CODES AND STANDARDS ENHANCEMENT INITIATIVE (CASE)

Multi-Head Showers and Lower-Flow Shower Heads

2013 California Building Energy Efficiency Standards

California Utilities Statewide Codes and Standards Team September 2011

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1. Purpose

The purpose of this CASE study is to propose changes to the 2013 California Energy Efficiency Code (California Code of Regulations, Title 24, Part 6), regarding the energy savings achievable by reducing the flow rate of shower heads, and the number of shower heads that can be installed in new construction projects, in both residential and nonresidential buildings.

There have been many utility programs and research studies that have assessed savings by retrofitting of lower-flow (<2.5gpm) shower heads in various types of housing (to replace both regular shower heads and multi-head showers). These programs and studies have focused mainly on flow rate per shower head, although a few have gathered data on the prevalence of multi-head showers. The resulting evaluation reports and research papers provide a substantial body of literature that allows us to estimate savings (water and energy) from lower-flow shower heads with a high degree of certainty. The savings from eliminating multi-head showers have a lower degree of certainty.

Note that we have used the term “lower flow” shower heads, rather than a term such as “ultra low-flow”, because the modifier “ultra” is likely to be used in future shower head standards, in the same way that it is already used in toilet flush standards.

2. Overview

Description	The proposed measure would require shower heads installed in new construction in California to have a maximum rated flow rate at 80psi of less than or equal to 2.0 gallons per minute (gpm), and would make multi-head showers non-compliant with code unless the *total* flow rate from all heads at any given time were less than or equal to 2.0gpm. This flow rate requirement is consistent with the Federal WaterSense requirement, and would be measured using the methods set out in ASME A112.18.1M. To prevent home builders from circumventing the ban on multi-head showers, the proposed measure would also require showers to have only one shower head, unless that shower is large enough to require two heads (spacing between heads must be at least four feet). Note that the proposed change to the flow rate requirement is subject to the rules on Federal preemption, due to the existence of a Federal standard for flow rate. However, the Federal standard is required to be updated every five years to avoid pre-emption, and has not been updated since 1996 DOE therefore issued a ruling to waive Federal pre-emption for shower head flow rate standards, effective December 2010[1]. The proposed change to the minimum distance between shower heads is not subject to Federal pre-emption because no equivalent Federal standard exists. The Federal DOE issued guidance in March 2011 stating that multi-head showers will have to meet the maximum flow rate for single head showers (2.5gpm) from March 2013 onward. Since March 2013 is before the anticipated implementation date of Title 24 2013(Jan 1 2014), we have assumed that this interpretation will be in force by that time.
Type of Change	**Mandatory Measure** The change would add a mandatory requirement for maximum shower head flow rate, and would limit the number of shower heads per shower. It would also require a shower head to be installed in each shower, to avoid developers installing showers without heads and then install high flow showers at time of sale. This change would increase the scope of the current Standards, because shower heads are not currently regulated (though other water-heating equipment and systems are regulated). This change would not require implementation of systems or equipment that are not already readily available on the market and for use in the proposed applications. The Standards and Manuals language would be modified in order to include the new requirements.

[1] http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/plumbingproducts_finalrule_preemptionwaiver.pdf

Energy Benefits

The energy savings benefit of this measure that reduces the shower fixture flow rate from 2.5 gpm to 2.0 gpm is reduced gas consumption for water heaters. The value of the gas saved is projected to be roughly $1.3 million statewide in the first year (assuming 100% compliance).

Time Period	Statewide Technical Potential Energy Savings (Million Therms)	
	Single Family	Multi-Family
First Year	1.7	0.3
Measure Life	64	11

Using CEC projections of residential construction for 2013 (See Section 8 Appendix Figure 18), the measure delivers statewide energy reductions shown in the table above. These data are derived from estimates of annual energy reductions of approximately 18 and 12 therms/year/unit for single family and multi-family, respectively.

Non-Energy Benefits

A reduction in flow rate from 2.5gpm to 2.0gpm would save roughly 500 million gallons of water statewide annually (assuming 100% compliance), or 15 billion gallons of water over the 30-year effective life of the measure. These estimates are calculated based on reduction estimates of 3,600 gallons and 2,400 gallons per household for single family and multi-family, respectively.

