5.3.1, the proposed lavatory faucet standard is very cost effective even with this conservative assumption.

5.2.2 Per Unit Incremental Cost: Urinal

The Utility C&S Team evaluated the cost of urinal fixtures (bowls) and valves (flush mechanisms) rated between 0.125 gpf (waterless) and 0.5 gpf that were available on the market

[17] The list of cities identified by BSC as customizing building codes and identified by Utility C&S Team as adopting water measures include: Daily City, Irwindale, Los Angeles, Mountain View, Napa, Palo Alto, Pomona, San Francisco, and Santa Rosa with a total of 15 percent of the state population. While not every city has adopted all CALGreen water measures, it was assumed that the 15 percent estimate is conservative due to the drought emergency.

in 2013. Results of this analysis are presented in Figure 5. The average cost of 0.5 gpf fixtures, valves, and fixture-valve systems was $277, $614, and $884 respectively. The average cost of 0.125 gpf fixtures, valves, and fixture-valve systems was $353, $648, and $786, respectively. This analysis suggests that there is an overall price premium of $76 and $34 for 0.125 gpf fixtures and valves, respectively, relative to 0.5 gpf alternatives. This represents a premium of about 12 percent. However, some manufacturers like American Standard offer 0.125 gpf and 0.5 gpf fixture-valve urinal systems with similar features for the same price. These fixture-valve systems come with the fixture and the valve packaged and sold together. In fact, research that the Utility C&S Team conducted in 2013 showed that the average cost of 0.125 gpf fixture-valve systems was $98 less than the average cost of 0.5 gpf fixture-valve systems. For example, the American Standard Washbrook Urinals System with Selectronic Flush Valve is available in a 0.125 gpf, 0.5 gpf, or 1.0 gpf configuration; all three packages retail for $938 (model numbers are: 6590.525, 6590.505, and 6501.61). This information provides evidence that 0.125 gpf urinal combinations can be purchased at no cost premium (CA IOUs 2013a), and possibly even lower cost than a 0.5 gpf fixture.

a) b) c)

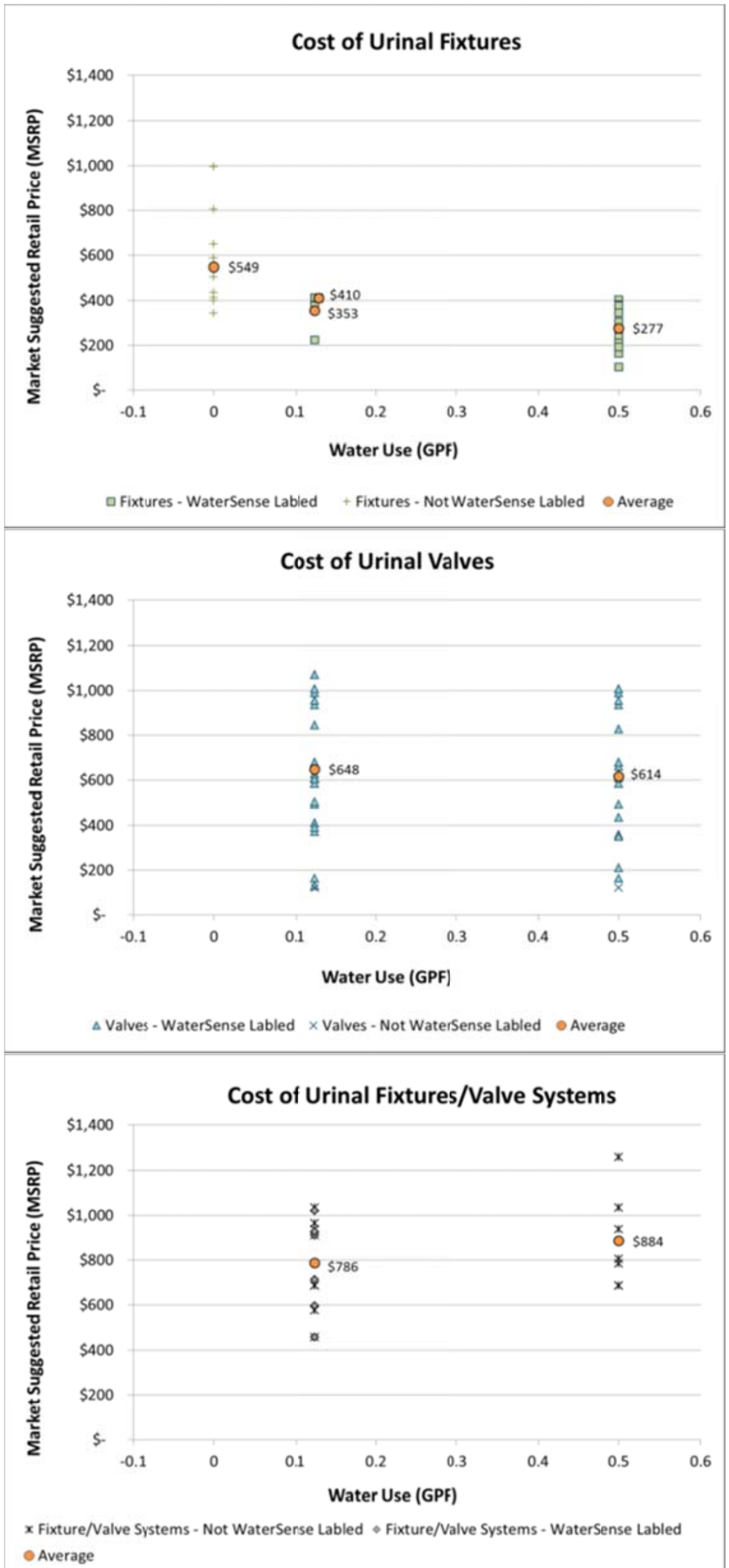

Figure 5: Cost of zero to 0.5 gpf Urinal Fixtures (a), Valves (b), and Fixture/Valve Systems (c)

Source: Utility C&S Team Analysis 2013

5.2.3 Per Unit Incremental Cost: Premium Efficiency Water Closets

While standard efficiency toilets are often available for less than $100 at stores like Home Depot, a wide range of pricing exists and high-end/designer toilets (standard efficiency) can exceed $500 or more. Toilets that meet the requirements of MaP Premium (maximum effective flush volume of 1.06 gpf and waste extraction performance of 600 grams or higher) are usually offered in the range of $300-$500. They are harder to find at lower prices, though we have identified one MaP Premium Efficiency toilet (Niagara Stealth) selling in the $120 - $150 range, suggesting that the incremental measure cost for premium efficiency toilets does not necessarily have to be large (~$20-50).

5.2.4 Per Unit Incremental Cost: Compact Hot Water Distribution Design

When the Utility C&S Team evaluated the water and energy savings of compact hot water distribution design for consideration for the 2013 Title 24, Part 6 Standards, the Utility C&S Team found compact distribution design would have an incremental cost of $390. These cost estimates include: adding 30 feet of gas line piping (water heater relocation), adding 15 feet of water heater vent pipe, and reducing polyethylene (PEX) piping length (varies by plan from 21' to 158') (CA IOUs 2012).

5.3 Per Unit Water and Energy Savings

5.3.1 Per Unit Water and Energy Savings: Lavatory Faucets

Per unit annual water and energy use of the baseline faucet that is rated at 1.5 gpm and a faucet that meets the proposed standard are presented Table 5. The table also shows the annual savings per unit at 1.0 gpm. Each 1.0 gpm faucet will result in annual savings of 397 gallons of water, which is associated with an embedded electricity savings of 3.9 kWh. If the building has natural gas water heating (~90 percent of buildings have water heating natural gas water heating), the proposed standard will result in an annual savings of 1.6 therms from the reduced water heating load. If the building has electric water heating, the 1.0 gpm faucet standard will result in an annual savings of 29 kWh.

See Appendix B for the assumptions and methodology used to calculate per unit and statewide energy and water savings estimates.

Table 5: Per Unit Energy Water Use and Savings: Lavatory Faucets

Product Class	Water (gallons/yr)	Natural Gas from Water Heating (therms/yr)	Electricity from Water Heating (kWh/yr)	Embedded Electricity Consumption (kWh/yr)
Baseline (1.5 gpm)	1,767	7.2	130	17.7
Standard Case (1.0 gpm)	1,370	5.6	101	13.8
Per Unit Savings	**397**	**1.6**	**29**	**3.9**

5.3.2 Per Unit Water and Energy Impacts: Urinals

Per unit annual water and energy use of the baseline urinal that uses 0.5 gpf and a urinal that meets the proposed standard are presented Table 6. The table also shows the annual savings per unit. Each urinal will result in an annual savings of 1,755 gallons of water, which is associated with an embedded electricity savings of 17.6 kWh.

See Appendix B for the assumptions and methodology used to calculate per unit and statewide energy and water savings estimates.

Table 6: Per Unit Energy Water Use and Savings: Urinals

Product Class	Water (gallons/yr)	Embedded Electricity Consumption (kWh/yr)
Baseline (0.5 gpf)	2,340	23.5
Standard Case (0.125 gpf)	585	5.9
Per Unit Savings	**1,755**	**17.6**

5.3.3 Per Unit Water and Energy Savings: Premium Efficiency Water Closets

Per unit annual water and energy use of the baseline water closet that uses 1.28 gpf and a water closet that meets the proposed standard are presented Table 7. The table also shows the annual savings per unit. Each toilet will result in an annual savings of 593 gallons of water, which is associated with an embedded electricity savings of 6 kWh.

See Appendix B for the assumptions and methodology used to calculate per unit and statewide energy and water savings estimates.

Table 7: Per Unit Energy Water Use and Savings: Premium Efficiency Water Closet

Product Class	Water (gallons/yr)	Embedded Electricity Consumption (kWh/yr)
Baseline (1.28 gpf)	3,450	34.7
Standard Case (1.06 gpf)	2,857	28.7
Per Unit Savings	**593**	**6.0**

5.3.4 Per Unit Water and Energy Savings: Compact Hot Water Distribution Design

The Utility C&S Team found that compact hot water distribution design would result in an annual savings of 2,550 gallons and 24.2 therms per single family home, considering only homes with natural gas heating (CA IOUs 2012).

5.4 Per Unit Lifecycle Cost Savings and Benefit/Cost Ratio

5.4.1 Per Unit Lifecycle Cost Impact: Lavatory Faucets

Table 8 presents the incremental costs and lifecycle (10-year) cost savings of the proposed faucet standard on a per unit basis. The water cost savings over the 10-year period of analysis was estimated to be $32. The cost savings to heat water over the 10-year period was $52 for buildings with an electric water heater and $15 for buildings with a natural gas water heater.

Overall, if the faucet is installed in a building with electric water heating, the net cost benefit would be $79 and the B/C ratio would be greater than 16. If the faucet is installed in a building with natural gas water heating, the net cost benefit would be $42 and the B/C ratio would be greater than 9. While there is some variation in the measure cost, such as costs associated with upgrading from a non-PCA to PCA, this analysis uses a conservative assumption regarding cost and the potential for variability is small compared to the much larger cost savings.

Table 8: Per Unit Lifecycle Cost Savings and Benefit/Cost Ratio: Lavatory Faucets

Electric Water Heating		**Natural Gas Water Heating**	
Cost		**Cost**	
Incremental Cost	$5	Incremental Cost	$5
Maintenance Cost	$0	Maintenance Cost	$0
TOTAL COST	$5	TOTAL COST	$5
Benefit		**Benefit**	
Water Cost Savings	$32	Water Cost Savings	$32
Electricity Cost Savings	$52	Natural Gas Cost Savings	$15
TOTAL BENEFIT	$84	TOTAL BENEFIT	$47
Net Lifecycle Cost Savings	**$79**	**Net Lifecycle Cost Savings**	**$42**
Benefit / Cost Ratio	**16.8**	**Benefit / Cost Ratio**	**9.4**

5.4.2 Per Unit Lifecycle Cost Impact: Urinals

Table 9 presents the incremental costs and lifecycle (12-year) cost savings of the proposed urinal standard. The analysis was completed on a per urinal basis. It was assumed that the measure does not have any incremental costs. Using the methodology presented in Section 5.1.3, the Utility C&S Team estimated that the water cost savings over the 12-year period of analysis would be $156. The net cost benefit would be $156 and the B/C ratio is not applicable because there are no costs and therefore the measure is clearly cost-effective.

Table 9: Per Unit Lifecycle Cost Savings and Benefit/Cost Ratio: Urinals

Lifecycle Cost	Lifecycle Benefit	Net Lifecycle Cost Savings	Benefit / Cost Ratio
$0	$156	$156	No costs

5.4.3 Per Unit Lifecycle Cost Impact: Premium Efficiency Water Closets

Table 10 presents the incremental costs and lifecycle (25-year) cost savings of the proposed toilet standard. The analysis was completed on a per toilet basis. It was assumed that the incremental cost would be $50 per toilet. As discussed in Section 5.2.3, toilets that meet the proposed efficiency level are often found at higher prices; however, there are examples where premium efficiency toilets are available with incremental costs of $20-$50. The lifecycle cost analysis presented below represents the cost savings using the incremental cost of $50. The water cost savings over the 25-year period of analysis was estimated to be $81. There are no cost savings associated with heating water. The net cost benefit would be $31 and the B/C ratio would be 1.6.

Table 10: Per Unit Lifecycle Cost Savings and Benefit/Cost Ratio: Premium Efficiency Water Closets

Lifecycle Cost	Lifecycle Benefit	Net Lifecycle Cost Savings	Benefit / Cost Ratio
$50	$81	$31	1.6

5.4.4 Per Unit Lifecycle Cost Impact: Compact Hot Water Distribution Design

Table 11 presents the incremental costs and lifecycle (30-year) cost savings of the proposed compact design standard. The analysis was completed on a per house basis. When the C&S Team evaluated the cost effectiveness of compact hot water distribution design for consideration for the 2013 California Building Energy Efficiency Standards, the C&S Team found that compact hot water distribution would result in a lifecycle cost savings in the range of $111 to $643, depending on the size and design of the home. It was estimated that the average cost for homes throughout the state was $318 (CA IOUs 2012). The average cost savings over the 30-year period of analysis was $670. The net cost benefit would be $352 and the B/C ratio would be 2.1.

Table 11: Per Unit Lifecycle Cost Savings and Benefit/Cost Ratio: Compact Hot Water Distribution Design

Lifecycle Cost	Lifecycle Benefit	Net Lifecycle Cost Savings	Benefit / Cost Ratio
$318	$670	$352	2.1

5.5 Statewide Water and Energy Savings

5.5.1 Statewide Water and Energy Savings: Lavatory Faucets

During the first year the proposed lavatory faucet efficiency standard is in effect, it would result in an estimated annual statewide water savings of 119 million gallons. After the standard is in effect for 10 years, the cumulative water savings from all faucets installed in new construction since the effective date would be 1.29 billion gallons (3,940 acre feet), which has an associated embedded electricity savings of 12.9 GWh (see Table 12 and Table 13).

Table 12: First Year (2017) Statewide Annual Water and Energy Impacts: Lavatory Faucets

	Water (Million Gallons/yr)	Natural Gas from Water Heating (Million Therms/yr)	Electricity from Water Heating (MWh/yr)	Embedded Electricity (MWh/yr)
Baseline (1.5 gpm)	551	1.8	2,876	5,533
Standard (1.0 gpm)	432	1.4	2,253	4,335
Statewide Savings	**119**	**0.4**	**623**	**1,199**

Table 13: Full Deployment (2026) Statewide Annual Water and Energy Impacts: Lavatory Faucets

	Water (Million Gallons/yr)	Natural Gas from Water Heating (Million Therms/yr)	Electricity from Water Heating (MWh/yr)	Embedded Electricity (MWh/yr)
Baseline (1.5 gpm)	5,930	19.7	30,957	59,568
Standard (1.0 gpm)	4,646	15.4	24,252	46,665
Statewide Savings	**1,285**	**4.3**	**6,706**	**12,903**

5.5.2 Statewide Water and Energy Impacts: Urinals

The statewide water and energy impacts of the proposed urinal efficiency standard are presented in Table 14. During the first year the proposed urinal efficiency standard would be in effect, it would result in an annual water savings of 9.3 million gallons. After full deployment in 12 years, the annual water savings from the entire stock of urinals will be 116 million gallons per year, which has an associated embedded electricity savings of 1.16 GWh/yr.

Table 14: Statewide Annual Water and Energy Impacts: Urinals

	First Year Only (2017)		After Full Deployment (2028)	
	Water (Million Gallons/yr)	Embedded Electricity (MWh/yr)	Water (Million Gallons/yr)	Embedded Electricity (MWh/yr)
Baseline (0.5 gpf)	14.1	141	175	1,761
Standard (0.125 gpf)	4.8	48	59	597
Statewide Savings	9.3	93	116	1,164

5.5.3 Statewide Water and Energy Savings: Premium Efficiency Water Closets

The statewide water and energy impacts of the proposed toilet efficiency standard are presented in Table 15. During the first year, the proposed voluntary standard would result in an estimated annual water savings of 24 million gallons. After full deployment in 25 years, the annual water savings from the entire stock of toilets would be 731 million gallons per year, which has an associated embedded electricity savings of 7.34 GWh/yr.

Table 15: Statewide Annual Water and Energy Impacts: Premium Efficiency Water Closets

	First Year Only (2017)		After Full Deployment (2041)	
	Water (Million Gallons/yr)	Embedded Electricity (MWh/yr)	Water (Million Gallons/yr)	Embedded Electricity (MWh/yr)
Baseline (1.28 gpf)	995	9,997	30,331	304,675
Standard (1.06 gpf)	971	9,756	29,600	297,331
Statewide Savings	24	241	731	7,344

5.5.4 Statewide Water and Energy Savings: Compact Hot Water Distribution Design

The statewide water and energy impacts of the proposed compact hot water distribution design standard are presented Table 16. During the first year, the proposed voluntary standard would result in an estimated annual water savings of 39 million gallons. After full deployment in 30 years, the annual water savings from the entire building stock that was built since the standard took effect would be 1,199 million gallons per year, which has an associated embedded electricity savings of 12.0 GWh/yr.

Table 16: Statewide Annual Water and Energy Savings: Compact Hot Water Distribution Design

	Water Savings (Million Gallons/yr)	Natural Gas Savings from Water Heating (Million Therms/yr)	Electricity Savings from Water Heating (MWh/yr)	Embedded Electricity Savings (MWh/yr)
Statewide Savings First Year (2017)	39	0.3	Was not calculated	390
Statewide Savings Full Deployment (2041)	1,199	9.3	Was not calculated	12,045

5.6 Other Environmental Benefits

Water efficiency standards have a number of important environmental benefits in addition to water and energy savings and contributing to the state's drought response (see Section 2.3). These benefits include water quality, air quality, and greenhouse gas reduction benefits as described below.

5.6.1 Water Supply and Water Quality Benefits

Improving water efficiency reduces demand; helps maintain higher water levels in lakes, rivers and streams; and improves water quality, protecting human health and the environment (WaterSense 2013). As the ongoing drought diminishes surface water flows throughout California, the survival of many fish and wildlife species that are reliant on these natural water sources may be at risk. Threatened and endangered species are most at risk; some endangered fish species rely on adequate water quality and volume for survival and reproduction. Water efficiency measures, such as the proposed code changes, will result in increased surface water flows in many habitats due to the reduced need for human consumption, and thus increase healthy habitats for species at risk.

Low water levels and lack of freshwater flow can increase the likelihood of water fouling due to saltwater intrusion, which occurs when an influx of seawater flows into freshwater sources. Furthermore, fouling due to algal blooms can occur as the lack of freshwater flow increases nutrient concentrations in some water bodies, which can harm fish, animals and humans. Therefore, improved water efficiency as a result of the proposed measures can help ensure that more water resources are available for beneficial human and environmental use.

Groundwater resources also benefit from the reduction in human use as a result of water conservation. Reducing the amount of water pumped out of stressed aquifers can increase water quality, since over-pumping results in precipitous drops in underground water levels and the deterioration of groundwater quality (USGS 2014). In reducing groundwater draws, water conservation can result in long term environmental benefits such as the avoidance of land subsidence and saltwater intrusion into aquifers due to over-pumping.

Just as water-dependent wildlife species benefit from water efficiency measures, people that rely on water resources for employment or enjoyment will also benefit from these measures. As noted earlier, lack of water availability has significantly impacted agricultural employment. Californians also depend on water resources for recreation activities and related jobs supporting activities such as boating, water sports, fishing and swimming. The current drought has dried up streams, lakes and reservoirs used for recreation, bringing them to unprecedented low levels and preventing freshwater releases from reservoirs to sources downstream. Water efficiency standards will help mitigate demand on these resources.