Time Period	Statewide Technical Potential Water Savings (Million Gallons)	
	Single Family	Multi-Family
First Year	340	63
Measure Life	13,000	2,200

Environmental Impact

In addition to energy savings, there are also significant water savings as shown in the second table below.

Material Increase, (Decrease), or No Change (NC): (All units are lbs/year)

	Mercury	Lead	Copper	Steel	Plastic	Others
Per shower head (lower flow)	NC	NC	NC	NC	NC	NC
Per shower head (multi-head)	NC	NC	NC	NC	NC	NC

Water Consumption:

	On-Site (Not at the Powerplant) Water Savings (Gallons/Year)
For standard fixture conversion	330,000,000 (SF) 62,000,000 (MF)
For multi-head fixture conversion	5,400,000 (SF) 1,000,000 (MF)

Water Quality Impacts:

Comment on the potential increase (I), decrease (D), or no change (NC) in contamination compared to the basecase assumption, including but not limited to: mineralization (calcium, boron, and salts), algae or bacterial buildup, and corrosives as a result of PH change.

	Mineralization (calcium, boron, and salts)	Algae or Bacterial Buildup	Corrosives as a Result of PH Change	Others
Impact (I, D, or NC)	NC	NC	NC	NC
Comment on reasons for your impact assessment				

Air Quality in lbs/Year, Increase, (Decrease), or No Change (NC):

Note that, for simplicity, this table shows air quality impacts for both the lower flow and multi-head measures. The contribution of the multi-head measure is only 1-2% of the total.

Building Type	Savings Description	**Avoided Emissions** (lbs/year)				
		CO_2	CO	PM_{10}	NOx	SOx
Residential Single-Family	per dwelling unit	206	0.05	0.02	0.18	0.12
	per square foot	0.10	0.00	0.00	0.00	0.00
Residential Multi-Family	per dwelling unit	135	0.04	0.01	0.12	0.08
	per square foot	0.09	0.00	0.00	0.00	0.00

Technology Measures	**Measure Availability and Cost:** Technology to satisfy the proposed measure is readily and widely available from multiple manufacturers. See section 5.4. **Useful Life, Persistence and Maintenance:** The life of shower heads is unknown, but does not affect the payback of the measure because the incremental cost is zero. There is no reason to expect that lower flow shower heads would have a shorter service life than regular shower heads, because they use the same technologies to regulate flow rate.
Performance Verification	No performance verification is required
Cost Effectiveness	The measure is cost effective with immediate payback because the measure is no more expensive than the base case. See section 5.6 for details.
Analysis Tools	The benefits from this measure can be quantified using the current reference methods. The installation and operation of this measure, along with impacts on energy consumption can be modeled in the current reference methods and analysis tools. However since this measure is proposed as mandatory, analysis tools are not relevant since the measure is not subject to whole building performance trade-offs.
Relationship to Other Measures	Because lower flow showers and multi-head showers affect the amount of water used for showering, they will likely influence the economics of solar water heating measures. For instance, reduced water consumption would reduce the required area for solar collectors, making it more technically feasible to install these systems.

3. Existing Standards and Regulations

3.1 Federal Standards

The Federal Energy Policy Act of 1992 (EPAct) set a requirement for "low flow" shower heads at no more than 2.5gpm at 80psi flowing pressure[1]. EPAct refers to American Society of Mechanical Engineers (ASME) test procedure A112.18.1M-1989, which was updated in 1996 to A112.18.1M-1996.

The Federal U.S. Code[2] allows states to implement their own, more stringent standards if the ASME/ANSI standard is not amended to improve the efficiency of shower heads within five years:

> *If, after any period of five consecutive years, the maximum flow rate requirements of the ASME/ANSI standard for shower heads are not amended to improve the efficiency of water use of such products, or after any such period such requirements for faucets are not amended to improve the efficiency of water use of such products, the Secretary shall, not later than six months after the end of such five-year period, publish a final rule waiving the provisions of section 6297 (c) of this title with respect to any State regulation concerning the water use or water efficiency of such type or class of shower head or faucet if such State regulation—*
>
> *(i) is more stringent than the standards in effect for such type of class of shower head or faucet; and*
>
> *(ii) is applicable to any sale or installation of all products in such type or class of shower head or faucet.*

The U.S. Code contains procedures for prescribing new or amended standards.

Because the ASME/ANSI standard has not been amended to improve efficiency since the Energy Policy Act was passed in 1992, California is now able to introduce an improved standard without contravening the rules on Federal pre-emption.

There is no issue of federal pre-emption with multi-head showers, because neither the Energy Policy Act nor any other act mentions multi-head showers.

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[1] H.R. 776. Energy Policy Act of 1992. Subtitle C, Section 123, Energy Conservation Requirements for Certain Lamps and Plumbing Products.

[2] United States Code, TITLE 42, CHAPTER 77, SUBCHAPTER III, Part A, § 6295 Energy Conservation Standards. Accessed at http://www.gpoaccess.gov/uscode/ on May 14, 2009.

4. Methodology

This section summarizes the methods we used to collect data for this CASE report. We gathered data from a wide variety of sources and conducted several different kinds of analyses. This section sets out our broad methodology and describes how those methods contributed to the recommendations.

This CASE requires code to make an enforceable distinction between the various shower head options available in the market. We used the classifications defined by Biermayer (2006) to describe available multi-head showers into four types:

- Multiple-head shower
  - Two or more spray nozzles connected to one pipe (for instance a fixed shower head and a handheld shower head).
  - Easily replaces single fixture
- Shower panel or shower tower
  - Sprays water from several shower heads mounted at different heights on a vertical panel.
- Rain systems
  - Simulate rain fall by allowing water to fall from a large overhead fixture, or one with multiple heads
  - Body spas
- Multiple shower heads
  - Shower heads - supplied by different pipes - spray water from multiple directions
  - Vertical equivalent of a whirlpool tub
- Recirculating systems
  - Often part of body spa system and includes heater and pump
  - Therapeutic function, but can also be disabled to allow for normal operation

Note that some very high flow "spa" systems use pumps to recirculate the water, so their energy and water consumption may not be greater than a single-head shower. Recirculating systems on normal flow showers are commonly used in countries such as Australia that experience water shortages.

4.1 Consumer Satisfaction with Lower Flow Showers

We conducted a literature search for studies that had assessed consumer satisfaction with lower flow showers. We found two studies (Tampa 2004 and Tachibana & Schuldt 2008) that assessed user satisfaction with lower flow shower heads in the field. The two studies used different shower heads, but in each study only one model of replacement shower head was distributed, so these studies represent only two data points in terms of shower head models.

We also found one study (CEC PIER 2010) that assessed user satisfaction in a controlled laboratory setting. This study used a large number of different shower heads that represent the current (2010) state of the shower market, so we believe that this study on its own is sufficient to compare user satisfaction between normal and lower flow shower heads.

4.2 Thermal Shock

We specifically investigated the issue of thermal shock because this was raised by a number of experts with whom we discussed this CASE project. HMG participated in two meetings of the ASME Joint Shower Head Task Force (JSTF), which included discussion of the phenomenon of "thermal shock", and whether it may be more prevalent with lower flow shower heads.

Thermal shock is a sudden increase (or decrease) in shower temperature which results from a sudden change in demand for cold water elsewhere in a system that can lead to a change in pressure in the cold water supply to the shower head. The pressure change can alter cold water flow rate and consequently increase shower temperature. This effect is reduced by the presence of pressure compensating valves or thermostatic valves, which have been required by federal law in new construction and in permitted retrofits for some time. However, compensating valves rated for use with 2.5gpm shower heads may or may not perform adequately with showers that flow at lower rates, so we spoke with a variety of experts to request information about compensating valve performance, and made a formal request at an ASME meeting in January 2009 for data or calculations that would substantiate an increased prevalence of thermal shock from lower flow shower heads. We also followed up by email and telephone[1]. The provided information was used for analysis (see Section 5.2)

4.3 Market Assessment

4.3.1 Prevalence of Multi-head Showers

To estimate the magnitude of potential energy and water savings, we conducted a literature search and contacted researchers in the field to assess the prevalence of multi-head showers. We identified four sources of data. The two most significant in terms of the number of homes surveyed were a survey performed by Tachibana and Schuldt that provides data on 71 homes in the Seattle area, and a Seattle Public Utilities survey of 1139 customers. Limited data was also available from Bierneyer (2006) and the AIA Home Design Trends survey (2009).