5.6.2 Greenhouse Gas and Air Quality Benefits

Table 17 provides estimated GHG impacts for each product class in this report. The Utility C&S Team estimates that the proposed measure will result in more than 1100 metric tons per year of carbon dioxide equivalents ($MTCO_{2e}$) avoided in the first year that standards are in place, which will increase significantly in future years. The total avoided CO_2e is based on CARB's estimate of 437 $MTCO_2e$/GWh and 53 $MTCO_2e$/million therms of natural gas, which includes the impacts associated with electrical transmission and distribution loses (CARB 2008). The GHG emissions reductions estimates include emissions reductions associated with energy embedded in water.

The range of societal benefits per year can be determined based on a range of annual dollars per metric ton of CO_2 (in 2013 dollars) sourced from the U.S. Government's Interagency Working Group on Social Cost of Carbon (SCC) (Interagency Working Group 2013). The low end uses the average SCC, while the high end incorporates SCC values which use climate sensitivity values in the 95th percentile, both with a 3 percent discount rate. It is important to note that this range can be lower and higher, depending on the approach used, so policy judgments should consider this uncertainty. See Appendix B for more details on the valuation of GHG emissions reductions.

Table 17: Estimated Statewide Greenhouse Gas Savings and Cost Savings

Product Class	Annual GHG Savings for First Year Standards are in Effect - 2017 ($MTCO_2e$/yr)	Value of GHG Savings for First Year Standards are in Effect – 2017 Low Estimate	Value of GHG Savings for First Year Standards are in Effect – 2017 High Estimate
Faucets	817	$38,047	$109,135
Urinals	41	$1,899	$5,448
Toilets	105	$4,904	$14,067
Compact Hot Water Distribution Design	187	$8,686	$24,916
TOTAL	**1,150**	**$53,536**	**$153,566**

The proposed measure will also result in air quality benefits such as reduced emissions of pollutants that cause fine particulate and ground-level ozone pollutants. The direct combustion of fuel for on-site heating results in local emission of nitrogen oxides (NOx) and carbon monoxide (CO). Energy used for water supply and treatment also results in emissions of these pollutants, among others. Air quality impacts were not quantified, and the lifecycle cost-benefit analysis does not include the benefit of reduced emissions. As such, the estimated total benefits presented in this report are conservative.

5.6.3 Other Potential Environmental Effects

There are no known incremental hazardous materials impacts from the efficiency improvements as a result of the proposed standards. The Utility C&S Team has not identified other potential environmental impacts.

6. COMPLIANCE AND ENFORCEMENT

6.1.1 Compliance and Enforcement: Faucets, Urinals and Toilets

Building officials are already required to verify compliance with efficiency requirements for plumbing fixtures and fittings. The proposed amendments to existing efficiency standards for faucets, urinals, and toilets would not change existing compliance determination methods nor require any additional methods or procedures for building officials.

6.1.2 Compliance and Enforcement: Compact Hot Water Distribution Design

The voluntary requirement for compact distribution design would represent a new requirement for building officials to verify. Compact hot water distribution design can be a difficult measure to verify as piping is not visible when the building is complete, and location of the points of use relative to the water heater are not necessarily a good indication of the length of pipe. A common finding in field studies that evaluate hot water distribution systems is that the length of pipe is consistently longer than expected based on the location of the use points and the water heater (CEC 2005, CEC 2012b). Because compliance with pipe length requirements can be difficult, the proposed standard recommends that a HERS Rater complete a field verification to confirm the plumbing design meets the code requirements. A HERS Rater is a person who has been trained, tested, and certified to perform the field verification and diagnostic testing required for demonstrating compliance with the Part 6 of Title 24. The proposed compact hot water distribution design requirements are based on requirements that were added to the Reference Appendix of Part 6 of Title 24 for the 2013 Standards and builders have the option of receiving compliance credit for compact design if they are complying with the Part 6 standards using the performance approach (CEC 2012a).[18] Since HERS-verified compact design standards already exist in Part 6 as a performance option, HERS Raters are already trained to verify compliance with pipe length requirements.

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[18] Residential Appendix Section 3.6.5 HERS-Verified Compact Hot Water Distribution System.

Requiring HERS verification will alleviate building officials from the burden of determining compliance with pipe length requirements.

The proposed measure is a voluntary requirement. Local jurisdictions can evaluate whether local building officials are sufficiently trained to verify compliance and enforce the standard when they are evaluating whether to adopt the standard in their jurisdictions.

7. STAKEHOLDER CONSULTATION

7.1 Stakeholder Engagement Process

In the effort to research, develop and vet the proposed standards, the Utility C&S Team reached out to over 70 stakeholder organizations, many of which would be key players in the eventual implementation of the proposed code changes. Maintaining contact with these stakeholders throughout every point of the code change process has ensured the consideration of a variety of stakeholder positions. The Utility C&S Team continues to be in contact with these stakeholders as part of ongoing outreach efforts. The types of stakeholders contacted vary widely across a diverse range of sectors. These stakeholders include state government agencies, code setting bodies, industry representatives, union associations, manufacturer associations, water resources advocates, environmental protection NGOs and water agencies.

The process to gather input from stakeholders was extensive. The Utility C&S Team conducted general outreach to keep all identified stakeholders informed on the code process, regardless of priority level. The Utility C&S Team conducted both phone and in-person interviews to explain the proposals to stakeholders, to attain feedback and to address any potential concerns. Some standardized email messaging was used for all stakeholders in order to present a uniform message and to ensure that all stakeholders were equally informed, but extensive personalized messaging was also used to address stakeholder-specific concerns. Prior to participating in the October 2014, and February 2015, BSC Workshops, the Utility C&S Team conducted outreach to gauge and address stakeholder support or opposition to the code change proposals. Furthermore, at the February workshop, Utility C&S Team presented the proposals for live feedback from workshop attendees.

Examples of key stakeholder organizations include the California Building Industry Association, Plumbing Manufacturers International, IAPMO, NRDC, and the State Pipe Trade Association. The following section contains additional information regarding a number of concerns raised during stakeholder consultation.

7.2 Responses to Stakeholder Input

7.2.1 Potential Wasted Water and Energy When Waiting for Hot Water to Arrive at 1.0 gpm Lavatory Faucets

Some stakeholders have raised concerns that the reduction of lavatory faucet water use in residential buildings could lead to the unintended consequence of longer hot water wait times leading to wasted water and energy. This concern is addressed in Appendix D, which presents a document that the Utility C&S Team developed for CEC’s open rulemaking for proposed revisions to Title 20 to address this issue. The key findings are that the more stringent faucet standard results in significant cost-effective savings, even after considering the possibility of water wasted when waiting for "hot enough" water to arrive. Surveys have also shown that 1.0 gpm faucets are acceptable to consumers. In addition, longer run times can be mitigated by deploying compact hot water distribution designs in newly constructed buildings, as recommended in this report.

7.2.2 Opportunistic Pathogens in Green Plumbing Systems

Some researchers have raised concerns about the potential link between green plumbing systems and increased risk of exposure to opportunistic pathogens. The existing body of research is insufficient to show that faucet flow rate is correlated to an increased risk of exposer to opportunistic pathogens. See Appendix E for a discussion on opportunistic pathogens and faucet flow rates.

7.2.3 Metering Faucets

The Utility C&S Team recommends that HCD update the efficiency standards for metering faucets so the efficiency standard for residential buildings matches the efficiency requirements for nonresidential buildings. During the 2013 Intervening Cycle, BSC updated the efficiency requirements for metering faucets in nonresidential buildings from a maximum flow of 0.25 gallons per cycle (gpc) to 0.20 gpc (Section 5.303.3.4.4). Before adopting the standard, BSC concluded that the 0.20 gpc requirement is appropriate and feasible.

During a February 5, 2015 public workshop that the BSC held to discuss proposed changes to the CALGreen standards for nonresidential buildings, Plumbing Manufacturers International (PMI) recommended reverting back to the previous version metering faucet standard for nonresidential buildings. That is, roll back the 0.20 gpc standard that BSC adopted during the 2013 intervening cycle to the previous level of 0.25 gpc. PMI noted that the requirements for residential and nonresidential should be consistent.[19]

While the Utility C&S Team agrees that consistency between the nonresidential standard and the residential standard is desirable, the appropriate solution is to update the residential standard rather than to reverse the recent updates for nonresidential buildings. Since most metering faucets are found within nonresidential buildings, the Utility C&S Team recommends that HCD follow BSC's lead on efficiency standards. Metering faucets are not common in residential buildings, but they are sometimes installed in public lavatories within multifamily buildings.

John Koeller P.E., principal at Koeller& Company who has been an active participant in establishing standards for plumbing products for decades, noted during February 5, 2015 BSC workshop that the 0.25 gpc federal efficiency standard was adopted over 20 years ago in 1992 with little problems and a move to 0.20 gpc is reasonable. There are products currently on the market that use as little as 0.09 gpc. As discussed below, the Utility C&S Team confirmed that 0.2 gpc faucets are readily available from a range of manufacturers.

[19] Agenda item 5m. http://www.documents.dgs.ca.gov/bsc/2015TriCycle/Pre-Cycle-2015/Green2/5m.pdf.

As of March 2015, the U.S. Department of Energy (DOE) Appliance Compliance Certification Database lists five manufacturers that offer metering faucets that meet DOE's minimum efficiency requirement of 0.25 gpc or less. Three of the five manufacturers offer metering faucets that use 0.2 gpc or less. The DOE database lists the basic model number and the individual model numbers, which are usually slight variations on the basic model. There are 34 basic models – 13 (38 percent) of which use 0.20 gpc or less. There are 236 individual models, 66 (28 percent) of which use 0.2 gpc or less (DOE 2015).

Table 18: Metering Faucets Listed in DOE's Appliance Efficiency Database

Source: DOE 2015

Manufacturer	Basic Models		Total # of Models	
	Number of Basic Models 0.25 gal/cycle or less	Number of Basic Models 0.2 gal/cycle or less	Total Models 0.25 gal/cycle or less	Number Models 0.2 gal/cycle or less
Chicago Faucet	1	0	11	
Moen	4	4	4	4
Symmons	13	0	108	
T&S Brass and Bronze Works, Inc.	12	5	69	18
Toto	4	4	44	44
Grand Total	**34**	**13**	**236**	**66**
Percent	100%	38%	100%	28%

7.2.4 Low Flow Urinals and Building Drainage Systems

Some stakeholders have expressed concerns that low flow 0.125 gpf urinals, or "pint urinals," can lead to clogged drainlines, particularly in existing buildings where plumbing systems were not designed for low flow fixtures. In response, the Utility C&S Team has provided CEC with information related to this concern as part of CEC's open rulemaking to update Title 20. CEC is proceeding with the recommended 0.125 gpf urinal efficiency standard for all urinals offered for sale in California.

Experience Indicates that Drainlines Do Not Clog After Installing 0.125 gpf Urinals

Low flow 0.125 gpf urinals, or "pint urinals," have now been installed and provided satisfactory service at many locations for a period of several years, including the University of Washington, the Seattle Public Utilities District, the City of Los Angeles, and California state government facilities. The report authors were unable to find any evidence that these fixtures cause damage to an existing building's sanitary drainage system or drainlines.

For instance, in 2009 the City of Los Angeles passed an ordinance that established water efficiency requirements for newly constructed buildings and renovations of existing buildings. The ordinance added Article V to Chapter XII of the City's Municipal Code. Among other provisions, the code requires that the maximum flush volume for urinals installed after October 1, 2010, cannot exceed 0.125 gpf (City of Los Angeles 2009). A letter the LADWP submitted to CEC in June 2014, in support of CEC's pre-rulemaking activities for the Title 20 faucet standards stated:

"LADWP sponsored a local ordinance in 2010 to establish a maximum urinal flush rate of 0.125 gallons per flush (GPF) in the City of LA. An exception to grant the permission to install urinals with an alternate flush rate was written into the ordinance where the 0.125 GPF or less urinals were determined to not be feasible. As of this date, the Los Angeles Department of Building and Safety Inspection and Engineering staff informed us that they have not yet approved any exceptions for the 0.125 GPF urinals. The exception in the ordinance is meant to address existing installations, especially where obsolete fixture types are installed in systems that could prove to be unfeasible for 0.125 GPF urinals to replace the existing fixtures," (LADWP 2014).

The City of Los Angeles confirmed this finding in a personal communication with the authors in December 2014. The fact that no exceptions to the City of Los Angeles's urinal efficiency standards were needed is an indication that builders and the Los Angeles Building Department have not identified any buildings where installing 0.125 gpf urinals is not feasible.

In 2010, the Seattle Public Utilities Commission interviewed facility managers that manage buildings with high efficiency toilets and urinals to assess their experience with these high-performance fixtures. Key findings relevant to urinals were that maintenance requirements for 0.125 urinals were minimal and drainline clogging was not a significant problem.

In the summer of 2014, the Utility C&S Team contacted the California Department of General Services (DGS) to get feedback on their high-efficiency fixtures. DGS reported that one of their buildings has 12 urinals that are rated at 0.13 gpf and 6 that are rated at 0.125 gpf and they noted "No additional operation issues or additional maintenance, either mechanical or custodial, has been noted" (personal communication with DGS 2014).

Given this information, plumbing in existing buildings will not need to be replaced as a result of installing 0.125 gpf urinals.

Neither Manufacturers nor Plumbing Codes Recommend Drainline Requirements for 0.125 gpf Urinals

While manufacturers of waterless urinals publish information that recommend drainline specifications (i.e. to have the appropriate slope to allow proper drainage)[20], the Utility C&S Team is not aware of any similar information limiting 0.125 gpf urinals to buildings with specific types of drainlines.[21] The lack of information recommending design requirements for drainlines used in conjunction with 0.125 gpf urinals is an indication that manufacturers do not see drainline clogging as a tangible risk.

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[20] Sloan publishes recommendations for drainline cleaning and design specifications for consideration when installing waterless urinals (http://www.sloanvalve.com/Installation_Guides/0816560.pdf). Sloan does not publish similar information for consideration when installing pint urinals. Publishing literature on drainline clogging would minimize the risk of consumer dissatisfaction, and could help mitigate possible legal risk if manufacturers believe that drainline clogging is a possible concern.

[21] An inspection of manufacturer literature (e.g., specification sheets, installation manuals, warranty information, care and maintenance instructions, etc.) for 8 unique brands of WaterSense® certified pint urinals reveals that none of the manufacturers include recommendations on building drainage systems when installing pint urinals. The following manufacturers were included in the review of installation manuals and specifications for 0.125 gpf urinals: American Standard, Kohler, Sloan Valve Company, Toto, and Zurn Industries. Several of the installation manuals applied to more than one pint urinal model. Some manufacturers include design specifications for the building's water supply system (e.g., a urinal is appropriate if the water supply pressures is between 20 psi and 125 psi).

In addition, the California Plumbing Code (Part 5 of Title 24), which is based on the IAPMO's UPC, does not include any unique requirement on the drainline system if pint urinals are installed, nor does it recommend or require that drainage systems be upgraded if pint urinals are installed. While Section 402.9 of the California Plumbing Code requires that "water-conserving fixtures shall be installed in strict accordance with manufacturer's installation instructions to maintain their rated performance," as noted earlier manufacturer literature does not include requirements for drainlines or recommend modification to the existing drainage system.

Maintenance Practices for Drainlines

While the Utility C&S Team has not found evidence that pint urinals lead to drainline clogging, there are maintenance practices that can be deployed to help maintain clean drainlines such as infrequent hot water flushing used at one facility, and chemicals can be poured down the urinal on a prescribed schedule to help maintain drainlines. As mentioned above, the manufacturer guidelines the Utility C&S Team reviewed do not include instructions or recommendations for cleaning and maintaining the drainlines, only the fixture itself, so these practices would go beyond manufacturer guidelines if building operators feel that they are necessary.[22]

7.2.5 Impact of Low Flow Fixtures on Wastewater Collection Systems

Some stakeholders have expressed concerns that reducing water use in buildings could lead to major problems with the municipal wastewater collection system, including clogging, odors, and pipe corrosion. Many wastewater collection systems were designed over 100 years ago when water use in buildings was higher than it is today (Environment Agency 2008). As California pursues water efficiency and conservation goals, such as the statewide 20x2020 goal noted earlier, urban water use will continue to decline, in turn, decreasing the amount of water in wastewater collection systems.

While the Utility C&S Team acknowledges the theoretical threat that reducing flow rates in wastewater collection systems poses, the proposed urinal efficiency standard will not have a relevant impact on the total amount of water flowing through wastewater collection systems. Wastewater collection systems in California typically see flows of about 200 gallons per capita per day (gpcd), including flows from buildings and from inflow and infiltration. The proposed indoor water efficiency standard will reduce water return flows by significantly less than 1 percent after the standard has been in effect for ten years,[23] and a reduction of this scale is not expected to have a significant impact on flow regimes within municipal wastewater pipes.

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[22] Some fixtures are now designed to reduce maintenance needs. For example, American Standard's WASHBROOK® FloWise® 0.125 gpf urinal system has a self-cleaning piston that helps prevent clogging and reduces maintenance for the fixture itself. One consumer review on the manufacturer's website states that no maintenance calls have been received since installing the urinal system.

[23] Annual water savings of 657 million gallons divided by California population of 38.33 million (US Census http://quickfacts.census.gov/qfd/states/06000.html) divided by 365 days per year equals savings of 0.05 gpcd, which is less than 0.1% of the 200 gpcd wastewater flow rate.

The few incidents of challenges with wastewater collection systems that have been reported in recent years are attributed to circumstances that are very different than would result from this proposal. For instance, a 2009 odor incident in the City of San Francisco was mischaracterized as the result of low flow toilets. The San Francisco Public Utilities Commission (SFPUC) refuted this claim in a letter submitted to CEC in June 2013 in which they argued that odor issues cannot be attributed to low flow fixtures. During this incident, the system had a combined flow reduction of 25 percent. In addition, it should be noted that San Francisco has a combined system in which stormwater and municipal waste water are collected into the same pipes. Combined systems, which are unusual in California, have larger pipes that require more water to move solids than traditional wastewater collection systems that do not combine stormwater and wastewater.

An incident in Melbourne, Australia has also been incorrectly cited as an example of wastewater system impacts that could occur due to water efficiency standards. During an extreme drought the wastewater collection system was severely stressed by a drop in potable water usage by 65 percent from 90 gpcd to 30 gpcd,[24] and because of the drought there was very little inflow and infiltration, further reducing wastewater flows. Baseline flows in California (200 gpcd) are much higher than baseline flows in Melbourne. An 85 percent reduction in wastewater flows would be required to reduce these levels to 30 gpcd – several orders of magnitude larger than the reduction expected to occur due to this proposal.

A recent academic study explored how various water efficiency and conservation practices could contribute to odor and corrosion issues in a wastewater collection system in Melbourne (Marleni et al. 2011). The study concluded that aggressive water conservation practices can lead to odor and corrosion problems. The aggressive water management scenario assumes that water entering the collection system will be reduced by 43 percent from the already efficient baseline scenario, creating risk of significant pipe corrosion. While this example indicates the importance of proper wastewater collection system design and sizing, the flow reductions are approximately two orders of magnitude larger than expects from these CALGreen proposals.

The broader solution is not to slow down efforts to achieve water conservation and water efficiency goals. Rather, California should evaluate the systematic impacts of water conservation and the wastewater collection and treatment systems and develop a strategy to achieve broader long-term water conservation goals along with reliable wastewater collection and treatment systems.

7.2.6 Hybrid Urinals

Stakeholders have recommended that the proposed standards for flushing urinals should be developed so hybrid urinals could meet the proposed efficiency requirements. Hybrid urinals normally operate as waterless urinals, but they are connected to a waterline and have the capability of using water to flush the urinal on a periodic basis. Hybrid urinals have emerged on the market recently, and represent a growing share of the market for "waterless" urinals. Hybrid urinals are new to the market and there is little data on how the flush feature is being

[24] Flow rates are now back up to 40 – 50 gpcd.

used (e.g., how frequently flushes are happening, how much water is used per flush, etc.). For now, the Utility C&S Team recommends that hybrid urinals be classified as waterless urinals. Hybrid urinals would not be subject to the efficiency requirement for flushing urinals. However, HCD and BSC might consider adopting requirements for hybrid urinals into the voluntary section of CALGreen that would establish a maximum flush volume of 1.0 gpf and a default setting for urinals with automatic controls that the urinal be flushed no more than once per week. This maximum flush volume requirement would establish the maximum amount of water that could be flushed for the purpose of maintaining waterless urinals. In the future, after hybrid urinals have been available for a longer period of time, HCD and BSC may want to reevaluate efficiency standards for hybrid urinals.