4.3.2 Lower Flow Shower Heads

We were not able to find estimates of market penetration of lower flow shower fixtures. While the California Energy Commission (CEC) sponsored Residential Appliance Saturation Survey (RASS) did query whether "low flow" fixtures were installed in a occupant's shower, the structure of the question does not provide results applicable to this CASE topic. The question "Do you have low-flow showerheads installed in the shower(s)?" does not provide the survey participant with clarification about what low-flow means (in fact low-flow in this survey means federal maximum 2.5gpm) nor any assurance that the participant confirms the rated (at 80psi) flow rate of the shower fixture.

The quantity of lower flow shower fixtures that would be installed as a result of a proposed mandatory code change to lower the maximum rated flow rate is determined based on

[1] We contacted the following people for data on thermal shock: Ron George (President, Ron George Design and Consulting Services), Michael Martin , Gary Klein (California Energy Commission), Kim Wagoner (WaterSense), John Bertrand (Moen Inc.).

conservative estimates of new construction area, full bathrooms per new construction area, and shower fixtures installed per full bathroom. Estimates for shower fixtures installed per household was conservatively chosen to be 1 shower fixture installed per household, while this could be lower than the actual average, HMG is confident that this supports a conservative estimate for statewide savings. New construction area is taken from CEC published construction forecasts through 2042 (or the life of the proposed measure).

4.3.3 Availability and Pricing Survey

HMG conducted a survey of the prices and availability of lower flow shower heads at major home improvement retailers and manufacturer distributors. In an effort to reflect the average price throughout the state of California, HMG collected contact information for a number of distributors of showerhead manufacturers.

From the websites of these manufacturers, HMG collected distributor's contact information (primarily phone conversations, some email) from six (6) regions of California: Sacramento, San Francisco Bay Area, Los Angeles, San Diego, Inland Empire, and Other (primarily Central Valley). Collecting distributors from various regions in the state was essential to ensure that sale price averages reflect the variations across California.

A random sample of distributors were contacted (at least ten from each region, some never responded). The conversations were typically free form; however conversations usually began with "which showerhead is your highest volume product?". Distributors would offer prices for their highest volume product and on average three (3) additional models. HMG also asked "Do you sell any less than 2.5 gpm showerheads?" during every conversation to glean what range of products the distributors were familiar with and which products were in stock.

4.4 Energy Consumption

We undertook the following activities to gather data on energy effects of multi-head showers and lower flow showers.

4.4.1 Multi-Head Showers

We conducted a literature search and found that there have been no studies that directly addressed the prevalence, use, and market for multi-head showers, but were able to find two studies that indicate the likely effect of an individual multi-head shower on energy use. Studies by the Seattle Public Utilities (2006) and Biermeyer (2006) give values for water flow rate, which is a good proxy for energy consumption.

4.4.2 Low Flow Showers

Several extensive and detailed studies have been performed to measure flow rates under laboratory conditions (RMA 2010) and *in situ (*Seattle Public Utilities 2006, Tachibana and Schuldt 1994). These studies have collected data that includes:

- Flow rate (gallons per capita per day)
- Showers per day
- Shower duration and
- Flow rate in situ.

This data is sufficient to accurately quantify the savings that would achieved by requiring lower flow shower heads under code.

4.4.3 Structural Waste

"Structural waste" is a term used to describe the amount of hot water left in the pipes at the end of a shower, which most likely cools below useable temperature before the next shower is taken, and therefore is wasted.

We were not able to find field data on the amount of structural waste that is typically associated with showering, but from discussions with experts we believe that structural waste would not be affected by a code requirement for lower flow showers, because structural waste depends only on the diameter and length of the pipes that supply the shower head, not on the shower head itself. However, in the longer term, if supply pipe diameters were reduced in line with the reduced flow requirement, reductions in structural waste could be expected.

4.5 Methodology for Cost-Effectiveness Calculations

Shower fixtures are considered to have a useful life of 15 years according to the CEC's cost-effectiveness methodology (CEC 2002). HMG estimated annual energy savings and the resulting value of savings over 15 years, and expressed this as a net present value of savings. By subtracting capital and labor costs from the net present value of the cumulative savings, we calculated the net financial benefit of the measure.

HMG conducted the life cycle cost calculation using the California Energy Commission (CEC) Time Dependent Valuation (TDV) methodology for the 2008 standards (CEC 2002). Each hour is assigned an estimated price for energy, and the sum of these prices over the life of the measure yields the present dollar value of savings. Life cycle cost is the difference between the TDV $ value for energy savings and capitol plus installation cost of the measure. Cost effectiveness is proved when this difference is positive.

5. Analysis and Results

This section summarizes the results of the data collection and analysis described above.

5.1 Consumer Satisfaction with Lower Flow Showers

We were able to find field studies and laboratory studies that dealt with consumer satisfaction. The findings of those studies are summarized below.

5.1.1 Field Studies

HMG reviewed two studies (Tampa 2004 and Tachibana & Schuldt 2008) that assessed user satisfaction with lower flow shower heads in the field. In both studies, user satisfaction was high. The two studies used different shower heads, but this still represents only two data points in terms of shower head models.

In correspondence with Debra Tachibana of Seattle City Light in October 2008 we received the following additional information, which was not included in Tachibana and Schuldt (2008):

> *Solicitations of interest in shower head kits were mailed to customers in June-August 2007; Kits were sent to respondents in July-December 2007; and the follow-up survey was fielded in April-May 2008. The 83% installation rate is calculated from that follow-up mail survey. On average, participants would have had their kits for about six+ months, at the time they received the follow-up survey.*
>
> *We asked, "How satisfied are you with the spray pattern and the amount of water that comes out of your new shower head?" The vast majority of survey respondents who had installed a shower head (92%) were satisfied with the program shower head: most said "very satisfied" (69%) and a quarter said "somewhat satisfied" (23%). Few respondents were dissatisfied: half of those said "not too satisfied" (4%) and the rest said "not at all satisfied" (4%).*
>
> *We asked, "How do you like the new shower head compared to your old one?" The vast majority of survey respondents (90%) felt that the new shower head was better than or equal to their old one: most said they like it "better than the old one" (62%) and a quarter said they like it "about the same as the old one" (28%). Few respondents felt the new shower head was "worse than the old one" (10%).*

Surveys show an overwhelming majority of users included in lower flow shower fixture replacement programs were satisfied with the change from standard (2.5gpm) fixtures to lower flow fixtures (<2.0 gpm) and felt that the lower flow fixtures were "better than the [previous] one."

5.1.2 Laboratory Studies

There is, to our knowledge, only one laboratory study of user satisfaction with lower flow showers. This is the CEC PIER consumer satisfaction survey (CEC 2010). The study was conducted by Robert Mowris and Associates (RMA). RMA recruited 72 participants, each of whom tested 48 different shower heads, yielding a very large repeated-measured data set. None of the survey participants worked for RMA and none worked on the alternative product testing certification efforts.

The CEC PIER study asked participants to rate each showerhead on noise, overall satisfaction, and time required to rinse a small amount of conditioner from their hair. It also asked whether participants would buy that shower head ("buy percentage"). It should be noted that participants were rating their satisfaction with the shower heads only *in comparison to other showers*, not in absolute terms, i.e. the results indicate relative preference rather than a threshold of "acceptability", and rating products side by side tends to amplify differences.

Participants rated "overall satisfaction" on a continuous scale from 1 ("excellent") to 3 ("poor"). Figure 1 shows that "overall satisfaction" was lower for lower flow showers than for higher flow showers, and also that people were more likely to say that they would buy the higher flow showers. Both these results are significant at the p<0.001 level, i.e. the probability that this result arose by chance alone is less than 0.1%. A straight line of best fit shows that the difference in satisfaction between 2.0 and 2.5gpm is around 0.2 points on the overall satisfaction scale, which is small in comparison to the overall span from 1 to 3. .