7.2.7 Demand Controlled Recirculation Systems

During a public meeting held on April 2, 2014, HCD requested feedback on their draft proposal to add a mandatory requirement that new homes be plumbed with hot water recirculation systems (HCD 2015). Recirculation systems can save water and reduce hot water wait times, but they can also result in energy penalties due to energy requirements for pumping and energy losses associated with water cooling down as it circulates through pipes that are typically not as well insulated as hot water storage tanks (i.e., distribution losses). To minimize this energy penalty, recirculation systems should also have manual demand controls, which only circulate water when the user indicates hot water is needed. Part 6 of Title 24 requires manual controls for recirculation systems serving individual dwelling units (Section 150.1(c)(8)). Part 6 of Title 24 also requires all piping associated with hot water recirculation systems in both residential and nonresidential buildings to be insulated (Section 120.3(a), Section 150.0(j)).

A 2014 DOE study modeled energy and water use of several distribution systems in a variety of climates in high growth areas of the United States. The study found that demand recirculation systems with a long recirculation loop and short run-outs (pipes running from the recirculation loop to the point of use) resulted in a significant increase in energy use relative to a base case trunk and branch distribution system with uninsulated pipes. Researchers found a 41 percent increase in distribution losses and a 7 percent increase in water heating energy use, averaged over climate zones and occupancy rates. While the study found a significant energy penalty associated with one particular recirculation system design, there are ways to minimize the energy penalty by modifying the design. The study concluded that, “the reduction in distribution losses must be balanced out with the recirculation losses to maximize energy savings,” (DOE 2014).

At the time of writing, there is limited data available that documents the performance of various distribution systems, including “conventional” distribution systems, compact systems, and demand recirculation systems with manual controls. There is not enough data to say categorically that demand recirculation systems result in consistent water savings or if the on-site energy penalty is justified given the expected water savings and embedded energy savings.

Thus, the Utility C&S Team recommends that HCD adopt a voluntary requirement that allows designers to use either compact hot water distribution design (i.e., minimize the length and size of pipe between the water heater and the end-use) or use a demand recirculation system with manual controls. The voluntary requirement that allows builders to use either strategy provides the opportunity for builders to experiment with both options. Adopting a voluntary requirement that allows both compact design and recirculation loops could provide an opportunity to study the performance of both types of systems further, which can help inform future code changes.

This CASE Report does not include detailed information about the costs and benefits of demand recirculation systems with manual controls. Anecdotally, the Utility C&S Team has heard that cost of a recirculation system may tend to exceed the expected cost of compact design systems. It is expected that builders that wish to go beyond code minimum and comply with the proposed voluntary standard will evaluate the costs and benefits of compact design and recirculation systems and implement the least cost approach that results in the end-goal of reducing hot water wait times and the amount of water wasted when waiting for hot water.

8. PROPOSED CODE LANGUAGE

The proposed changes to the mandatory measures (Chapter 4 and Chapter 5 of CALGreen) and voluntary measures (Appendix A4 to CALGreen) are provided below. All changes to the current 2013 Interim Cycle Documents are marked in red with new language marked with underlining and deletions marked with ~~strikethroughs~~.

8.1 Draft Express Terms: Mandatory Measures (Chapters 4 and 5)

CHAPTER 4

RESIDENTIAL MANDATORY MEASURES

SECTION 4.303

4.303.1.2 Urinals. The ~~effective~~ flush volume of urinals shall not exceed ~~0.5~~ 0.125 gallons per flush.

4.303.1.4 Faucets.

4.303.1.4.1 Residential lavatory faucets. [N] The maximum flow rate of residential lavatory faucets in newly constructed buildings shall not exceed ~~1.5~~ 1.0 gallon~~s~~ per minute at 60 psi. ~~The minimum flow rate of residential lavatory faucets shall not be less than 0.8 gallons per minute at 20 psi.~~ [A] The maximum flow rate of residential lavatory faucets in additions and alterations shall not exceed ~~1.5~~ 1.2 gallon~~s~~ per minute at 60 psi.

4.303.1.4.2 Lavatory faucets in common and public use areas. The maximum flow rate of lavatory faucets installed in common and pubic use areas (outside of the dwellings or sleeping units) in residential buildings shall not exceed 0.5 gallons per minute at 60 psi.

4.303.1.4.3 Metering faucets. Metering faucets when installed in residential buildings shall not deliver more than 0.20~~5~~ gallons per cycle.

4.303.1.4.4 Kitchen faucets. The maximum flow rate of kitchen faucets shall not exceed 1.8 gallons per minute at 60 psi. Kitchen faucets may temporarily increase the flow above the maximum rate, but not to exceed 2.2 gallons per minute at 60 psi, and must default to a maximum flow rate of 1.8 gallons per minute at 60 psi.

Note: Where complying faucets are unavailable, aerators or other means may be used to achieve reduction.

CHAPTER 5

NONRESIDENTIAL MANDATORY MEASURES

SECTION 5.303
INDOOR WATER USE

5.303.3.2 Urinals. The ~~effective~~ flush volume of urinals shall not exceed ~~0.5~~ 0.125 gallons per flush.

8.2 Draft Express Terms: Voluntary Measures (Appendix A4)

APPENDIX A4

RESIDENTIAL VOLUNTARY MEASURES

SECTION A4.303

INDOOR WATER USE

A4.303.1 Water conserving fixtures and fittings

A4.303.1.1 Water closets.

A4.303.1.1.1 Water closets shall either meet either alternative 1 or alternative 2:

1) The effective flush volume of all water closets shall not exceed 1.06 gallons per flush. The waste extraction performance of the toilet shall be equal to or greater than 600 grams and shall meet the requirements in Section 7 of ASME A112.19.2-2013.

2) Be rated and labeled as a Maximum Performance (MaP) Premium Product.

A4.303.1.1.2. Tank-type water closets shall be certified to the performance criteria of the U.S. EPA WaterSense Specification for Tank Type Toilets, Version 1.2

Note: The effective flush volume of dual flush toilets is defined as the composite, average flush volume of two reduced flushes and one full flush.

A4.303.1.2 Kitchen faucets. The maximum flow rate of kitchen faucets shall not exceed 1.5 gallons per minute at 60 psi. Kitchen faucets may temporarily increase the flow above the maximum rate, but not to exceed 2.2 gallons per minute at 60 psi, and must default to a maximum flow rate of 1.5 gallons per minute at 60 psi.

Note: Where complying faucets are unavailable, aerators or other means may be used to achieve reduction.

A4.303.2 Alternate water sources for nonpotable applications. Alternate nonpotabel water sources are used for indoor potable water reduction. Alternative nonpotable water sources shall be installed in accordance with the *California Plumbing Code.*

A4.303.3 Appliances. Dishwashers and clothes washers in residential buildings shall comply with the following:

Install at least on ENERGY STAR appliance with maximum water use as follows:

1. Standard Dishwasher – 4.25 gallons per cycle.

2. Compact Dishwasher – 3.5 gallons per cycle.

3. Clothes Washer – water factor of 6 gallons per cubic ~~feet~~ foot of drum capacity.

Note: See Section A5.303.3 for nonresidential dishwashers and clothes washers.

A4.303.4 Nonwater supplied urinals and waterless toilets. Nonwater supplied urinals and composting toilets are installed.

A4.303.5. Standards for reducing water and energy loses from indoor plumbing systems.

A4.303.5.1 HERS-verified maximum measured water heater to use point distance. For systems serving individual dwelling units, HERS field measurements shall verify that the longest measured pipe run length between a hot water use point and the primary water heater providing service shall be no more than the distance specified in Table A4.303.5. The table specifies the maximum pipe length as a function of Floor Area Served, where Floor Area Served is defined as the conditioned floor area divided by the number of installed water heaters. The hot water distribution system piping between a hot water use point and the water heater must take the most direct path.

Table A4.303.5

Floor Area Served (ft^2)	**Maximum Measured Water Heater To Use Point Distance (ft)**
<1000	28 feet
1001 – 1600	43 feet
1601 – 2200	53 feet
2201 – 2800	62 feet
>2800	68 feet

Note: Hot water use point means all faucets (excluding faucets used exclusively to fill a bathtub) and showerheads. Mini-tank electric water heaters and hot water dispensers do not qualify as primary water heaters.

A4.303.5.3 Demand recirculation system with manual control. For hot water end uses that are further away from the water heater than the maximum distances in Table A4.303.5, the hot water to these end uses shall be delivered by a Demand Recirculation System with a manual control. The recirculation pump shall be initiated by a manual control and the pump shall automatically turn off upon the recirculation loop achieving a setpoint temperature. All piping associated with the recirculation system must be insulated as required by the California Plumbing Code and the California Building Energy Efficiency Standards.

8.3 Statement of Justification for Prescriptive Standards

BSC has recently found that a performance approach for mandatory indoor plumbing requirements was not utilized and has removed this option in order to simplify CALGreen. The proposed prescriptive approach for the measures in this report is consistent with the BSC's approach of simplifying the mandatory indoor plumbing codes by omitting a performance-based approach.

8.4 Consideration of Reasonable Alternatives

The Utility C&S Team considered two types of alternatives: status quo and stricter standards. The status quo alternative would not satisfy the state's compelling policy needs for water savings and would forgo cost-effective water savings that the standards would achieve. The Utility C&S Team is also aware that some products could achieve even greater water savings such as 0.5 gpm lavatory faucets and waterless urinals. The authors of this report do not currently have sufficient information to consider stricter standards based on these other products.

9. REFERENCES

[75 Fed. Reg.245, 22 December 2010] Federal Register. "Waiver of Federal Preemption of State Regulations Concerning the Water Use or Water Efficiency of Showerheads, Faucets, Water Closets and Urinals." 75:245 (22 December 2010). p. 80289.

The Alliance for Water Efficiency. 2012. "Assessing the Economic and Environmental Benefits of Industrial Water Use Efficiency."

Aquacraft, Inc. Water Engineering and Management. Seattle Home Water Conservation Study: the Impacts of High Efficiency Plumbing Fixture Retrofits in Single-family Homes.2000. Prepared for Seattle Public Utilities and the United States Environmental Protection Agency. http://www.aquacraft.com/sites/default/files/pub/Mayer-%282000%29-Seattle-Home-Water-Conservation-Study.pdf. Boulder, Colo.: Aquacraft, Inc. Water Engineering and Management

__. Residential Indoor Water Conservation Study: Evaluation of High Efficiency Indoor Plumbing Fixture Retrofits in Single-family Homes in the East Bay Municipal Utility District Service Area. 2003. Prepared for East Bay Municipal Utility District and the United States Environmental Protection Agency.

__. Tampa Water Department Residential Water Conservation Study: The Impacts of High Efficiency Plumbing Fixture Retrofits in Single-Family Homes. 2004. Prepared for Tampa Water Department and The United States Environmental Protection Agency. http://www.aquacraft.com/sites/default/files/pub/Mayer-%282004%29-Tampa-Water-Department-Residential-Water-Conservation-Study.pdf. Boulder, Colo.: Aquacraft, Inc. Water Engineering and Management.

__. California Single Family Water Use Efficiency Study. 2011. Prepared by DeOreo, W., Mayer, P., Martien, L., Hayden, M., Funk, A., Kramer-Duffield, M. & R. Davis. http://www.aquacraft.com/node/63. Boulder, Colo.: Aquacraft, Inc. Water Engineering and Management. Black & Veatch. "2009/2010 50 Largest Cities Water/Wastewater Rate Survey." 2010.

Black & Veatch. (2010). "2009/2010 50 Largest Cities Water/Wastewater Rate Survey."

Building Standards Commission. "Guide to the 2013 California Green Building Standards Code (Nonresidential)". 2014. http://www.documents.dgs.ca.gov/bsc/CALGreen/CALGreen-Guide-2013-FINAL.pdf ISBN: 978-1-60983-523-1

[California AB 715, 2007] California Assembly Bill 715. Assembly Member John Laird. 2007-2008 Legislative Session. (2007). http://www.leginfo.ca.gov/pub/07-08/bill/asm/ab_0701-0750/ab_715_bill_20071011_chaptered.pdf.

[California SB 407, 2009] California Senate Bill 407. Senator Alex Padilla. 2009.

[CARB] California Air Resources Board. 2008. "AB 32 Technical Stakeholder Working Group Meeting. Cost-Effectiveness." http://www.arb.ca.gov/cc/scopingplan/economics-sp/meetings/060308/ce_white_paper.pdf. June, 3 2008.

__. 2010. "Proposed Regulation for a California Renewable Electricity Standard Staff Report: Initial Statement of Reasons Appendix D." http://www.arb.ca.gov/regact/2010/res2010/res10isor.pdf. Accessed July 24, 2013.

__. 2011. California Air Resources Board. "Appendix C: Cost Effectiveness Calculation Methodology." http://www.arb.ca.gov/msprog/moyer/guidelines/2011gl/appc_3_10_11.pdf. March 10.

__. 2013. "Mail-Out #MSC 13-09." http://www.arb.ca.gov/msprog/mailouts/msc1309/msc1309.pdf. March 25.

[CEC] California Energy Commission. 2005. "Hot Water Distribution System Research – Phase I." Prepared by Applied Energy Technology. Public Interest Energy Research Program. November 2005. Report number: CEC-500-2005-161. http://www.energy.ca.gov/pier/project_reports/CEC-500-2005-161.html.

__. 2006. California Energy Commission. 2006 "Refining Estimates of Water-related Energy Use in California." (CEC-500-2006-118). Prepared by Navigant Consulting, Inc., Public Interest Energy Research Program (December 2006). http://www.energy.ca.gov/2006publications/CEC-500-2006-118/CEC-500-2006-118.PDF.

__. 2009. "California Statewide Residential Appliance Saturation Study. 2009". Saturation Report: Water Heating, Cleaned primary water heater fuel. Accessed July 2013.

__. 2012a. "2013 Reference Appendices: The Building Efficiency Standards for Residential and Nonresidential Buildings." CEC-400-2012-005-CMF-REV3. http://www.energy.ca.gov/2012publications/CEC-400-2012-005/CEC-400-2012-005-CMF-REV3.pdf.

___. 2012b. "Water Heating Design Guide." Prepared by Davis Energy Group and Gas Technology Institute. December 2012. Report number: CEC-500-2013-126. http://www.energy.ca.gov/2013publications/CEC-500-2013-126/CEC-500-2013-126.pdf.

__. 2015a. “Existing Buildings Energy Efficiency Action Plan-Draft”. March 5, 2015. http://www.energy.ca.gov/ab758/

__. 2015b. “Proposed Revisions to the California Building Energy Efficiency Standards California Code of Regulations, Title 24, Part 1, Chapter 10, and Part 6: 45-day Language.” http://www.energy.ca.gov/title24/2016standards/rulemaking/documents/express_terms/01_2016%20T24%20Standards%20Parts%201%20and%206%20-%2045%20Day%20Language.pdf.

__. 2015c. “2016 Revisions to the California Building Energy Efficiency Standards Revised Attachment to Fully Executed Economic Impact Statement” March 13, 2015. http://www.energy.ca.gov/title24/2016standards/rulemaking/documents/EFIS_2016_title24_parts_01_06/.

__. 2015d. “Resolution Adopting Amendments to the Appliance Efficiency Regulations.” April 2015. Resolution Number 15-0408-29. http://www.energy.ca.gov/business_meetings/2015_packets/2015-04-08/Item_29_Appliance_Efficiency_Regulations/Item_29b_Emergency_Rule_Adoption_Resolution.pdf

__. 2015e. “Proposed Amendments to Appliance Efficiency Regulations: California Code of Regulations Title 20, Sections 1602 through 1608.” April 2015. Docket Number 15-AAER-4. CEC-400-2015-015. http://www.energy.ca.gov/business_meetings/2015_packets/2015-04-08/Item_29_Appliance_Efficiency_Regulations/Item_29a_Appliance_Efficiency_Regulations.pdf.

[CA Exec. Order No. B-26-14] California Executive Order Number B-26-14. September 19, 2014. (http://gov.ca.gov/news.php?id=18712).

[CA Exec. Order No. B-29-15] California Executive Order Number B-29-15. April 1, 2015. http://gov.ca.gov/docs/4.1.15_Executive_Order.pdf.

[CA DWR] California Department of Water Resources. “California Water Plan Update 2013 — Public Review Draft.” 2013. Available at: http://www.waterplan.water.ca.gov/cwpu2013/prd.

___. 2015a. “Snow Water Equivalents.” California Data Exchange Center. http://cdec.water.ca.gov/cgi-progs/snow/DLYSWEQ

___. 2015b. “Conditions for Major Reservoirs.” California Data Exchange Center – Reservoirs. http://cdec.water.ca.gov/cdecapp/resapp/getResGraphsMain.action

California Farm Water Coalition. 2014. “Estimate of unplanted acres jumps to 800,000; consumers expected to feel impacts.” http://farmwater.org/california-drought-information-mulitmedia/releases/new-31814-estimate-of-unplanted-acres-jumps-to-800000-consumers-expected-to-feel-impacts/.

[CA IOUs]. California Investor Owned Utilities. 2011. “Codes and Standards Enhancement Initiative (CASE) Report for the 2013 California Building Energy Efficiency Standards: Single Family Water Heating Distribution System Improvements.” September 2011. http://www.energy.ca.gov/title24/2013standards/prerulemaking/documents/current/Repor ts/Residential/Water_Heating/2013_CASE_R_SEMPRA_Single_Family_DHW_%20Sept_2011.pdf.

__. 2013a "Codes and Standards Enhancement (CASE) Initiative For PY 2013: Title 20 Standards Development: Faucet Water Efficiency." July 2013. 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.

__. 2013b "Codes and Standards Enhancement (CASE) Initiative For PY 2013: Title 20 Standards Development: Toilets & Urinals Water Efficiency." July 2013. 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.

__. 2014. "Comments regarding draft regulations: Faucets, Toilets & Urinals." June 2014. 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

[CA Proclamation, 1-17-2014] California Declaration of Drought State of Emergency. January 17, 2014. http://gov.ca.gov/news.php?id=18379.

[CA Proclamation, 4-24-2014] California Proclamation of a Continued State of Emergency. April 24, 2014 http://gov.ca.gov/news.php?id=18496

California Native Plant Society. 2015. "Benefits of Native Plants." http://www.cnps.org/cnps/grownative/benefits.php

[CPUC] California Public Utilities Commission Energy Division. "Embedded Energy in Water Studies Study 1: Statewide and Regional Water-Energy Relationship." 2010. Prepared by GEI Consultants/Navigant Consulting. http://www.cpuc.ca.gov/PUC/energy/Energy+Efficiency/EM+and+V/Embedded+Energy+in+Water+Studies1_and_2.htm.

__. 2010b. "Embedded Energy in Water Studies Study 2: Water Agency and Function Component Study and Embedded Energy-Water Load Profiles." 2010. Prepared by GEI Consultants/Navigant Consulting. http://www.cpuc.ca.gov/PUC/energy/Energy+Efficiency/EM+and+V/Embedded+Energy+in+Water+Studies1_and_2.htm.

__. 2011a. "Embedded Energy in Water Studies. Study 3: End-use Water Demand Profiles." 2011. Prepared by Aquacraft Inc. CALMAC Study ID CPU0052. http://www.cpuc.ca.gov/PUC/energy/Energy+Efficiency/EM+and+V/Embedded+Energy+in+Water+Studies1_and_2.htm.

__. 2011b. "Embedded Energy in Water Pilot Programs Impact Evaluation: Final Report. Prepared by ECONorthwest." http://www.cpuc.ca.gov/NR/rdonlyres/51BF9A0B-42C9-4104-9E71-A993E84FEBC8/0/EmbeddedEnergyinWaterPilotEMVReport_Final.pdf

__. 2011c. "Order Approving Pilot Water Conservation Programs Within the Energy Utilities' Energy Efficiency Programs." December 20, 2007. Decision 07-12-050.

California Sustainability Alliance. "Water - Energy Toolkit For Sustainable Development : A Practical Guide To Implementing Water-Energy Conservation Policies And Projects For Local Governments, Developers, Water Agencies And Supporting Parties." 2013.