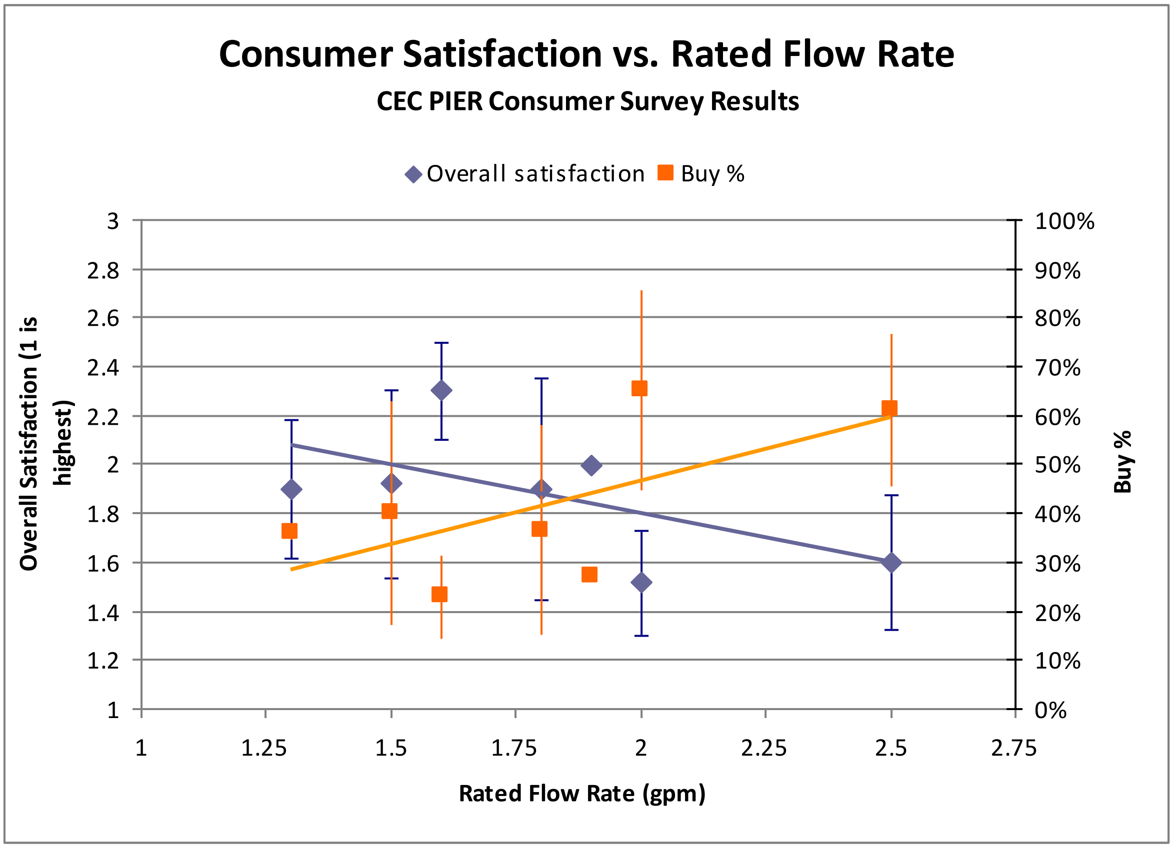

Figure 1. Consumer Satisfaction vs. Rated Flow Rate, in a Laboratory Test

When "overall satisfaction" is compared with *actual* (not rated) flow rate (see Figure 2), the relationship between satisfaction and actual flow rate is somewhat weaker than is suggested by Figure 2Figure 1. A straight line of best fit shows that the difference in satisfaction between 2.0 and 2.5 gpm is around 0.12 points on a scale from 1 (excellent) to 3 (poor). Using this analysis, the flow rate would have to drop to around 1.15 gpm before the average satisfaction would drop below 2 (the mid-point). The relationship between actual flow rate and consumer satisfaction has an r-squared value of 0.18, i.e. flow rate explains 18% of the difference in consumer satisfaction between shower heads—other factors (presumably such as coverage, force, noise) account for the rest. This suggests that manufacturers may be able to make up for any reduction in satisfaction due to flow rate by improving the performance of their shower heads in those other regards.

The conclusion that Robert Mowris and Associates drew from their data was that the state should not immediately adopt a lower flow limit for shower heads, and that instead the state should give manufacturers time to develop lower flow shower heads that perform consistently well. Because the anticipated adoption date of the Title 24 standard is January 2014, and manufacturers have been working with the new WaterSense 2.0gpm standard since it was released in 2010, they will have at least three years to develop improved products. Also, as described in the analysis above, we draw a slightly different conclusion from RMA's own data than they did[1], based on the coefficients of the correlations between flow rate and satisfaction. The CASE team worked closely with RMA during the development of this CASE report, and the research that led to RMA's PIER report.

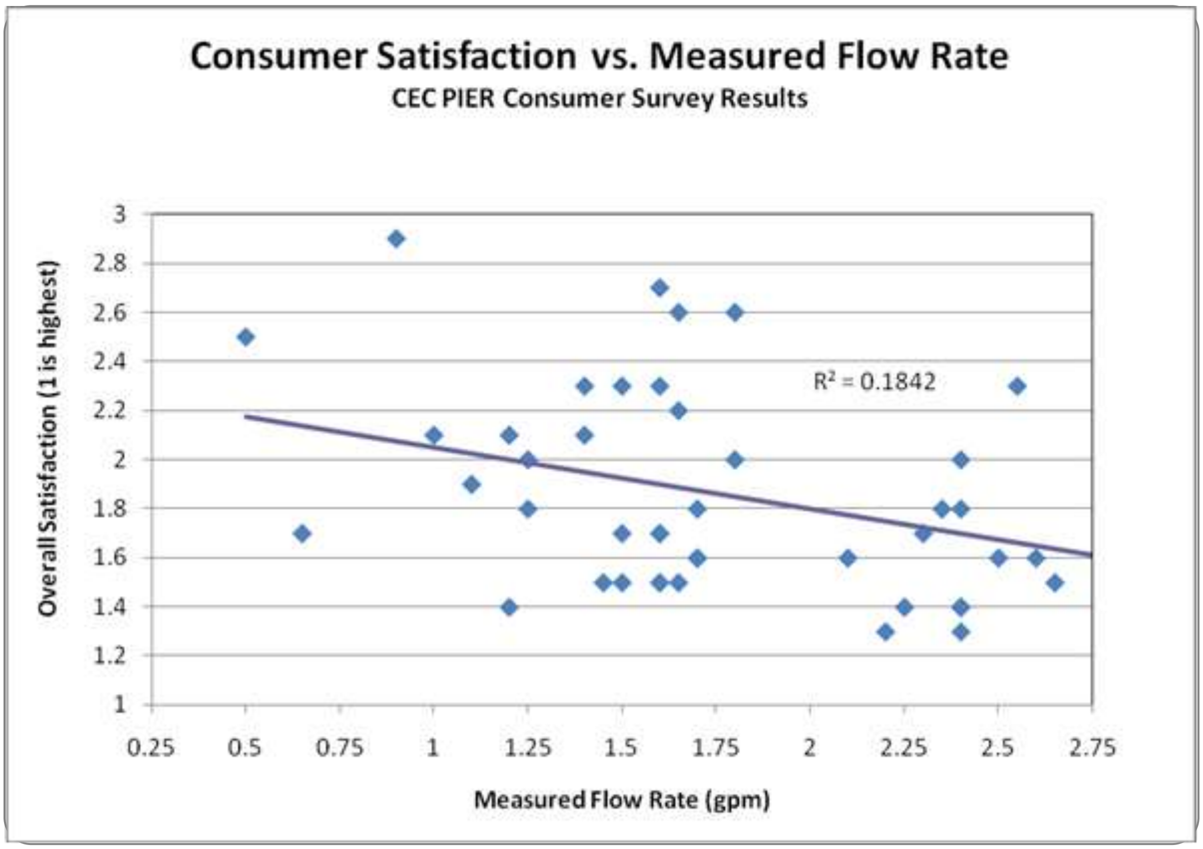

Figure 2. Consumer Satisfaction vs Measured Flow Rate, in a Laboratory Test

5.2 Thermal Shock

In response to a decision taken at a meeting of the Joint Harmonization Task Force (JHTF) between American Society of Mechanical Engineers (ASME) and American Society of Safety

[1] See the ACEEE paper that RMA wrote based on the PIER report, at http://www.aceee.org/files/pdf/conferences/hwf/2010/2D_Robert_Mowris.pdf

Engineers (ASSE) meeting in 2007, Martin and Johnson (2008) wrote up results from "manufacturers and other interested parties [who] agreed to test a combination of valves and shower heads to evaluate the effect of flow rate on their temperature control performance:" The intention of the tests was to find out whether pressure-compensating valves and thermostatic valves rated for 2.5gpm would perform adequately at lower flow rates. This information was provided to the CASE team in response to our requests for information at the ASME task force meetings (see section 4.2).