Christina-Smith, Juliet, Matthew Herberger, and Lucy Allen. 2012. "Urban Water Demand in California 2100: Incorporating Climate Change." Pacific Institute. http://pacinst.org/wp-content/uploads/sites/21/2014/04/2100-urban-water-efficiency.pdf.

[City of Los Angeles] City of Los Angeles, California. 2009. "Water Efficiency Requirements for New Development and Renovations of Existing Buildings." Ordinance Number 180822.

[DOE] United States Department of Energy. "Evaluating Domestic Hot Water Distribution System Options With Validated Analysis Models." September 2014. Prepared by E. Weitzel and M. Hoeschele Alliance for Residential Building Innovation. http://apps1.eere.energy.gov/buildings/publications/pdfs/building_america/evaluating_domestic_hot_water.pdf.

Cooley, H., & M. Heberger. 2013. "Key Issues in Seawater Desalination in California: Energy and Greenhouse Gas Emissions." Pacific Institute. http://pacinst.org/publication/energy-and-greenhouse-gas-emissions-of-seawater-desalination-in-california/.

[HCD] California Department of Housing and Community Development. "Excerpts from Draft Express Terms." March 20, 2015.

Howitt, R.E., J. Medellin-Azuara, D. MacEwan, J.R. Lund & D. A. Sumner. 2014. "Economic Analysis of the 2014 Drought for California Agriculture." Center for Watershed Sciences, University of California, Davis. https://watershed.ucdavis.edu/files/content/news/Economic_Impact_of_the_2014_California_Water_Drought.pdf

[Interagency Working Group] Interagency Working Group on Social Cost of Carbon, United States Government. 2013. "Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866." http://www.whitehouse.gov/sites/default/files/omb/inforeg/social_cost_of_carbon_for_ria_2013_update.pdf.

[IAPMO] 2014a International Association of Plumbing and Mechanical Officials. "IAPMO Green Plumbing and Mechanical Code Supplement (GPMCS) 2015 Proposed Changes for Public Comment." 2014. https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=2&cad=rja&uact=8&ved=0CCcQFjAB&url=http%3A%2F%2Fwww.iapmo.org%2FDocuments%2Fgreen%2FMatrix%2520of%25202015%2520GPMCS%2520Proposals.pdf&ei=7-B2VLuCIsOkgwTLroGABw&usg=AFQjCNHB-m_wjpt1d9cJLuFlDGnT21Cb0g&sig2=v2YJvl2y8Jr2vYcYkNa88g&bvm=bv.80642063,d.eXY.

__. "2014b "Report on Comments: A Compilation of IAPMO Plumbing Technical Committee Report on Comments for Review Prior to Consideration at the IAPMO September

Association Technical Convention." 2014 http://www.iapmo.org/UPC%20Report%20On%20Comments/2015%20Uniform%20Plumbing%20Code%20Cycle/2013%20UPC%20Report%20on%20Proposals.pdf.

[LADWP] Los Angeles Department of Water and Power. "Comments on Title 20 Rulemaking: Docket 12-AAER-2C." 2014. http://www.energy.ca.gov/appliances/2013rulemaking/documents/comments/12-AAER-2C_Water_Appliances/12-AAER-2C_LADWP_Email_Re_Support_and_Recommendations_Title_20_2014-06-06_TN-73174.pdf.

Marleni, N., S. Gray, A. Sharma, S. Burn and N. Muttil. "Scenario Analysis of Source Management Practices: Impact on Sewerage Networks." Conference Paper for 19th International Congress on Modelling and Simulation, Perth, Australia, 12–16 December 2011.

[MaP] Maximum Performance Testing.(2014). "Maximum Performance (MaP) Testing. "Database of High-efficiency Urinals (HEU)." Accessed November 24, 2014. http://www.map-testing.com/downloads.html.

[Raftelis 2008]. Raftelis Financial Consultants, Inc. 2008 "Water and Wastewater Rate Survey." Prepared for American Water Works Association. Values from Western Region.

__. 2011 "2011 California-Nevada Water Rate Survey." Prepared for California-Nevada Section, American Water Works Association.

[SFPUC] San Francisco Public Utilities Commission. (2013, June 3). "Letter to California Energy Commission Appliance Efficiency Standard Staff Regarding 2013 Appliance Efficiency Rulemaking for Water Appliances." Docket 12-AAER-2C. 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.

[SPUC] Seattle Public Utilities Commission. "An On-The-Ground Perspective: How High Efficiency Restroom Fixtures Really Perform." 2010.

[SWRCB]. California Environmental Protection Agency, State Water Resources Control Board. "The California Water Boards' Annual Performance Report FY 2010-11." 2012. Accessed November 28, 2014: http://www.waterboards.ca.gov/about_us/performance_report_1011/plan_assess/12514_ww_reclamation.shtml.

United States Drought Portal. 2015. "U.S. Drought Monitor – California." National Integrated Drought Information System. http://www.drought.gov/drought/area/ca

[U.S. EPA] "Water: Sustainable Infrastructure: Sustainable Water Infrastructure." EPA Water Website. Accessed July 2013. http://water.epa.gov/infrastructure/sustain/wec_wp.cfm

[USGS] United States Geological Survey. 2014. "The California Drought." California Water Science Center. http://ca.water.usgs.gov/data/drought/drought-impact.html

___. 2015. "Table of daily streamflow compared to historical streamflow for the day of the year (California)". WaterWatch.

http://waterwatch.usgs.gov/index.php?region_cd=ca&map_type=pa01d&web_type=table2

[UC Berkeley]. University of California, Berkeley "California Workforce Training and Needs Assessment for Energy Efficiency, Distributed Generation and Demand Response." 2011. http://www.irle.berkeley.edu/vial/publications/WET_Part1.pdf.

[UC Davis]. University of California Davis Center for Watershed Sciences. "Economic Analysis of the 2014 Drought for California Agriculture." 2014. Available online at: https://watershed.ucdavis.edu/files/biblio/DroughtReport_23July2014_0.pdf.

Water Reuse Foundation. "Project to Conduct Survey Research to Obtain Information/Data from All Water Recycling Facilities in California." 2008. http://www.watereuse.org/files/s/docs/06-001-01.pdf .

[WaterSense 2007a] U.S.EPA WaterSense. 2007. "EPA WaterSense ® Response to Public Comments Received on February 2007 Draft WaterSense® High-Efficiency Bathroom Sink Faucet Specification." http://www.epa.gov/WaterSense/docs/faucet_comment_response508.pdf.

__. 2007b. "High-Efficiency Lavatory Faucet Specification." 2007.

__. 2007c U.S.EPA WaterSense. "U.S.EPA WaterSense ® High-Efficiency Lavatory Faucet Specification Supporting Statement". 2007http://www.epa.gov/WaterSense/docs/faucet_suppstat_final508.pdf.

__. 2009a. "WaterSense Specification for Flushing Urinals: Version 1.0." (2009). https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0CCAQFjAA&url=http%3A%2F%2Fwww.epa.gov%2FWaterSense%2Fdocs%2Furinal_finalspec508.pdf&ei=lSySVPLLNIqeyASewYLYAw&usg=AFQjCNEycoP109nOk2B1dKuLAYyvGqz2zw&sig2=0Klfpc8luMyuFn_AK4wibw&bvm=bv.82001339,d.aWw.

__. 2009b. "WaterSense Specification for Flushing Urinals Supporting Statement: Version 1.0." (2009). https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=2&ved=0CCcQFjAB&url=http%3A%2F%2Fwww.epa.gov%2FWaterSense%2Fdocs%2Furinal_suppstat508.pdf&ei=lSySVPLLNIqeyASewYLYAw&usg=AFQjCNHidM7DAjyEezBaN0L7HQMllHcvLw&sig2=WYNu6ulr5cas7GGWkNFgwQ&bvm=bv.82001339,d.aWw.

__. 2009c. "Comments on the January 2009 Draft Specification for High-Efficiency Flushing Urinals." (2009). https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0CCAQFjAA&url=http%3A%2F%2Fwww.epa.gov%2FWaterSense%2Fdocs%2Furinal_comments508.pdf&ei=aiySVOWcMMSmyATKioKIBA&usg=AFQjCNEUdTOzLE32sSP09noDaAhvjL6mDQ&sig2=O6FKn4UZSJU-92IX0DoNdQ.

__. 2009d. "Response to Comments Received on the January 2009 Draft WaterSense High-Efficiency Flushing Urinals Specification." (2009). https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=2&cad=rja&uact=8&ved=0CCgQFjAB&url=http%3A%2F%2Fwww.epa.gov%2FWaterSense%2Fdocs%2Furinal_comment_response508.pdf&ei=aiySVOWcMMSmyATKioKIBA&usg=AFQjC

NFN9lMTmrnKSHK8et4hd0h2svy6PA&sig2=XCK1iPzWuhM1IESMdIXIVg&bvm=bv.82001339,d.aWw.

__. 2012. "Saving Water in Restaurants. 2012.

__. 2013a. "WaterSense: Our Water: Why Water Efficiency." WaterSense Website. Accessed July 2013. http://www.epa.gov/watersense/our_water/why_water_efficiency.html.

__. 2014a. "WaterSense Specification for Tank-Type Toilets: Version 1.2." Accessed March 2015. http://www.epa.gov/WaterSense/docs/Revised%20HET%20specification_V1%202_060214_final508d.pdf

__. 2014b. WaterSense Product Search. http://www.epa.gov/watersense/product_search.html.

10. APPENDIX A: ECONOMIC AND FISCAL IMPACT STATEMENT (INPUT FOR FORM 399)

This appendix provides information required by the California Department of Finance Economic and Fiscal Impact Statement (Form 399) which is available on the California Building Commission website.[25] This information includes the proposed standards for urinals, toilets, lavatory faucets and compact design (Costs may be lower to the extent that builders are able to utilize the recirculation system option at lower cost). Information on the methodology used for these calculations is explained under item D.3 below.

Economic Impact Statement

A. ESTIMATED PRIVATE SECTOR COST IMPACTS

Estimated economic impact. (Form 399 Economic Impacts Section A.2)

The estimated total Economic and Fiscal Impact is $8.1million. Estimated impacts are based on 12 months of implementation, consistent with the instructions for the Economic Impact Statement item (E.4).

Number of businesses impacted. (Form 399 Economic Impacts Section A.3)

This measure does not directly regulate California businesses, however the Utility C&S Team does expect that California businesses will generally benefit from the standards as noted below.

Number and type of businesses and jobs created and eliminated. (Form 399 Economic Impacts Section A.4, A.6, and A.7)

The proposed Standards are cost effective over the life of the measure and are likely to increase total jobs and businesses in California. Though increasing water efficiency in California's buildings will have short term initial costs, the long term benefits of decreased utility costs and increased statewide water supply far outweigh the initial costs of compliance. The proposed Standards will also increase disposable income for individuals, which may increase in-state spending.

While the specific number of businesses and jobs that will be created based from the implementation of the proposed Standards is not certain, several types of industries are likely to benefit. The University of California Berkeley evaluated the expected impacts of a range of residential and commercial sector policies including water efficiency, energy efficiency, renewable generation and demand response. The research found that the following industries, as classified under the North American Industry Classification System (NAICS), are the most likely to be positively impacted (UC Berkeley 2011; Table 3.10 et seq., pages 69-75)[26]:

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[25] Form 399 is available, as of March 29, 2015, from this website: http://www.documents.dgs.ca.gov/bsc/proc_rsltn/2009/STD-399-EconomicandFiscalImpactStatement.pdf

[26] Note that the water-energy nexus is included in the scope of policies addressed per Table 3.1.

- Residential Building Construction (NAICS 2361)
- Nonresidential Building Construction (NAICS 2362)
- Electrical Contractors (NAICS 23821)
- Plumbing, Heating, and Air-Conditioning Contractors (NAICS 23822)
- Manufacturing (NAICS 32412, 3279, 3332, 3334, 3336, 3341, 3342, 3344, 3345, 3351, 3352, 3353, 3359 (part))
- Advertising and Related Services (NAICS 5418)
- Engineering Services, Architectural Services, Environmental Consulting Services, Other Scientific and Technical Consulting Services (NAICS 54 (part))
- Management of Companies and Enterprises, Public Administration (NAICS 5511, 92 (part))
- Office Administrative Services (NAICS 5611)
- Drywall and Insulation Contractors (NAICS 23831

B. ESTIMATED COSTS

The total statewide dollar costs that businesses and individuals may incur to comply with this regulation over its lifetime. (Form 399 Economic Impacts Section B.1.)

The sum of the proposed measure costs for all newly constructed buildings, additions and alternations in 2017 is $8.1 million. The Statewide Utility C&S Team does not expect any increased future maintenance nor increased equipment replacement costs.

Initial costs for a small business and initial costs for a typical business. (Form 399 Economic Impacts Section B.1a and B.1b.)

The proposed Standards do not directly regulate California businesses.

Initial costs to an individual. (Form 399 Economic Impacts Section B.1(c).)

The initial cost to an average individual is approximately $0.21. The initial cost to an individual purchasing an average new single family home in 2017 is $62, with lifecycle benefits much higher than upfront costs.

Low-rise multifamily buildings (those with three or fewer habitable stories) are also subject to the proposed residential Standards. The cost of residential construction impacts the building owner and the not individual tenants in rental situations. If multi-family dwelling units are included in the calculation for all newly constructed residential buildings along with single-family homes, the average initial cost for an individual home buyer would be $61 based on a ratio derived from relative costs reported by the CEC for energy and water efficiency standards (CEC 2015c). The cost impact of the proposed standards for additions and alterations is based on a multiplier estimate of the ratio of dollar activity of residential newly constructed buildings to residential additions and alterations provided by the California Industrial Relations Board.

Describe other economic costs that may occur. (Form 399 Economic Impacts Section B.1d.)

The Utility C&S Team does not expect any other economic costs to occur.

If multiple industries are impacted, enter the share of total costs for each industry. (Form 399 Economic Impacts Section B.2.)

The Utility C&S Team estimates that the share of total costs will be approximately 63 percent for nonresidential construction and approximately 37 percent for residential construction. This is based on CEC's estimates for proposed energy and water efficiency standards (CEC 2015c).

Impacts to housing costs. (Form 399 Economic Impacts Section B.4.)

The estimated average initial cost per housing unit (single family and low-rise multi-family buildings) of newly constructed housing in 2017 is $61.

The number of housing units (132,400) is an approximate value that represents the total estimated number of newly constructed single family homes (108,033) and low-rise multifamily buildings (24,309) in 2017 (CEC 2015c). High-rise, multi-family buildings (over 4 stories) are regulated as nonresidential buildings in the Title 24 Standards. The potential costs for high-rise, multi-family buildings are likely to be comparable, on a per unit basis, to low-rise multi-family buildings.

Are there comparable Federal regulations? (Form 399 Economic Impacts Section B.5.)

On December 22, 2010, the United States (U.S.) Department of Energy (DOE) waived federal preemption for energy and water conservation standards with respect to any state regulation concerning the water use or water efficiency of products including faucets, showerheads, and urinals (75 Fed. Reg.245, 22 December 2010). This waiver allows states to set their own standards for the relevant plumbing products as long as the state standard is as stringent than the federal standard. Therefore, California has authority to set state standards that achieve greater water and energy savings and economic benefits.

C. ESTIMATED BENEFITS

Briefly summarize the benefits of the regulation, which may include the health and welfare of California residents, worker safety, and the State's environment. (Form 399 Economic Impacts Section C.1.)

Individuals and businesses will benefit from the reduction in water and energy costs as noted below. Businesses that provide water conservation and energy efficiency products and services may experience an increase in revenue and employment. All State and local government agencies and their tenants will benefit. Agriculture and other water-dependent industries will benefit from reduced competition for water supplies.

Additional environmental benefits include improved water quality and supply, benefits to aquatic ecosystems, and associated greenhouse gas reductions and air quality improvements.

Are benefits the result of specific statutory requirements, or goals developed by the agency based on broad statutory authority? (Form 399 Economic Impacts Section C.2.)

The Building Standards Commission (BSC) has authority granted by statute to adopt statewide building energy efficiency standards.

What are the total statewide benefits from this regulation over its lifetime? (Form 399 Economic Impacts Section C.3.)

The total economic benefits of the proposed Standards are $26.5 million. This value is the sum of the net water and energy savings for all newly constructed buildings, discounted to 2015 dollars, for implementation of the proposed measures in 2017. As noted above, this measure will also result in additional non-quantified benefits.

Briefly describe any expansion of businesses currently doing business within the State of California that would result from this regulation. (Form 399 Economic Impacts Section C.4.)

California businesses producing water efficiency products or services that meet or exceed the proposed Standards will likely expand their sales of those products and services due to the implementation of the proposed Standards. In addition, cost savings and reduced pressure on California's dwindling water supplies are likely to provide benefits to a wide range of California businesses.

D. ALTERNATIVES TO THE REGULATION

List alternatives considered and describe them below. If no alternatives were considered, explain why not. (Form 399 Economic Impacts Section D.1.)

At this time the Utility C&S Team is not aware of alternatives to the proposed regulations that would be more effective than the proposed regulations in achieving water and energy efficiency goals, or that would be equally effective and have a lower adverse impact on small businesses (or on any other economic interests). The Utility C&S Team conducted an extensive stakeholder engagement process that considered many suggestions from stakeholders about (1) alternatives that could improve the feasibility of the proposed regulations or could reduce their adverse impacts; (2) the technical and cost-effectiveness analyses of those preliminary proposals; and (3) the language in those proposals. The main suggestions and the Utility C&S Team's responses are discussed further in the "Indoor Domestic Water Use Efficiency CALGreen CASE Report" (Sections 7 and 8 addressing stakeholder outreach and alternatives analysis).

Summarize the total statewide costs and benefits from this regulation and each alternative considered. (Form 399 Economic Impacts Section D.2.)

The total statewide costs are $8.1 million and benefits are $26.5million in 2015 dollars over the lifetime of the proposed Standards (effective 2017). Since there were no alternatives that were considered to be equally or more effective than the proposed Standards, no alternatives were included in this analysis.

Briefly discuss any quantification issues that are relevant to a comparison of estimated costs and benefits for this regulation or alternatives. (Form 399 Economic Impacts Section D.3.)

Per unit costs are based on the per unit costs listed in the Indoor Domestic Water Use Efficiency CALGreen CASE report section 5.4.

Expected produce lifetimes are 10 years, 12 years, and 25 years for faucets, urinals and toilets respectively and 30 years for compact hot water distribution design, as noted in section 4.5 of the Indoor Domestic Water Use Efficiency CALGreen CASE report. These estimates are based on CEC estimates (30 years for residential building envelope measures and 15 years for others) tailored based on additional information for specific products.

Deployment rates are based on total market sales minus baseline sales of energy efficient products as listed in Appendix B of the Indoor Domestic Water Use Efficiency CALGreen CASE. (Sources of market sales data are CA IOUs 2013a, CA IOUs 2013b, CEC Demand Analysis Office)

Were performance standards considered to lower costs? (Form 399 Economic Impacts Section D.4.)

Performance standards were considered. However, a prescriptive approach was determined to be the simplest and most practical implementation option. In addition, the proposed Standards will provide greater benefits than costs.

E. MAJOR REGULATIONS

Will the regulation subject to OAL review have an estimated economic impact to business enterprises and individuals located in or doing business in California exceeding $50 million in any 12-month period between the date the major regulation is estimated to be filed with the Secretary of State through 12 months after the major regulation is estimated to be fully implemented? (Form 399 Economic Impacts Section E.4.)

The economic impact to business enterprises and individuals located in or doing business in California does not exceed $50 million during this period because the total economic impact is less than $50 million as stated on line A.2 of Form 399.

Fiscal Impact Statement

A. FISCAL EFFECT ON LOCAL GOVERNMENT

Additional expenditures and savings. (Form 399 Fiscal Impacts Statement A.2, A2.f and A.3.)

The first year the proposed standards will be in effect is 2017. Data on local government existing building stock is very limited, as is data on proposed local government building construction. Only local government owned buildings, not leased buildings, are relevant to these calculations. These expenditures and savings values were calculated based on an estimate that less than 1 percent of the total costs of newly constructed residential buildings, additions, and alterations to existing buildings would apply to local government. This estimate is based on a ratio of publicly-owned housing units to total housing units.[27]

Based on these assumptions, the expenditures per year in line A.2 of Form 399 are estimated at $21,000 while the net present value annual savings are estimated at $67,000. This regulation is not reimbursable because it provides savings that will offset the additional costs (see line A.2.f of Form 399).

B. FISCAL EFFECT ON STATE GOVERNMENT

Additional expenditures and savings. (Form 399 Fiscal Impacts Statement B.1 and 2.)

No significant additional costs to state-owned facilities are expected.

The state will realize direct cost savings of $25,000 annually. The state will also realize potential savings from partial mitigation of drought-related unemployment and emergency relief and decreased loss of tax revenues. These positive effects have not been quantified.

C. FISCAL EFFECT ON FEDERAL FUNDING OF STATE PROGRAMS. (Form 399 Fiscal Impacts Statement C.4.)

State agencies that are reimbursed for construction and/or utility costs by the federal government may have higher upfront costs and reduced utility costs. Changes in federal reimbursements could offset these costs and savings.

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[27] This number is based on 13,790,495 total California housing units per "California", US Census, accessed 3-29-2015, http://quickfacts.census.gov/qfd/states/06000.html; and US Housing and Urban Development data showing that California total public housing equals 360,000 units (based on aggregating 100 jurisdictions).

11. APPENDIX B: COST AND BENEFITS METHODOLOGY AND ASSUMPTIONS

11.1 Water and Energy Savings Analysis Methodology

11.1.1 Water and Energy Savings Analysis Methodology: Lavatory Faucets

To calculate statewide water and energy impacts of the proposed lavatory faucet proposal, the Utility C&S Team first estimated annual impacts per unit, as explained in Table 19. Per unit impacts were extrapolated to statewide savings using the faucet installation estimates shown in Table 20. The Title 20 CASE Report includes more information about assumptions (CA IOUs 2013a). The analysis presented here only includes units that are installed in newly constructed buildings; savings from retrofits are not included.

When calculating statewide impacts, it was assumed that 4.7 percent of faucets installed in new construction would be 1.0 gpm even if the proposed standard is not adopted. Only those savings from the other 95.3 percent of faucets that use more than 1.0 gpm before the standard is adopted are included in estimates presented in Table 19.

The number of faucets in buildings with natural gas or electric water heating was derived using data from the CEC's 2009 California Statewide Residential Appliance Saturation Study (RASS) (CEC 2009). The study found that 92.7 percent of homes have water heating. Of these homes, 87.9 percent have natural gas water heaters, 7.6 percent have electric water heaters, 4.3 percent have propane heaters, and the remaining households use propane, solar or another source for water heating. The cost and energy analysis presented in this report includes energy and cost savings from homes with natural gas or electric water heaters.

Table 19: Water Savings Assumptions and Findings: Faucets

Metric	Value	Source / Notes
Assumptions		
Lavatory Faucet Events per Day [A]	7.81 lavatory faucet events per household/day	Aquacraft. 2011, CA IOUs 2013a, IOU Team Analysis
Average Duration of Faucet Event [B]	37 seconds	Aquacraft et. al. 2011
Baseline Flow Rate [C]	1.5 gallons per minute (gpm)	Current CALGreen Standard
Proposed Flow Rate [D]	1.0 gpm	Proposed CALGreen Standard
1.5 gpm flowrate derating factor [E]	0.67	Aquacraft 2000
1.0 gpm flowrate derating factor [F]	0.75	Aquacraft 2004
Additional water wasted when waiting for hot-enough water to arrive (1.5 gpm v. 1.0 gpm) [G]	0.14 gallons per faucet per day	PMI 2014
Percent of Water Use that is Hot [H]	50%	WaterSense 2007c, EBMUD 2003, A
Percent of Households with Natural Gas Water Heating [I]	81.52%	RASS 2009

Percent of Households with Electric Water Heating [J]	7.08%	RASS 2009
Percent of Households with no Water Heater or Other Water Heating [K]	11.4%	RASS 2009
Natural Gas Required to Heat Water [L]	8,133 Therms/million gallons	Assumes cold water inlet temperature is 65°F and hot water supply is 124 °F, and a gas storage water heater with an energy factor of 0.60.
Electricity Required to Heat Water [M]	147.5 MWh/ million gallons	Assumes cold water inlet temperature is 65°F and hot water supply is 124 °F, and an electric storage water heater with an energy factor of 0.97.
Embedded Electricity Factor [N]	10.045 MWh/million gallons	CEC 2006, Population-weighted average embedded electricity value for indoor water use assuming 39.1% of California's population is in Northern California and 60.95 in Southern California.
Faucets added per year in new construction in 2017 [O]	315,046	CA IOUs 2013a
Percent of faucets expected to be 0.125 gal/flush (lo flow) without standard [P]	4.66%	CA IOUs 2013a
Results		
Annual Water Use per Faucet (Baseline) [Q]	1,767 gallons/faucet/yr	Q = A × B ÷ 60 sec/min × C × E × 365 days/yr
Annual Water Use per Faucet (Proposed) [R]	1,370 gallons/faucet/yr	R = A × B ÷ 60 sec/min × D × F × 365 days/yr + H
Annual Water Savings per Faucet [S]	397 gallons/faucet/yr	S = Q − R
Statewide Annual Water Savings in 2017 (first year standards are in place) [T]	119.3 million gallons/yr	T = S × (1-P) × O / 10^6
Statewide Annual Natural Gas Savings from Water Heating in 2017 (first year standards are in place) [U]	0.40 million therms /yr	U = T × H × I × L ÷ 1 million therms
Statewide Annual Electricity Savings from Water Heating in 2017 (first year standards are in place) [V]	623 MWh /yr	V = T × H × J × M
Statewide Annual Embedded Electricity Savings in 2017 (first year standards are in place) [W]	1,199 MWh/yr	W = T × N

Table 20: Lavatory Faucets Installed in Newly Constructed Residential Buildings

Source: CA IOUs 2013a

Year	Units Installed in Newly Constructed Buildings
2017	256,838
2018	261,027
2019	265,325
2020	269,676
2021	274,032
2022	278,460
2023	282,961
2024	287,536
2025	292,186
2026	296,912
2027	301,717
2028	306,601
2029	311,565
2030	256,838

11.1.2 Water and Energy Savings Analysis Methodology: Urinals

To calculate statewide water and energy impacts, the Utility C&S Team first estimated annual impacts per urinal, as explained in Table 21. Per unit impacts were extrapolated to statewide savings using the urinal installation estimates shown in Table 22. The Title 20 Codes and Standards Enhancement (CASE) Report includes more information about assumptions for urinal installations (CA IOUs 2013b). The analysis presented here only includes urinals that are installed in newly constructed buildings; savings from retrofits are not included.

When calculating statewide impacts, it was assumed that 35 percent of urinals installed in new construction would be 0.125 gpf urinals even if the proposed standard is not adopted. Only savings from the other 65 percent urinals that use more than 0.125 gpf before the standard takes effect are included in estimates presented in Table 21.

Table 21: Water Savings Assumptions and Findings: Urinals

Metric	Value	Source / Notes
Assumptions		
Daily Flushes per Urinal [A]	18 flushes/day	WaterSense 2009b
Flush Days per Year [B]	260 days/yr	WaterSense 2009b
Baseline Flush Volume [C]	0.5 gallons/flush	Current CALGreen Standard
Proposed Flush Volume [D]	0.125 gallons/flush	Proposed CALGreen Standard
Embedded Electricity Factor [E]	10,045 kWh/million gallons	CEC 2006, Population-weighted average embedded electricity value for indoor water use assuming 39.1% of California's population is in Northern

		California and 60.9% in Southern California.
Urinals added per year in new construction in 2017 [F]	8,145	CA IOUs 2013b
Percent of urinals expected to be 0.125 gal/flush (low flow) without standard [G]	35%	CA IOUs 2013b
Results		
Annual Water Use per Urinal (Baseline) [H]	2,340 gallons/urinal/yr	H = A × B × C
Annual Water Use per Urinal (Proposed) [I]	585 gallons/urinal/yr	I = A × B × D
Annual Water Savings per Urinal [J]	1,755 gallons/urinal/yr	J = H – I
Statewide Annual Water Savings in 2017 (first year standards are in place) [K]	9.3 million gallons gal/yr	K = J × (1-G) × F ÷ 1 million gallons
Statewide Annual Electricity Savings in 2017 (first year standards are in place) [L]	93,435 kWh/yr	L = K × E

Table 22: Annual Urinal Installations in Newly Constructed Buildings (2017 – 2028)

Source: CA IOUs 2013b

Year	Urinals Installed in Newly Constructed Buildings
2017	8,145
2018	8,202
2019	8,259
2020	8,317
2021	8,375
2022	8,434
2023	8,493
2024	8,552
2025	8,612
2026	8,672
2027	8,733
2028	8,794

11.1.3 Water and Energy Savings Analysis Methodology: Premium Efficiency Water Closets

To calculate statewide water and energy impacts, the Utility C&S Team first estimated annual impacts per toilet, as explained in Table 23. Per unit impacts were extrapolated to statewide savings using the toilet installation estimates shown in Table 24. The Title 20 Codes and Standards Enhancement (CASE) Report includes more information about assumptions for toilet installations (CA IOUs 2013b). The analysis presented here only includes toilets that are installed in newly constructed buildings; savings from retrofits are not included.

When calculating statewide impacts, it was assumed that 1 percent of toilets installed in new construction would be 1.06 gpf toilets even if the proposed standard is not adopted. It was also assumed that due to the proposed standard being adopted, 15 percent of toilets installed in new construction in 2017 would be 1.06 gpf. Only savings from the 14 percent of toilets that will comply with the proposed efficiency level as a result of the standard being adopted are counted in the statewide savings estimates presented in Table 23.

Table 23: Water Savings Assumptions and Findings: Premium Efficiency Water Closet

Metric	**Value**	**Source / Notes**
Assumptions		
Daily Flushes per Person per Day [A]	4.76 flushes/person/day	Aquacraft et. al. 2011
Number of Toilets per Person [B]	0.64 toilets/person	CA IOUs 2013b; based on estimates of total toilet stock in 2010 (24 million) divided by total California population in 2010 (37.3 million)
Flush Days per Year [C]	365 days/yr	
Baseline Flush Volume [D]	1.28 gallons per flush (gpf)	Current CALGreen Standard
Proposed Flush Volume [E]	1.06 gpf	Proposed CALGreen Standard
Embedded Electricity Factor [F]	10,045 kWh/million gallons	CEC 2006, Population-weighted average embedded electricity value for indoor water use assuming 39.1% of California's population is in Northern California and 60.9% in Southern California.
Toilets installed in new construction in 2017 [G]	288,966	CA IOUs 2013b
Assumed percentage of toilets expected to be 1.06 gpf without standard [H]	1%	Naturally occurring market adoption is assumed to be low due to current low market adoption rates.
Assumed percentage of toilets expected to comply with 1.06 gpf standard [I]	15%	The list of cities identified by BSC as customizing building codes and identified by Utility C&S Team as adopting water measures include: Daily City, Irwindale, Los Angeles, Mountain View, Napa, Palo Alto, Pomona, San Francisco, and Santa Rosa with a total of 15% of the state population. Note that while not every city has adopted all CALGreen water measures, we assume that the 15% estimate is conservative due to the drought emergency.
Results		

Annual Water Use per Toilet (Baseline) [J]	3,450 gallons/toilet/yr	J = A ÷ B × C × D
Annual Water Use per Toilet (Proposed) [K]	2,857 gallons/toilet/yr	K = A ÷ B × C × E
Annual Water Savings per Toilet [L]	593 gallons/toilet/yr	L = J – K
Statewide Annual Water Savings in 2017 (first year standards are in place) [M]	24 million gallons gal/yr	K = L × G × (1 – H - I) ÷ 1 million gallons
Statewide Annual Embedded Electricity Savings in 2017 (first year standards are in place) [N]	240,968 kWh/yr	N = M × F

Table 24: Annual Toilets Installations in Newly Constructed Buildings (2017 – 2039)

Source: CA IOUs 2013b

Year	Toilets Installed in Newly Constructed Buildings
2017	288,966
2018	293,633
2019	298,421
2020	303,268
2021	308,122
2022	313,056
2023	318,070
2024	323,166
2025	328,345
2026	333,609
2027	338,960
2028	344,398
2029	349,925
2030	355,542
2031	361,252
2032	367,055
2033	372,954
2034	378,949
2035	385,042
2036	391,235
2037	397,530
2038	403,928
2039	410,432

11.1.4 Water and Energy Savings Analysis Methodology: Compact Hot Water Distribution Design

This analysis uses the per building water and natural gas savings estimates presented in the Single Family Water Heating Distribution System Improvements CASE Report that the CA IOUs developed for the 2013 code change cycle for Title 24, Part 6 (CA IOUs 2012).The methodology and assumptions used to calculate first year statewide water and energy impacts, including embedded energy savings, are presented in Table 25.

The CEC Demand Analysis Office provided the projected annual residential dwelling starts for the single family and multifamily sectors for use analyses the Utility C&S Team completed cost effectiveness analyses on proposed change to Part 6 of Title 24. CEC provided three projections: low, mid and high estimates with each case broken out by forecast climate zones (FCZ). The Utility C&S Team translated this data to building climate zones (BCZ) using the weighting of FCZ to BCZ as presented in Table 26. The Utility C&S Team used the mid scenario of forecasted single family residential new construction for statewide savings estimates used in this analysis (see Table 27).

When calculating statewide impacts, it was assumed that 1 percent of newly constructed single family homes would be built incompliance with the proposed standard, even if the standard is not adopted. It was also assumed that due to the proposed standard being adopted, 15 percent of newly constructed single family homes would meet the proposed requirements. Only savings from the 14 percent homes that will comply as a result of the standard being are adopted are counted in estimates of statewide impacts.

Table 25:Water Savings Assumptions and Findings: Compact Hot Water Distribution Design

Metric	Value	Source / Notes
Assumptions		
Annual water savings per home [A]	2,550 gallons/home/yr	CA IOUs 2012
Annual natural gas savings per home [B]	24.2 therms/home/yr	CA IOUs 2012
Embedded Electricity Factor [C]	10,045 kWh/million gallons	CEC 2006, Population-weighted average embedded electricity value for indoor water use assuming 39.1% of California's population is in Northern California and 60.9% in Southern California.
New home construction in 2017 [D]	108,849	CEC Demand Forecasting
Percent of households with natural gas water heating [E]	81.52%	RASS 2009
Assumed percentage of expected to comply with proposal even if standard is not adopted [F]	1%	Naturally occurring market adoption is assumed to be low due to current low market adoption rates.
Assumed percentage of expected to comply with proposal after standard is	15%	The list of cities identified by BSC as customizing building codes and

adopted [G]		identified by Utility C&S Team as adopting water measures include: Daily City, Irwindale, Los Angeles, Mountain View, Napa, Palo Alto, Pomona, San Francisco, and Santa Rosa with a total of 15% of the state population. Note that while not every city has adopted all CALGreen water measures, we assume that the 15% estimate is conservative due to the drought emergency.
Results		
Statewide annual water savings in 2017 (first year standards are in place) [H]	24 million gallons gal/yr	H = A × D × (G – F) ÷ 1 million gallons
Statewide Annual natural gas savings in 2017 (first year standards are in place) [I]	1.8 million therms/yr	I = B × D × E × (G – F) ÷ 1 million gallons
Statewide Annual Embedded Electricity Savings in 2017 (first year standards are in place) [J]	2,398 MWh/yr	J = H× C

Table 26: Translation from FCZ to BCZ

		Building Standards Climate Zones (BCZ)																
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Grand Total
Forecast Climate Zones (FCZ)	1	22.51%	20.62%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	9.80%	33.14%	0.16%	0.00%	0.00%	13.77%	100.00%
	2	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	22.00%	75.70%	0.00%	0.00%	0.00%	2.30%	100.00%
	3	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	20.95%	22.76%	54.50%	0.00%	0.00%	1.79%	100.00%
	4	0.15%	13.73%	8.36%	46.03%	8.94%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	22.81%	0.00%	0.00%	0.00%	0.00%	100.02%
	5	0.00%	4.23%	89.13%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	6.64%	0.00%	0.00%	0.00%	0.00%	100.00%
	6	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	100.00%
	7	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	75.80%	7.08%	0.00%	17.12%	100.00%
	8	0.00%	0.00%	0.00%	0.00%	0.00%	40.37%	0.00%	51.08%	8.09%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.46%	100.00%
	9	0.00%	0.00%	0.00%	0.00%	0.00%	6.97%	0.00%	24.54%	57.85%	0.00%	0.00%	0.00%	0.00%	6.68%	0.00%	3.95%	99.99%
	10	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	74.90%	0.00%	0.00%	0.00%	12.27%	7.90%	4.93%	100.00%
	11	0.00%	0.00%	0.00%	0.00%	0.00%	33.04%	0.00%	24.75%	42.21%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
	12	0.00%	0.00%	0.00%	0.00%	0.00%	0.92%	0.00%	20.20%	75.19%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	3.69%	100.00%
	13	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	69.55%	0.00%	0.00%	28.77%	0.00%	0.00%	0.00%	1.56%	0.09%	0.00%	99.97%
	14	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
	15	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.12%	99.88%	0.00%	100.00%
	16	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
	17	2.95%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	97.05%	100.00%

Table 27:New Construction Forecast

Source: CEC Demand Analysis Office

Year	Newly Constructed Single Family Buildings
2017	108,849
2018	110,723
2019	112,646
2020	114,595
2021	116,543
2022	118,524
2023	120,539
2024	122,588
2025	124,672
2026	126,792
2027	128,947
2028	131,139
2029	133,369
2030	135,636
2031	137,942
2032	140,287
2033	142,672
2034	145,097
2035	147,564
2036	150,072
2037	152,623
2038	155,218
2039	157,857
2040	160,540
2041	163,270

11.2 Greenhouse Gas Emissions Impacts Methodology

The avoided GHG emissions were calculated assuming an emission factor of 353 metric tons of carbon dioxide equivalents ($MTCO_2e$) per GWh of electricity savings. The Utility C&S Team calculated air quality impacts associated with the electricity savings from the proposed measure using emission factors that indicate emissions per GWh of electricity generated.[28]

[28] California power plants are subject to a GHG cap and trade program and linked offset programs until 2020 and potentially beyond.

When evaluating the impact of increasing the Renewable Portfolio Standard (RPS) from 20 percent renewables by 2020 to 33 percent renewables by 2020, California Air Resources Board (CARB) published data on expected air pollution emissions for various future electricity generation scenarios (CARB 2010). The Utility C&S Team used data from CARB's analysis to inform the air quality analysis presented in this report.

The GHG emissions factor is a projection for 2020 assuming the state will meet the 33 percent RPS goal. CARB calculated the emissions for two scenarios: (1) a high load scenario in which load continues at the same rate; and (2) a low load rate that assumes the state will successfully implement energy efficiency strategies outlined in the AB32 scoping plan thereby reducing overall electricity load in the state.

To be conservative, the Utility C&S Team calculated the emissions factors of the incremental electricity between the low and high load scenarios. These emission factors are intended to provide a benchmark of emission reductions attributable to energy efficiency measures that could help achieve the low load scenario. The incremental emissions were calculated by dividing the difference between California emissions in the high and low generation forecasts by the difference between total electricity generated in those two scenarios. While emission rates may change over time, 2020 was considered a representative year for this measure.

Avoided GHG emissions from natural gas savings were calculated using an emission factor of 5,303 $MTCO_2e$/million therms (U.S. EPA 2011).

11.3 Greenhouse Gas Valuation Discussion

The climate impacts of pollution from fossil fuel combustion and other human activities, including the greenhouse gas effect, present a major risk to global economies, public health and the environment. While there are uncertainties of the exact magnitude given the interconnectedness of ecological systems, at least three methods exist for estimating the societal costs of GHGs 1) the Damage Cost Approach 2) the Abatement Cost Approach and 3) the Regulated Carbon Market Approach. See below for more details regarding each approach.

11.3.1 Damage Cost Approach

In 2007, the U.S. Court of Appeals for the Ninth Circuit ruled that the National Highway Transportation Traffic Safety Administration (NHTSA) was required to assign a dollar value to benefits from abated carbon dioxide emissions. The court stated that while there are a wide range of estimates of monetary values, the price of carbon dioxide abatement is indisputably non-zero. In 2009, to meet the necessity of a consistent value for use by government agencies, the Obama Administration established the Interagency Working Group on the Social Cost of Carbon to establish official estimates (Johnson and Hope).

The Interagency Working Group primarily uses estimates of avoided damages from climate change which are valued at a price per ton of carbon dioxide, a method known as the damage cost approach.

11.3.2 Interagency Working Group Estimates

The Interagency Working Group SCC estimates, based on the damage cost approach, were calculated using three climate economic models called integrated assessment models which include the Dynamic Integrated Climate Economy (DICE), Policy Analysis of the Greenhouse Effect (PAGE), and Climate Framework for Uncertainty, Negotiation, and Distribution (FUND) models. These models incorporate projections of future emissions translated into atmospheric concentration levels which are then translated into temperature changes and human welfare and ecosystem impacts with inherent economic values. As part of the Federal rulemaking process, DOE publishes estimated monetary benefits using Interagency Working Group SCC values for each Trial Standard Level considered in their analyses, calculated as a net present value of benefits received by society from emission reductions and avoided damages over the lifetime of the product. The recent U.S. DOE Final Rulemaking for microwave ovens contains a Social Cost of Carbon section that presents the Interagency Working Group's most recent SCC values over a range of discount rates (DOE 2013) as shown in Table 28. The two $ metric ton of values used in this CASE report were taken from the two highlighted columns, and converted to 2013 dollars.

Table 28: Social Cost of CO_2 2010 – 2050 (in 2007 dollars per metric ton of CO_2) (source: Interagency Working Group on Social Cost of Carbon, United States Government, 2013)

Year	Discount Rate			
	5.0%	3.0%	2.5%	3.0%
	Avg.	Avg.	Avg.	95th
2010	11	33	52	90
2015	12	38	58	109
2020	12	43	65	129
2025	14	48	70	144
2030	16	52	76	159
2035	19	57	81	176
2040	21	62	87	192
2045	24	66	92	206
2050	27	71	98	221

The Interagency Working Group decision to implement a global estimate of the SCC rather than a domestic value reflects the reality of environmental damages which are expected to occur worldwide. Excluding global damages is inconsistent with U.S. regulatory policy aimed at incorporating international issues related to resource use, humanitarian interests, and national security. As such, a regional SCC value specific to the Western United States or California specifically should be at similarly inclusive of global damages. Various studies state that certain values may be understated due to the asymmetrical risk of catastrophic damage if climate change impacts are above median predictions, and some estimates indicate that the upper end of possible damage costs could be substantially higher than indicated by the IWG (Ackerman and Stanton 2012, Horii and Williams 2013).

11.3.3 Abatement Cost Approach

Abating carbon dioxide emissions can impose costs associated with more efficient technologies and processes, and policy-makers could also compare strategies using a different by estimating the annualized costs of reducing one ton of carbon dioxide net of savings and co-benefits. The cost of abatement approach could reflect established GHG reduction policies and establish values for carbon dioxide reductions relative to electricity de-carbonization and other measures. (While recognizing the potential usefulness of this method, this report utilizes the IWG SCC approach and notes that the value lies within the range of abatement costs discussed further below.)

The cost abatement approach utilizes market information regarding emission abatement technologies and processes and presents a wide-range of values for the price per ton of carbon dioxide. The California Air Resources Board data of the cost-effectiveness of energy efficiency measures and emission regulations would provide one source of potential data for an analysis under this method. To meet the AB 32 target, ARB has established the "Cost of a Bundle of Strategies Approach" which includes a range of cost-effective strategies and regulations (CARB 2008b). The results of this approach within the framework of the Climate Action Team Macroeconomic Analysis are provided for California, Arizona, New Mexico, the United States, and a global total identified in that same report, as shown in Table 29 below.

Table 29: Cost-effectiveness Range for the CAT Macroeconomic Analysis

Source: CARB 2008b

Exhibit 3: Cost-effectiveness Range for the CAT Macroeconomic Analysis, Selected States, United States, Global -

State	Cost-effectiveness Range $/ ton CO_2eq	Tons Reduced MMtCO_2e/yr	Percent of BAU
California 2020 (CAT[1], CEC[2])	- 528 to 615	132	22
Arizona[3] 2020	- 90 to 65	69	47
New Mexico[4] 2020	- 120 to105	35	34
United States (2030)[5]	-93 to 91	3,000	31
Global Total (2030)	-225 to 91	26,000	45

Source:
1. Climate Action Team Updated Macroeconomic Analysis of Climate Strategies, Presented in the March 2006 Climate Action Team Report, September 2007.
2. California Energy Commission, *Emission Reduction Opportunities for Non-CO2 Greenhouse Gases in California*, July 2005, ICF ($/MTC$0_2$eq).
3. Arizona Climate Change Advisory Group, *Climate Change Action Plan*, August 2006, ($/MTC$0_2$eq).
4. New Mexico Climate Change Advisory Group, Final Report, December 2006.
5. McKinsey & Company, *Reducing U.S. Greenhouse Gas Emissions: How Much at What Cost?* December 2007.
6. The McKinsey Quarterly, McKinsey & Company, *A Cost Curve for Greenhouse Gas Reduction*, Fall 2007.

Energy and Environmental Economics (E3) study defines the cost abatement approach more specifically as electricity de-carbonization and is based on annual emissions targets consistent with existing California climate policy. Long-term costs are determined by large-scale factors such as electricity grid stability, technological advancements, and alternative fuel prices. Near-term costs per ton of avoided carbon could be$200/ton in the near-term (Horii and Williams 2013), thus as noted earlier the value used in this report may be conservative.

11.3.4 Regulated Carbon Market Approach

Emissions allowance markets provide a third potential method for valuing carbon dioxide. Examples include the European Union Emissions Trading System and the California AB32 cap and trade system as described below. Allowances serve as permits authorizing emissions and are traded through the cap-and-trade market between actors whose economic demands dictate the sale or purchase of permits. In theory, allowance prices could serve as a proxy for the cost of abatement. However, this report does not rely on the prices of cap-and-trade allowances due to the vulnerability of the allowance market to external fluctuations, and the influence of regulatory decisions affecting scarcity or over-allocation unrelated to damages or abatement costs.

European Union Emissions Trading System

The European Union Emissions Trading System (EU ETS) covers more than 11,000 power stations, industrial plants, and airlines in 31 countries. However, the market is constantly affected by over-supply following the 2008 global recession and has seen prices drop to dramatic lows in early 2013, resulting in the practice of "back-loading" (delaying issuances of permits) by the European parliament. At the end of June 2013, prices of permits dropped to $5.41 per ton, a price which is well below damage cost estimates and sub-optimal for encouraging innovative carbon dioxide emission abatement strategies.

California Cap & Trade

In comparison, California cap-and-trade allowance prices were reported to be at least $14/ton in May of 2013, with over 14.5 million total allowances sold for 2013 (CARB 2013b). However, cap-and-trade markets are likely to cover only subsets of emitting sectors of the industry covered by AB 32. In addition, the market prices of allowances are determined only partly by costs incurred by society or industry actors and largely by the stringency of the cap determined by regulatory agencies and uncontrollable market forces, as seen by the failure of the EU ETS to set a consistent and effective signal to curb carbon dioxide emissions.

12. APPENDIX C: WATER, ELECTRICITY AND NATURAL GAS RATE ASSUMPTIONS

12.1 Electricity Rates

The electricity rates used in the analysis presented in this report were derived from projected future prices for residential, commercial and industrial sectors in the CEC's "Mid-case" projection of the 2012 Demand Forecast (2012), which used a 3 percent discount rate and provide prices in 2010 dollars. The sales weighted average of the 5 largest utilities in California was converted to 2015 dollars using an inflation adjustment of 1.07 (DOL 2013). See the rates by year below in Table 30.

Table 30: Statewide Sales Weighted Average Electricity Rates 2017 – 2026 (PG&E, SCE, SDG&E, LADWP and SMUD - 5 largest Utilities) in 2015 cents/kWh

	Electricity Rate (2015 cents/kWh)	
Year	**Residential**	**Commercial**
2017	17.24	15.02
2018	17.47	15.22
2019	17.71	15.42
2020	18.00	15.67
2021	18.34	15.98
2022	18.70	16.29
2023	19.06	16.61
2024	19.43	16.93
2025	19.81	17.27
2026	20.19	17.60
2027	20.59	17.95
2028	20.98	18.30

12.2 Natural Gas Rates

The natural rates used in the analysis presented in this report were derived from projected future prices for residential, commercial and industrial sectors in the CEC's "Mid-case" projection of the 2012 Demand Forecast (2012), which used a 3 percent discount rate and provide prices in 2010 dollars. The sales weighted average of the three largest utilities in California was converted to 2015 dollars using an inflation adjustment of 1.07 (DOL 2013). See the rates by year below in Table 31.

Table 31: Statewide Sales Weighted Average Residential Natural Gas Rates 2017 - 2026 (PG&E, SCE, and SDG&E - 3 largest Utilities) in 2015$/therm

Year	Natural Gas Rate (2015$/therm)	
	Residential	Commercial
2017	0.87	0.89
2018	0.89	0.90
2019	0.90	0.91
2020	0.93	0.94
2021	0.95	0.97
2022	0.98	0.99
2023	1.01	1.02
2024	1.04	1.05
2025	1.07	1.08
2026	1.10	1.11
2027	1.13	1.14
2028	1.16	1.17

12.3 Potable Water and Wastewater Rates

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

Wastewater rates are based on data from Black & Veatch on rates in the eight largest cities29 in California (Black & Veatch 2010). About 30 percent of Californians live in one of these eight cities, and it is assumed that these city's rates are representative of rates throughout the state. The CASE analysis uses the population-weighted wastewater rate from the eight cities. The 2009 residential rate is based on cost data that assumes customers use 15,000 gallons per month. The 2009 commercial wastewater rates were derived from cost data that assumes customers use 100,000 gallons per month.

Future potable water and wastewater rates were projected based on the Consumer Price Index (CPI) for Water and Sewer Maintenance and assuming a 3 percent annual discount rate. In recent years water rates have been increasing faster than CPI projections (Black & Veatch 2010, Raftelis 2011). It is likely that water rates will increase faster than the CASE analysis predicts, and it follows that the cost savings presented in this report could understate the true potential savings. See the rates by year below in Table 28.

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

Table 32: Statewide Average Potable Water and Wastewater Rates 2017 - 2026 in 2015$/1000gallons

Year	Water Rates (2015$/1000gallons)					
	Residential			Commercial		
	Potable Water	Waste-water	Total Water Cost	Potable Water	Waste-water	Total Water Cost
2017	$2.86	$4.73	$7.60	$2.64	$4.91	$7.55
2018	$2.92	$4.84	$7.76	$2.70	$5.01	$7.71
2019	$2.99	$4.94	$7.93	$2.76	$5.12	$7.88
2020	$3.05	$5.04	$8.09	$2.81	$5.23	$8.04
2021	$3.11	$5.15	$8.26	$2.87	$5.33	$8.20
2022	$3.17	$5.25	$8.42	$2.93	$5.44	$8.37
2023	$3.24	$5.35	$8.59	$2.99	$5.55	$8.53
2024	$3.30	$5.45	$8.75	$3.04	$5.65	$8.70
2025	$3.36	$5.56	$8.92	$3.10	$5.76	$8.86
2026	$3.42	$5.66	$9.08	$3.16	$5.87	$9.03
2027	$3.48	$5.76	$9.25	$3.22	$5.97	$9.19
2028	$3.55	$5.87	$9.41	$3.27	$6.08	$9.35
2029	$3.61	$5.97	$9.58	$3.33	$6.19	$9.52
2030	$3.67	$6.07	$9.74	$3.39	$6.29	$9.68
2031	$3.73	$6.18	$9.91	$3.45	$6.40	$9.85
2032	$3.80	$6.28	$10.07	$3.50	$6.51	$10.01
2033	$3.86	$6.38	$10.24	$3.56	$6.61	$10.18
2034	$3.92	$6.48	$10.41	$3.62	$6.72	$10.34
2035	$3.98	$6.59	$10.57	$3.68	$6.83	$10.50
2036	$4.05	$6.69	$10.74	$3.73	$6.93	$10.67
2037	$4.11	$6.79	$10.90	$3.79	$7.04	$10.83
2038	$4.17	$6.90	$11.07	$3.85	$7.15	$11.00
2039	$4.23	$7.00	$11.23	$3.91	$7.25	$11.16

12.4 Embedded Electricity in Water

The embedded energy value used in the analysis is 10,045 kWh/million gallons of water (MG). This value was derived from a California Energy Commission PIER study (CEC 2006), which states the embedded energy values shown in the table below “are sufficient for informing policy and prioritization of research and development investments.”

Table 33:Recommended Embedded Energy Estimates

Source: CEC 2006. Table 7.

	Indoor Uses		Outdoor Uses	
	Northern California kWh/MG	Southern California kWh/MG	Northern California kWh/MG	Southern California kWh/MG
Water Supply and Conveyance	2,117	9,727	2,117	9,727
Water Treatment	111	111	111	111
Water Distribution	1,272	1,272	1,272	1,272
Wastewater Treatment	1,911	1,911	0	0
Regional Total	5,411	13,022	3,500	11,111

The total regional values shown in Table 33 were weighted based on the population in Northern and Southern California in 2011 (U.S. Census Bureau). All water used in toilets and urinals is used indoors, so only the indoor embedded energy values apply.

The California Public Utilities Commission (CPUC) has conducted additional research on embedded energy since CEC's 2006 report was released. However, the values presented in CEC's 2006 report are still the most up-to-date values recommended for use to inform policies the Utility C&S Team has used CEC's 2006 embedded energy values for this analysis.

The CPUC has made notable progress in improving understanding of the relationship between water and energy in California. CPUC's Decision 07-12-050, issued December 20, 2007, authorized the largest electricity utilities to partner with water utilities and administer pilot programs that aimed to save water and energy (CPUC 2011c). The Decision also authorized three studies to validate claims that saving water can save energy and explore whether embedded energy savings associated with water use efficiency are measurable and verifiable. The pilot programs succeed at demonstrating that water conservation measures also result in energy savings.

The CPUC studies were effective at obtaining a more granular understanding of how energy use varies based on a number of factors including supply, (i.e. surface, ground, brackish, or ocean desalination), geography, and treatment technology. The authors found "that the value of energy embedded in water is higher than initially estimated in CEC's 2005 and 2006 studies." Although the data collected for the studies is the most comprehensive set of data on energy used to meet water demand, the data is still just a small sampling of all the potential data points in California. Since the authors did not find strong patterns within the sample data and there was no strong evidence that the sample data was representative for a particular region, process, or technology type, the authors did not have a strong basis to estimate the embedded energy values for specific geographic regions. Further, the CPUC studies did not recommend changes to the embedded energy values presented in CEC's 2006 report.

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

13. APPENDIX D: UTILITY TEAM RESPONSE TO COMMENTS ON WASTED WATER AND ENERGY WHEN WAITING FOR HOT WATER TO ARRIVE

Faucets

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

Comments regarding draft regulations:
Faucets

CA IOUs Response to Comments on Wasted Water and Energy When Waiting for Hot Water to Arrive

Docket: #15-AAER-1, Water Appliances

March 27, 2015

Prepared for:

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This report was prepared by the California Statewide Utility Codes and Standards Program and funded by the California utility customers under the auspices of the California Public Utilities Commission.

1 Summary

Some researchers have voiced concern that the reduction of lavatory faucet water use in residential buildings could lead to the unintended consequences of longer hot water wait times leading to wasted water and energy (PMI 2014). While the variability in water distribution system design makes it difficult to quantify the potential wasted water associated with reducing faucet flow rates, some of the assumptions made by PMI may result in an overstatement of wait times and wasted water and energy estimates. Moreover, even when using PMI's assumptions about wasted water when waiting for hot water to arrive, updating California's lavatory faucet efficiency standard from 2.2 gallons per minute (gpm) to 1.0 gpm will result in significant water and energy savings and the proposed standard remains cost effective. Moreover, surveys indicate that despite claims that hot water wait times could increase significantly, consumers are very satisfied when their 2.2 gpm lavatory faucets are replaced with 1.0 gpm faucets (Aquacraft 2004).

The CA IOUs recommend that California proceed with updating fixture flow rates and continue efforts to promote intelligent plumbing design, which will help address concerns about hot water delivery times. Updating standards for the sizing and design of hot water distribution systems will help ensure that hot water wait times are minimized in newly constructed buildings. In parallel with efforts to update the plumbing fixture efficiency levels in Title 20, the CA IOUs have been advocating for revisions to the California Building Code (Title 24) to help minimize hot water wait time.

2 Hot Water Distribution System Design and Hot Water Wait Times

Assessing the performance of residential hot water distribution systems is complex. Hot water wait time and the amount of water that is wasted when waiting for hot-enough water to arrive depends on many factors including: hot water temperature, initial pipe temperature, ambient temperature, pipe material, pipe size, pipe length, pipe insulation, fixture flow rate, and time between hot water draws (CEC 2005). Given the number of factors that contribute to hot water wait time and the reality that hot water distribution systems within existing buildings in California have not been well characterized, it is difficult to determine how much water will be wasted statewide when waiting for hot water to arrive at lavatory faucets.

The following observations about the assumptions PMI (2014) used in its test set up suggest that PMI's analysis might overstate the statewide average hot water wait time and wasted water and energy that is wasted when waiting for hot water to arrive:

- **Warm Enough:** First, PMI (2014) assumed that "warm-enough" water is 110°F whereas the CEC (2005) analysis assumes warm-enough water is 105°F.[4] Secondly and perhaps more importantly, it is commonly the case that for many activities, such as hand washing, very hot water is not required or even waited for by users. Each individual will perceive warm-enough water differently. California's mild climates mean that in most buildings "cold" water is not "freezing" cold, and some people feel that the "cold" water that comes

[4] For the CASE Report energy and water savings analysis, it was assumed that water was heated to 124°F at the hot water heater. The temperature at the faucet was not factored into the energy savings calculations.

from the faucet immediately is warm-enough for hand washing and other tasks performed at lavatory faucets. In fact, a 2012 CEC study presents results of a user behavior survey that evaluated how people use hot water in residential buildings. Only one-quarter of the approximately 500 respondents (respondents lived primarily in the greater Los Angeles area and San Francisco Bay Area where cold water temperatures are reasonably warm) said that they waited for hot water to arrive at the bathroom or kitchen faucets. That is, 75% of respondents *did not* wait for hot water to arrive (CEC 2012). Moreover, the Aquacraft 2004 study demonstrated that the installation of high efficiency aerators in Tampa homes resulted in the same duration of faucet use (roughly 10 min pre and post retrofit), and the use of less water. In other words, the households likely spent no additional time waiting for hot water. These studies indicate that in many cases warm- enough water is well below 110°F and is often actually cold water. Some offices and other nonresidential sinks are not even supplied with any hot water, which may accustom users to these conditions at their homes. PMI's assumption that warm-enough water is 110°F is hotter than the assumed warm-enough temperature used in other similar research efforts and is hotter than many peoples' perception of warm enough. Assuming that the statewide average warm-enough temperature for all people that use lavatory faucets in California is 110°F will result in an overstatement of the wasted water and energy when waiting for hot water to arrive.

- **Number of Cold Starts:** A cold start is defined as a hot water event in which the entire volume of water between the hot water source and the outlet is cold when the user turns on the hot water outlet. PMI assumed that there would be 2 cold starts per lavatory faucet per day. The CA IOU CASE Report did not quantify cold starts, but on average, each faucet would be used 15.73 times per day and that 50 percent (or 7.9) of those uses would be hot water draws.[5] Additionally, subsequently found data indicates that hot water draws tend to be clustered together in a relatively short period of time, so absolute cold starts are not common. A report Lawrence Berkeley National Laboratory published in 2012 (Lutz 2012), found that 75 percent of all hot water draws (including draws from all outlets in the home) occur within less than 15 minutes from the previous draw and 50 percent of draws occur with less than 3 minutes of the previous draw. Since hot water events tend to be clustered, warm enough water will oftentimes occupy at least a portion of water in the distribution system when the user turns on the faucet, so hot water will arrive sooner than it would in a cold start. The CA IOUs are not aware of any data to verify PMI's assumption of 2 cold starts per faucet per day. This estimate may be accurate for some users, though it may result in an overestimate of wasted water for statewide estimates.

- **Entrained Volume:** The volume of water inside the hot water pipes between the hot water source (usually the water heater, but could also be the recirculation loop), and the point of use is referred to as the entrained volume. PMI assumed an entrained volume of 1.5 and/or 1.38 gallons per 100 foot (both numbers are cited in the report), but there is some data that suggests these numbers could be high for the typical California home.

  A 2012 CEC study (CEC 2012) evaluated hot water distribution systems in 97 newly constructed single family homes and compared results to a previous study conducted in 2006. The researchers found that, on average, a typical 2,000 square foot home built in

[5] See CASE Report for more information about assumptions the CA IOUs used in energy and water savings analysis (CA IOUs 2013).

2011 held one gallon of water in the pipes between the hot water source and the point of use. This finding was consistent with findings from the survey completed in 2006. While the 2012 CEC study was not a comprehensive review of all plumbing systems in existing buildings in California, the results are representative of buildings that have been built in the past decade.

The 2012 CEC study also describes the conditions of older homes that could result in the same amount of entrained volume as newer homes. On the one hand, over the past ten to fifteen years copper pipe has been replaced with plastic pipe as the standard piping material. Plastic pipe has lower entrained volumes per 100 feet than copper pipe. The 2012 CEC report found that there is 20-30 percent less water entrained in ½ inch and ¾ inch PEX pipe than copper pipe (see Figure 1). On the other hand, while PEX has a lower entrained volume per 100 feet, the CEC report also notes that "one of PEX's main positive attributes (flexible pipe promotes ease of installation) has also resulted in abuses in terms of inefficient plumbing layouts." So, the benefits of the lower entrained volume of PEX relative to copper may be diminished because plumbing layouts that use PEX may use longer pipe lengths. PMI's analysis assumed entrained volume(s) are larger than the average volume observed in newly constructed homes in 2006 and 2011, and may be on the high-end of typical entrained volumes for all existing California residential buildings. As a result, PMI's estimates water and energy wasted statewide when waiting for hot water to arrive water may be overstated.

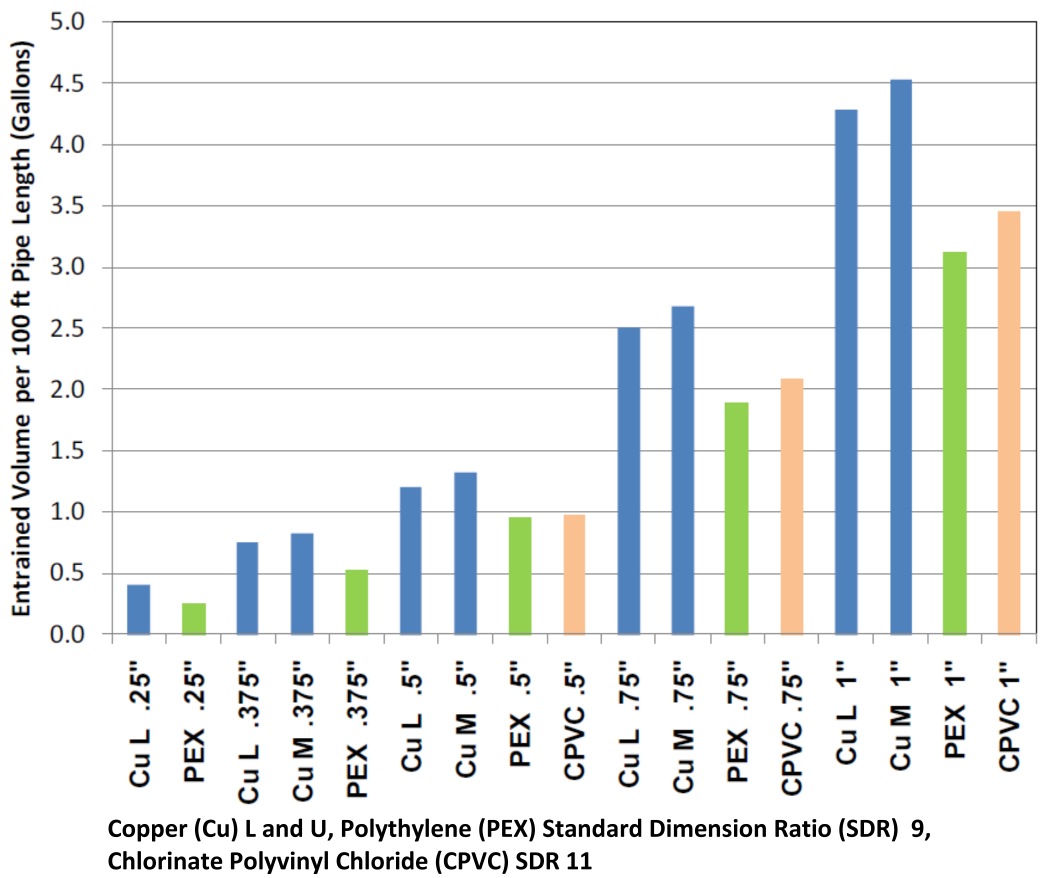

Figure 1: Entrained Pipe Volume Comparison – Copper versus Plastic Pipe

Source: CEC 2013

- **Pipe Insulation:** PMI 2014 did not specify if the pipe used in the analysis was insulated, but the CASE Team confirmed with the author that the pipe was not insulated for the analysis. As a result, PMI's results are not representative of the many buildings in California that have insulated pipes, and using PMI's estimates in a statewide savings analysis may result in an overstatement of water wasted when waiting for hot water to arrive. Pipe insulation has a significant impact on hot water delivery times; insulated pipes cool-down time 200-400 percent slower than un-insulated pipes (CEC 2005). Extending the period of time that water is at a useful temperature within the pipes reduces the number of times that warm water needs to be purged. Pipe insulation is particularly important because, as mentioned below, hot water draws tend to be clustered together in time. Pipe insulation has also been shown to reduce the hot water delivery times for cold starts, particularly when flow rates are low and pipes are in high heat-loss environments (CEC 2005).

In addition to the specific observations about PMI's assumptions listed above, PMI's results came from one set of measurements on one possible plumbing layout. Given the diversity of hot water distribution systems in California's buildings, the results of PMIs analysis should be considered judiciously, especially when evaluating wait times. As discussed in the next section, even when PMI's results are used for estimating wasted hot water, the savings from a faucets standard set at 1.0 gpm at 60 psi are still significant and cost-effective.

A 2005 CEC PIER report highlights the variability by providing more context as to how hot water distribution systems perform (CEC 2005). The study evaluated the impact of the following factors on wait times and the volume of water wasted when waiting for hot water to arrive: hot water temperature, initial pipe temperature, ambient temperature, length of pipe, pipe insulation and flow rate. The study found that performance of hot water delivery systems varies widely based on the plumbing system design, temperature settings, and ambient conditions. **Figure 2** and **Figure 3** present the results of testing performed for the 2005 CEC PIER Report. The tests were conducted on ¾ inch insulated (Figure 1) and un-insulated (Figure 2) PEX pipes.[6]

The CASE Team has not included a direct comparison between PMI's analysis and 2005 CEC PIER analysis, given that the two studies used different types of ¾ inch PEX pipe. The PEX pipe CEC used held 2.0 gallons per 75 feet of length whereas PMI's pipe held 1.38 gallons per 75 feet. While a direct comparison is not possible, the CEC PIER analysis provides additional data points for consideration. Note that both the PMI analysis and the 2005 CEC PIER study evaluate water wasted during cold starts as discussed above. As mentioned previously, hot water draws tend to be clustered together in time, so cold starts are not as common as draws in which warm enough water is closer to the outlet.

[6] The 2005 PIER Report did not evaluate impacts on ½ inch PEX pipe.

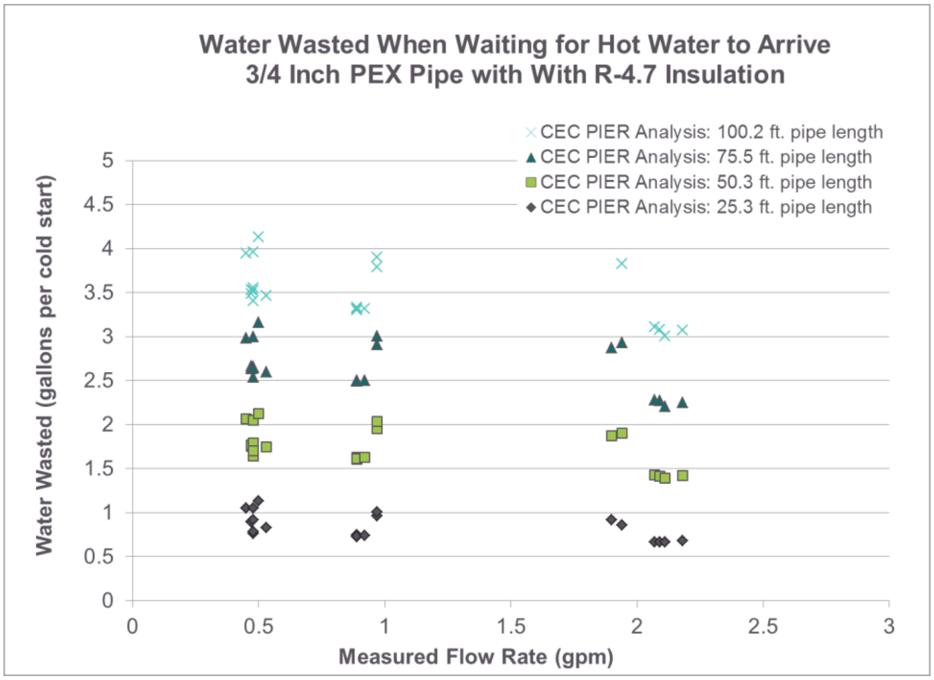

Figure 2: Results of CEC PIER Study (2006) Showing Wasted Water When Waiting for Hot Water to Arrive Through ¾ inch PEX Pipe with R-4.7 Insulation

Source: CEC 2005

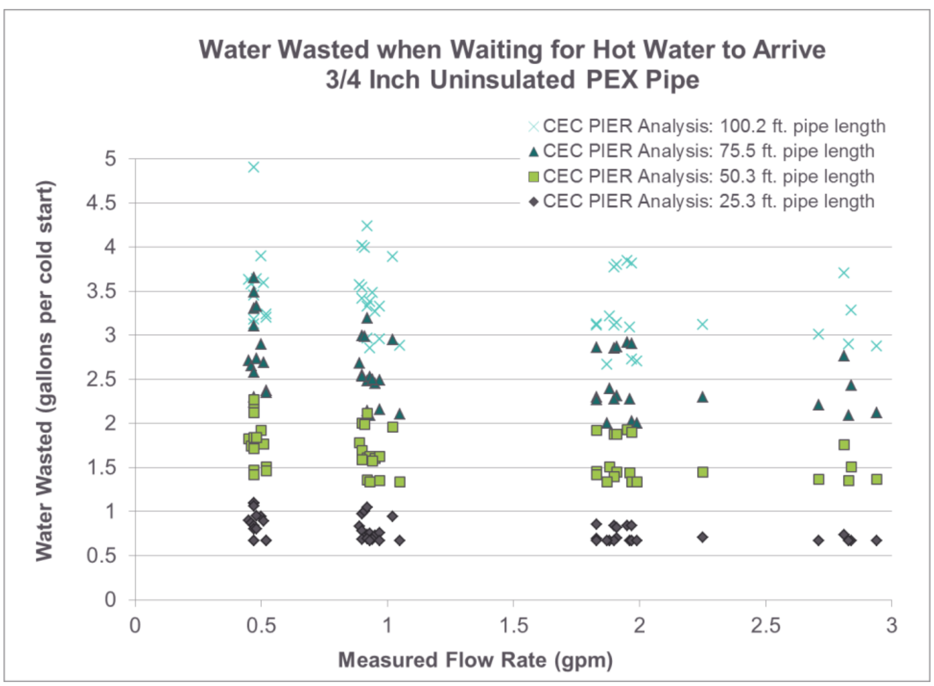

Figure 3: Results of CEC PIER Study (2006) Showing Wasted Water When Waiting for Hot Water to Arrive Through Uninsulated ¾ inch PEX Pipe

Source: CEC 2005

3 Impact of Wasted Water on Energy Savings and Cost Effectiveness of 1.0 GPM Faucet Standard

As described above, the assumptions PMI used in its analysis may overstate the average estimate to use for statewide savings estimates. In an effort to establish the upper level of possible water and energy waste, however, the CASE Team has provided below the water and energy savings analysis of the proposed 1.0 gpm faucet standard factoring in PMI's assumptions about water and energy wasted when waiting for hot water to arrive.

In summary, discounting the water savings to account for water wasted when waiting for hot water to arrive reduces the water and embedded energy savings of the proposed measure by about 6 percent relative to previous estimates. Natural gas and electricity savings from heating water are reduced by about 11 percent relative to our previous estimates.[7] The proposed standard of 1.0 gpm still results in significant, cost effective water and energy savings.

3.1 Implications on Water Savings

Table 1 presents the results of PMI's analysis on water wasted per faucet when waiting for hot water to arrive. PMI concluded that at low water pressures, a 1.0 gpm faucet will waste 0.4 gallons per faucet per day more than a 2.2 gpm faucet. Similarly, at low water pressure, a 1.0 gpm faucet will waste 0.14 gallons per faucet per day relative to a 1.5 gpm faucet. In the analysis presented in the CASE Report, the CASE Team found that of the lavatory faucets sold in California that do not already meet the 1.0 gpm level, 43 percent are rated at 1.5 gpm and 57 percent are rated at 2.2 gpm. That is, the baseline water use estimates used in the CASE Team's analysis assumes a weighted average of 1.5 gpm and 2.2 gpm faucets. Applying this same weighting factor to PMI's results, rather than assuming 100% of the baseline is 2.2 gpm as PMI did, the statewide average wasted water of moving from a baseline faucet to a 1.0 gpm faucet would be 0.24 gallons per faucet per day at high pressure or 0.29 gallons per faucet per day at low pressure. To be conservative, the CASE Team assumed that on average, 0.29 gallons of water would be wasted per faucet per day when waiting for hot water to arrive.

Table 1: PMI's Conclusions on Wasted Water per Faucet per Day

Faucet Flow Rates	Water Wasted per Faucet Per Day (gallons/faucet/day)	
	High Water Pressure	Low Water Pressure
2.2 gpm faucet to 1.0 gpm faucet	0.34	0.40
1.5 gpm faucet to 1.0 gpm faucet	0.10	0.14
Statewide Average*	0.24	0.29

* Assumes 57% of noncompliant faucets are 2.2 gpm and 43% are 1.5 gpm.

Before accounting for the wasted water when waiting for hot water to arrive, the CASE Team estimated that revising the Title 20 standard from 2.2 gpm to 1.0 gpm will result in water savings of 5.07 gallons per faucet per day. Applying PMI's estimated wasted water estimates (0.29 gallons per faucet per day on average statewide); the daily water savings is reduced to 4.78 gallons per faucet per day. As mentioned previously, the CASE Team assumed that, on average, each faucet

[7] Assumes that all water wasted during cold start events (i.e., average 0.29 gallons per faucet per day) is for hot water events and results in energy impacts from heating water.

would be used 15.7 times per day, each event lasts 37 seconds on average, and 50 percent of the faucet events would use hot water. On a high level, more than 2 gallons are saved every day from events that do not use hot water; savings from events that do not use hot water far exceed the amount of water wasted during cold start events when using PMI's assumptions. In total, discounting the water savings to account for water wasted when waiting for hot water to arrive reduces the water and embedded energy savings of the proposed measure by about 6 percent relative to previous estimates._See the CASE Report (CA IOUs 2013) for more assumptions about the energy savings analysis and cost effectiveness analysis, including assumptions about how faucet flow rates are derated to account for the impacts of lower water pressure and users not opening the faucets fully for every event.[8]

3.1.1 Correction Regarding PMI's Analysis of Natural Gas Savings

PMI's analysis claims that updating the Title 20 requirements from 2.2 gpm to 1.0 gpm would result in 28.3-32.9 million therms of wasted natural gas per year after stock turn over and would be three times larger than the CASE Team's estimate of natural gas savings after stock turn over. However, the CASE Team actually estimated that the proposed code change would result in over 90 million therms of savings per year after the stock turns over in 2024. Using PMI's results, natural gas savings would be reduced by to 31 to 37 percent, not by nearly 300%. Moreover, PMI's estimates of statewide natural gas waste are overstated because the analysis: 1) did not take into account that 5 percent of lavatory faucets sold in California already meet the 1.0 gpm standard, so wasted natural gas from those faucets should not be counted as an impact of the standard; 2) did not take into account that 43 percent of the lavatory faucets sold in California that do not already meet the proposed efficiency level of 1.0 gpm are 1.5 gpm – not 2.2 gpm, and therefore overestimated the wasted natural gas from 43 percent of faucets; and 3) assumed that all buildings in California have natural gas water heating while in reality only about 90 percent of California's buildings have natural gas water heating. The CASE Team's analysis provides a more accurate representation of the impacts associated with water wasted when waiting for hot water to arrive:, natural gas savings would be about 11 percent (10.6 million therms per year) lower than originally estimated after stock turn over in 2024, when using PMI's assumptions.

3.2 Implications on Cost-Effectiveness

The CASE Team found very little price difference between higher and lower efficiency faucets and faucet accessories. For example, the NEOPERL 2012 Wholesale catalog indicates no cost difference between non-qualifying (1.5 gpm) and qualifying faucet accessories (1.0 gpm). Basic faucet accessories cost about $1-2 dollars wholesale, and even the most expensive are less than $10 wholesale. It can be assumed that a 1.0 gpm faucet can cost the same as a 2.2 gpm faucet. Some manufacturers might choose to transition from using a non-pressure compensating 2.2 gpm aerator to a pressure compensating 1.0 gpm aerator, which could add several dollars to the overall cost of the faucet.

Table 2 presents the incremental costs and lifecycle (10-year) cost savings of the proposed faucet standard. The analysis was completed on a per faucet basis. It was assumed that the incremental cost would be $5 per faucet. The water cost savings over the 10-year period of analysis was estimated to be $72. The cost savings from water heating over the 10-year period was $158 if there

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[8] Assumed a derating factor of 0.67 for 2.2 and 1.5 gpm faucets and 0.75 for 1.0 gpm faucets. See CASE Report (CA IOUs) for more information about derating factors.

is an electric water heater and $45 if there is a natural gas water heater. Overall, if the faucet is installed in a building with electric water heating, the net cost benefit would be $225 and the benefit/cost (B/C) ratio would be 46.0. If the faucet is installed in a building with natural gas water heating, the net cost benefit would be $112 and the benefit/cost (B/C) ratio would be 23.4. **The proposed measure remains cost effective, even if manufacturers opt to use a more expensive pressure compensating aerator**.

Table 2: Per Faucet Cost and Cost Savings

Electric Water Heating					
Costs: (per Faucet)		**Benefit: Lifecycle Cost Savings (per Faucet)**		**Net Lifecycle Cost Benefit**	**Benefit / Cost Ratio**
Incremental Cost	$5.00	Water Cost Savings	$72		
		Electricity Cost Savings	$158		
TOTAL	**$5.00**	**TOTAL**	**$230**	**$225**	**46.0**
Natural Gas Water Heating					
Costs: (per Faucet)		**Benefit: Lifecycle Cost Savings (per Faucet)**		**Net Lifecycle Cost Savings**	**Benefit / Cost Ratio**
Incremental Cost	$5.00	Water Cost Savings	$72		
		Natural Gas Cost Savings	$45		
TOTAL	**$5.00**	**TOTAL**	**$117**	**$112**	**23.4**

4 User Satisfaction with Low Flow Faucets

Three studies conducted by Aquacraft, Inc. Water Engineering Management suggest that users are satisfied with low-flow faucets (Aquacraft 2000, Aquacraft 2003, and Aquacraft 2004). In Tampa, Florida 1.0 gpm faucets were installed, and 89 percent of study participants felt the high-efficiency faucets performed the same or better than their old fixtures. Based on this evidence that users are satisfied with faucets that consume less water, we are not expecting significant dissent from consumers regarding an updated California standard.

While research has shown that users are satisfied when existing lavatory faucets are replaced with 1.0 gpm fixtures, there are several ways existing buildings can be retrofit to reduce hot water wait time. Existing plumbing can be retrofitted to include a recirculation system between the water heater and any points-of-use so that water that has cooled while remaining stagnant in the pipes is circulated back to the hot water heater and freshly heated water is sent to the point-of-use. Recirculation systems can be self-installed and can be upgraded to include a higher speed pump, which further reduces hot water wait time. Adding insulation to hot water pipes can prolong the time warm enough water remains in the pipes, thereby reduce hot water wait time for draws that occur in close time proximity. Small electric water heaters can also be installed in between the heat source and the point-of-use (and can even be installed inside of bathroom vanity cabinets) to provide an additional heat source and reduce hot water wait time. While these retrofit options described above are available to home owner, the CASE Team does not expect these retrofits will be necessary as consumer satisfaction we anticipate most people will be satisfied with 1.0 gpm faucets.

5 Conclusions

Updating California's lavatory faucet efficiency standard from 2.2 gallons per minute (gpm) to 1.0 gpm will result in significant water and energy savings and the proposed standard remains cost effective, even after discounting the savings to account for wasted water when waiting for hot water to arrive. The CA IOUs recommend that California proceed with updating fixture flow rates and continue efforts to promote intelligent plumbing design, which will help address concerns about hot water delivery times.

6 References

Aquacraft, Inc. 2000. Water Engineering and Management. Seattle Home Water Conservation Study: the Impacts of High Efficiency Plumbing Fixture Retrofits in Single-family Homes. Prepared for Seattle Public Utilities and the United States Environmental Protection Agency. http://www.aquacraft.com/sites/default/files/pub/Mayer-%282000%29-Seattle-Home-Water-Conservation-Study.pdf. Boulder, Colo.: Aquacraft, Inc. Water Engineering and Management

__. 2003. Residential Indoor Water Conservation Study: Evaluation of High Efficiency Indoor Plumbing Fixture Retrofits in Single-family Homes in the East Bay Municipal Utility District Service Area. 2003. Prepared for East Bay Municipal Utility District and the United States Environmental Protection Agency.

__. 2004. Tampa Water Department Residential Water Conservation Study: The Impacts of High Efficiency Plumbing Fixture Retrofits in Single-Family Homes. Prepared for Tampa Water Department and The United States Environmental Protection Agency. http://www.aquacraft.com/sites/default/files/pub/Mayer-%282004%29-Tampa-Water-Department-Residential-Water-Conservation-Study.pdf. Boulder, Colo.: Aquacraft, Inc. Water Engineering and Management.

__. 2011. California Single Family Water Use Efficiency Study. 2011. Prepared by DeOreo, W., Mayer, P., Martien, L., Hayden, M., Funk, A., Kramer-Duffield, M. & R. Davis. http://www.aquacraft.com/node/63. Boulder, Colo.: Aquacraft, Inc. Water Engineering and Management. Black & Veatch. "2009/2010 50 Largest Cities Water/Wastewater Rate Survey." 2010.

[CEC] California Energy Commission. 2005. "Hot Water Distribution System Research – Phase I." Prepared by Applied Energy Technology. Public Interest Energy Research Program. November 2005. Report number: CEC-500-2005-161. http://www.energy.ca.gov/pier/project_reports/CEC-500-2005-161.html.

___. 2012. "Water Heating Design Guide." Prepared by Davis Energy Group and Gas Technology Institute. December 2012. Report number: CEC-500-2013-126. http://www.energy.ca.gov/2013publications/CEC-500-2013-126/CEC-500-2013-126.pdf.

Lutz, Jim and Moya Melody. 2012. "Typical Hot Water Draw Patterns Based on Field Data" Prepared Lawrence Berkeley National Laboratory. November 2012. http://www.escholarship.org/uc/item/56313762.

[PMI] Plumbing Manufacturers International. 2014. "The Unintended Consequences of Lowering Residential Lavatory Faucet Flow Rates: An Analysis Informed by Measurement." Prepared by Gary Klein and Associates. http://www.energy.ca.gov/appliances/2014-AAER-o1/prerulemaking/comments/Plumbing_Manufacturers_International_Report_for_Residential_Lavatory_Faucets_2014-10-29_TN-73923.pdf.

14. APPENDIX E: UTILITY TEAM RESPONSE TO COMMENTS ON OPPORTUNISTIC PATHOGENS

Faucets

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

Comments regarding draft regulations:
Faucets

CA IOUs Response to Comments on Opportunistic Pathogens

Docket: #15-AAER-1, Water Appliances

March 12, 2015

Prepared for:

PACIFIC GAS & ELECTRIC COMPANY	SOUTHERN CALIFORNIA EDISON	SAN DIEGO GAS AND ELECTRIC	SOUTHERN CALIFORNIA GAS COMPANY

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1 Summary

Some researchers have voiced concern that green plumbing practices that reduce water use in buildings and reduce hot water temperatures in buildings could lead to an increased risk of pathogen growth (Edwards, et. al. 2014, Klein 2014, etc.).

The information in this Appendix is intended to provide additional information on opportunistic pathogens, pathogen growth in water distribution systems, and research that has evaluated the correlation between faucets and faucet flow rates with pathogens in potable water. After completing a review of published research on opportunistic premise plumbing pathogens (OPPPs), the CASE Team has concluded that the existing body of research is insufficient to prove hypotheses researchers have made that faucet flow rate is correlated to an increased risk of exposure to opportunistic pathogens. In fact, research cited in this document indicates that pathogen growth does not depend on faucet type, type of faucet accessory, or faucet flow rate. Marc Edwards, a lead researcher in the field of OPPPs, confirmed that research is inconclusive when discussing the matter on a phone call with the CA IOUs in January 2014. During this call, Mr. Edwards stated that the only published research to date that directly evaluated the impact of flow rate on pathogen growth (Liu, et. al. 2006) resulted in the researchers concluding that they were "unable to demonstrate that stagnant conditions promote Legionella colonization."

As explained in more detail below, it is known that pathogens grow within biofilms in water distribution systems, including in plumbing within buildings (premise plumbing). It is hypothesized that the rate of pathogen grown depends on: 1) water temperature, 2) pipe reactivity, 3) pipe surface area to water volume ratio, and 4) water retention time, surface area to water volume. While minimizing exposure to pathogens should be a priority, the lack of evidence that demonstrates faucets or faucet flow rate have a significant impact on whether pathogens colonize in potable water distribution systems, especially the lack of a 1.5 gpm to 1.0 gpm comparison, concerns about pathogen exposure should not halt the adoption of efficiency standards for faucets that will result in the most cost-effective water and energy savings in the State. Colonization of opportunistic pathogens can and should be addressed through sound engineering of water treatment and distribution systems, including the design of potable water plumbing within the building. The CA IOUs recommend that California proceed with updating fixture flow rates and continue efforts to promote intelligent plumbing design, which will help address concerns about both pathogen colonization and hot water delivery times, in parallel.

2 What are Opportunistic Pathogens

Opportunistic pathogens are infectious microorganism such as bacteria, viruses, fungi, or protozoan infections that usually do not harm its host, but they can cause disease if the host's immune system is compromised. Opportunistic pathogens occur naturally in the environment and can survive water treatment and live within water distribution systems. Although there are regulations in place to manage opportunistic pathogens, opportunistic pathogens are the leading cause of waterborne disease in developed countries. The spread of opportunistic pathogens within potable water distribution systems is a growing concern. As discussed below, there are many reasons why pathogens colonize in water distribution systems, including longer water retention times due to water efficiency if water supply equipment sizing is not adjusted appropriately. There are also many factors that contribute to increased risk of exposure, including a trend towards lower water temperatures within buildings to help mitigate risk of scalding.

In the United States, there have been several actions taken to address water quality and address pathogens. The Safe Drinking Water Act of 1974 directed the United Stated Environmental Protection Agency (EPA) to establish standards for drinking water quality in all public water systems in the United States. Since the Safe Drinking Water Act was enacted, EPA has issued standards for Cryptosporidium, Giardia, Legionella, coliform bacteria and enteric viruses. Public water systems are required to regularly monitor water for contaminants and submit regular reports to consumers and agencies overseeing the public water systems. Violations of the Safe Drinking Water Act can result in fines to the public water systems.

Opportunistic pathogens, including Legionella, are present in all segments of potable water supply systems, including water treatment facilities, municipal potable water distribution systems, and within buildings themselves. As discussed below, Legionella thrives in biofilms that colonize throughout water distribution systems. Because biofilms are resistant to water treatment techniques, biofilms provide an opportune location for Legionella propagation (EPA 2001).

In the United States, Legionella is the most commonly reported pathogen identified in drinking water-associated outbreaks (CDC 2013). The remainder of this document focuses on Legionella because it is the most prominent opportunistic pathogen.

3 Opportunistic Pathogens in Water Distribution Systems

There is a lack of sound scientific consensus of the growth of pathogens within the water distribution system, including within buildings (in premise plumbing). Generally speaking, the conditions within premise plumbing systems can provide conditions for pathogen growth, and there can be numerous locations within premise plumbing systems for pathogens to grow to occur. Premise plumbing systems can also provide direct sources of transmission to humans by way of ingestion, inhalation of aerosols or skin contact. Conditions inside a building's plumbing system contribute to pathogen growth (Wang 2013). These conditions include:

- **Warm temperatures:** Warm water in building pipes can increase the rate of pathogen reproduction. Water heater temperature is considered a critical determining factor for Legionella colonization in household plumbing. Increasing water temperature beyond the point of pathogen reproduction is often an effective way of combating Legionella in premise plumbing.
- **Reactive pipes:** Corrosion in pipes leads to dissolved metals, which can provide nutrients to pathogens. Colonization of Legionella has been found to have a positive correlation with trace metals of zinc and manganese; different studies have found both positive and negative correlation with copper
- **High surface area to water volume ratio**: Plumbing systems within buildings provide many points of contact between water and solid surfaces where biofilms can grow.
- **Old water (high retention time):** Retention time may increase the concentration of pathogens as residual treatment chemicals diminish.

Buildings with complex hot water distribution systems such as those in hospitals and large commercial buildings are particularly prone to pathogen growth. Opportunistic pathogen colonization is quite common in large buildings, and is not uncommon in small commercial or single-family residential buildings, although the studies have found that the number of homes colonized with Legionella appeared to be low (Pedro-Botet, Stout and Yu 2002).

When Legionella does colonize within residential buildings, the plumbing within the building can provide conditions for Legionella to multiply. Wang (2013) evaluated the concentration of bacteria in water that has been stagnant in pipes for a period of time (~ 8 hrs) versus concentrations in water after the pipes had been flushed. Samples that were taken after pipes were flushed are representative of water arriving from the municipal distribution system. Bacteria concentrations were 2 to 3 times higher before the system was flushed. This indicates that conditions of premise plumbing can have a significant impact on Legionella growth (Wang 2013).

Legionella was detected more frequently in homes that used electricity to heat water, probably due to the lower water temperature at the bottom of the storage tank as a result of the placement of the heating coils (Pedro-Botet, Stout and Yu 2002). For example, in a survey of 211 homes in Quebec, Legionella was not found in any of the houses with gas-fired water heaters as compared to 39 percent of those with electric water heaters (Alary and Joly 1991). Given that approximately 90 percent of homes in California use natural gas to heat water, it can be assumed that the risk for Legionella colonization is greatly reduced relative to the country as a whole where about 50 percent of the water heaters are gas fired.

4 Faucet Flow Rate and Risk of Legionella

There has been much discussion and research that looks at the impact of the type of faucet (electronic v. manual) and the impact of aerators on the risk of exposure to Legionella. There has been speculation that the design of electronic faucets and faucet aerators is conducive to biofilm growth and will therefore lead to increased risk of exposure to Legionella.

Recent research published by NRC Research Press concluded that the type of faucet (electronic v. manual) had no direct effect on the presence of Legionella. This study evaluated the presence of Legionella in water from electronic and manual faucets located in various locations within a hospital that was known to have Legionella within the building's plumbing system. Researchers speculated that the location of the faucet within the building's distribution system, frequency of the faucet's use, and where hot and cold water mix may have a larger impact than the faucet itself (Mäkinen et. al. 2013).

Another recent study evaluated the effect of aerators and laminar flow devices on growth of Legionella (Huang and Lin 2007). Testing was completed in a hospital with a history of Legionella colonization. The test system consisted of six faucets arranged in parallel; two faucets had aerators, two had laminar flow devices, and two had no aerator attachment (control). When the water outlet was used at random, water flowed uniformly through all six test faucets. The mean flow rate was 6.0 L/min (1.5 gpm) for faucets with aerators and 1.2 L/min (0.3 gpm) for faucets with laminar water flow devices, compared with 11.0 L/min (2.9 gpm) for the control faucets. The test system is shown in the figure below. The researchers evaluated Legionella concentration in water from each of the six faucets and in biofilm from each of the six faucets. The study concluded that using aerators or laminar flow devices to reduce flow rate do not increase the concentration of Legionella in water or biofilm samples.

Figure 1: Experimental Set Up

FIGURE. Experimental set up of the model plumbing system (1, faucets with aerators; 2, control faucets; 3, faucets with laminar water flow devices).

Source: Huang and Lin 2007

A third study evaluated and compared the presence of Legionella in water within the plumbing system of a hospital and from water collected from faucet outlets (Cristina, et. al. 2014). This study found that there was not a statistically significant difference between the positive Legionella results in the plumbing system and faucet outlet. In other words, the existence of a faucet had no significant impact on the presence of Legionella. The study did find that the concentrations of Legionella were higher at the outlet than within the plumbing system. The study concluded, "The results obtained seem to indicate that contamination by [Legionella] can mainly be attributed to the water system itself, and that the presence of aerators influences the concentration of the microorganisms rather than the percentage of positive samples." Since the study did not look at attributes of the faucet and faucet aerators themselves, it did not draw any conclusions about the impact of faucet flow rate, faucet design, or aerator design on the concentration of pathogens.

Finally, a fourth study published in the Journal of Applied Microbiology in 2006 (Liu et al. 2006) attempted to prove the widely believed hypothesis that stagnation is a key factor in Legionella colonization and growth. The report states:

> "Stagnation within water systems has been cited by numerous authors as a condition favouring Legionella replication (Ciesielski et al. 1984; Harper 1988; Anon 1996). However, the effect of low flow conditions on the presence of Legionella in a water system has not been scientifically evaluated. Therefore, we investigated the effect of flow dynamics on the presence of Legionella in a model plumbing system under controlled conditions.
>
> Turbulent, laminar and stagnant flow conditions were created by regulating flow velocities through identical PVC pipes. The lowest concentration of Legionella was recovered in biofilm samples from the stagnant pipe

in each experiment compared with turbulent and laminar flow pipes. It was also visually apparent that turbulent flow resulted in the greatest accumulation of biofilm in the sampling pipe…."

Table 1: Legionella Concentrations

Table 1 *Legionella* concentrations in biofilm and planktonic samples from turbulent, laminar and stagnation flow pipes after 5 weeks of recirculation

Experiment ($Re_{laminar}$ *vs* $Re_{turbulent}$)	*Legionella* in inlet biofilm (CFU cm^{-2})	*Legionella* in outlet biofilm (CFU cm^{-2})	*Legionella* in planktonic sample (CFU ml^{-1})
1 (750 *vs* 40 000)			
Turbulent	6591	8759	1545
Laminar	635	927	4257
Stagnant	200	328	631
2 (355 *vs* 34 825)			
Turbulent	564	734	5067
Laminar	276	142	11 865
Stagnant	57	25	1938
3 (1400 *vs* 10 000)			
Turbulent	15000	14167	2125
Laminar	4183	2242	3900
Stagnant	392	1358	1074
4 (2000 *vs* 25 000)			
Turbulent	5408	4300	339
Laminar	2183	1817	633
Stagnant	1308	617	164

Source: Liu et al. 2006

Research conducted by Liu et al. 2006 "failed to show that stagnation promoted growth of Legionella." As shown in Table 1, the stagnant flow regime resulted in the lowest concentrations of Legionella in all test cases and turbulent (high) flow actually promoted the growth of Legionella.

In summary, the four studies presented above provide no evidence that a faucet's characteristics, including its flow rate, have a significant impact on the growth of Legionella in potable water supplies.

5 Conclusion

After completing a review of published research on opportunistic premise plumbing pathogens (OPPPs), the CASE Team has concluded that the existing body of research is insufficient to prove there is a correlation between faucet flow rate and an increased risk of exposer to opportunistic pathogens. Existing research provides insufficient evidence that a faucet's characteristics, including its flow rate, have a significant impact on the growth of Legionella in potable water supplies. While reducing flow rate of all fixtures within the house can increase retention time and longer retention times have been hypothesized (but not proven) to increase growth of Legionella in buildings where Legionella is already present, there is no conclusive evidence that a reduction of flow rate of faucets, especially a reduction from 1.5 gpm to 1.0 gpm, will lead to either the prominence of or increased concentration of Legionella.

6 References

California Department of Public Health. 2012. "Yearly Summary of Legionellosis in California, 2012". Available online at: http://www.cdph.ca.gov/programs/sss/Documents/Legionellosis-Yearly-Report2012.pdf

[CDC] United States Center for Disease Control. 2013. "Surveillance for Waterborne Disease Outbreaks Associated with Drinking Water and Other Nonrecreational Water — United

States, 2009–2010." Morbidity and Mortality Weekly Report. September 6, 2013 / Vol. 62 / No. 35. Available online at: http://www.cdc.gov/mmwr/pdf/wk/mm6235.pdf

Cristina, Maria Luisa BSc; Anna Maria Spagnolo, Beatrice Casini, Angelo Baggian, Pietro Del Giudice, Silvio Brusaferro, Andrea Poscia, Umberto Moscato, Fernanda Perdelli, and Paolo Orlando.2014. "The Impact of Aerators on Water Contamination by Emerging Gram-Negative Opportunists in At-Risk Hospital Departments." Infection Control and Hospital Epidemiology, Vol. 35, No. 2.February 2014. Available online at: http://www.jstor.org/stable/10.1086/674863.

Edwards, Marc, William Rhoads, Amy Pruden, Annie Pearce and Joseph O. Falkinham, III. 2014. "Green Water Systems and Opportunistic Premise Plumbing Pathogens." Plumbing Engineering. November 2014. Available online at: http://plumbingengineer.com/nov_14/edwards_feature.php.

[EPA] United States Environmental Protection Agency. 2001. "Legionella: Drinking Water Health Advisory." Publication Number EPA-822-B-01-005. Available online at: http://water.epa.gov/scitech/swguidance/standards/upload/2009_02_03_criteria_humanhealth_microbial_legionellaha.pdf.

Keane, Tim. 2012. "Impact of Electronic Faucets and Water Efficiency Guidelines on a Legionnaires Disease Outbreak in a Healthcare Facility." Presentation for the IAPMO and World Plumbing Council International Emerging Technologies Symposium. May 2012. Available online at: https://www.youtube.com/watch?v=KstUFCRMePc.

Mäkinen, Riika, Ilkka T. Miettinen, Tarja Pitkänen, Jaana Kusnetsov, Anna Pursiainen, Sara Kovanen, Kalle Riihinen and Minna M. Keinänen-Toivola. 2013. "Manual Faucets Induce More Biofilms than Electronic Faucets." NRC Research Press. Volume 59. 2013. Available Online at: http://www.nrcresearchpress.com/doi/abs/10.1139/cjm-2013-0131?url_ver=Z39.88-2003&rfr_id=ori%3Arid%3Acrossref.org&rfr_dat=cr_pub%3Dpubmed&#.VHLqZ_nF9Zs.

Liu, Z., Y.E. Lin, J.E. Stout, C.C. Hwang, R.D., and V.L. Yu. 2006. "Effect of Flow Regimes on the Presence of *LegionellaI* within Biofilm of a Model Plumbing System." Journal of Applied Microbiology. August 2006. 101(2):247-442.

Pedro-Botet, M.L., J.E. Stout, and V.L. Yu.2002."Legionnaires' Disease Contracted from Patient Homes: The Coming of the Third Plague?" European Journal of Clinical Microbiology & Infectious Diseases Volume 21, Issue 10, October 2002. Available online at: http://www.legionella.org/100960699-1.pdf.

Stout, Janet E. and Muder, Robert R. 2004."Legionella in Residential Water Systems." ASHRAE Journal, May 2004. Available online at: https://www.ashrae.org/file%20library/doclib/public/200442714379_326.pdf.

Wang, Hong. 2013. "Critical Factors Controlling Regrowth of Opportunistic Pathogens in Premise Plumbing." Dissertation submitted to the faculty of the Virginia Polytechnic Institute and State University in partial fulfillment of the requirements for the degree of Doctor of Philosophy In Civil Engineering. February 2013. Available online at: http://vtechworks.lib.vt.edu/bitstream/handle/10919/19305/Wang_H_D_2013.pdf?sequence=1&isAllowed=y.

Wen-Kuei Huang and Yusen Eason Lin. 2007. "A Controlled Study of Legionella Concentrations in Water from Faucets with Aerators or Laminar Water Flow Devices." Infection Control and Hospital Epidemiology. June 2007, vol. 28, no. 6. Available online at: http://www.specialpathogenslab.com/perch/resources/huang-and-lin-iche-2007-aerators-laminar-flow-infection-control-2.pdf.