The tests included 22 shower valves from six manufacturers, and the valves were assessed on their ability to maintain water temperature within certain bounds for a given time after a change in pressure event, as described by the ASSE 1016-2005 standard for shower valves. This test requires that the delivery temperature of pressure compensating valves must not vary by more than +/- 3.6 degrees Fahrenheit for more than one second in response to the following events:

- Decrease the hot supply pressure by 50 percent ± 1.0 psi
- Increase the hot supply pressure 50 percent ± 1.0 psi
- Decrease cold water supply pressure by 50 percent ± 1.0 psi
- Increase the cold water supply pressure by 50 percent ± 1.0 psi

The tests were performed with the shower flow rate set to 2.5, 2.0, 1.75, 1.5, and 1.0 gpm using a throttling valve. The results of the tests are provided in Figure 3.

Test flow rate (gpm)	**Percentage of pressure-balancing valves that pass ASSE 1016-2005 temperature fluctuation test**	**Number of compensating valves per flow rate category**
2.5	100%	15
2.0	77%	13
1.8	67%	6
1.5	67%	15
1.0	31%	12

Figure 3. Performance of Pressure-Balancing Valves on ASSE Temperature Fluctuation Test (Martin and Johnson 2008)

Results were more pronounced for thermostatic valves, with fewer than one-third of the valves meeting the ASSE test criteria at flow rates less than 2.5gpm.

These results indicate that shower valve temperature maintenance is strongly affected by flow rate, and that new showers with lower-flow shower heads would have to be installed with valves that are designed for 2.0 and lower flow rates.

5.3 Market Assessment

5.3.1 Multi-Head Shower Fixtures

The consumption and satisfaction data on multi-head showers is limited. Statistically significant data is available only for Seattle (Seattle Public utilities 2006). There is no evidence, one way or the other to indicate that consumer or developer purchasing decisions are significantly different in California.

Tachibana and Schuldt found no multi-head showers in the 71 houses they surveyed, but their sample included only houses within the city limits of Seattle, which were mostly old houses, and it should be expected that older homes would have a lower prevalence of multi-head showers.

Seattle Public Utilities (2006) surveyed 1139 households and found that 12% of households in the City of Seattle and 20% outside the City limits had multi-head showers, as shown in Figure 4. This supports the hypothesis that multi-head showers are more prevalent in new residential construction which according to Tachibana mostly takes place outside Seattle City limits.

	Within City Limits	**Outside City Limits**
Multi-Head Showers installed (% of total respondents)	12%	20%

Figure 4. Percentage of respondents with multi-head shower fixtures installed in the home (n = 1139)

AIA's Home Design Trends Survey (2008), has found consistently over the past four years that architects report specifying more multi-head showers in the houses they design.[1] However, the survey reports only whether there has been a change, and does not give any estimate of the number of multi-head showers being installed.

We did not find any statistical evidence regarding penetration of multi-head showers into commercial construction (i.e., hotels and motels), although there is anecdotal evidence about individual hotel chains purchasing multi-head showers.

Biermayer quotes a survey by W&W Services Incorporated[2], conducted in 2006, that asked members of the Plumbing Manufacturers Institute to estimate the percentage of showers that are currently being installed with any combination of two or more shower heads, body sprays or other shower outlets. Biermayer does not report the number of participants in the survey. The mean percentages of multi-head showers for new construction and retrofits are 4.8% and 5.7% respectively, see Figure 5. The W&W survey did not ask PMI members to indicate whether they think that the market for multi-head showers is growing.

1 http://www.aia.org/practicing/economics/AIAS077115

2 W&W Services, Inc., Bolingbrook, Illinois January 30, 2006 (memo provided to the Plumbing Manufacturers Institute by Charles Wodrich)

	Mean	Median
New construction	4.8%	5.0%
Existing that are retrofitted	5.7%	4.0%
Existing shower compartments	3.7%	3.5%

Figure 5. Percentage of houses in which two or more shower heads, body spas or other outlets are installed in a single shower

The difference between the percentages reported by Seattle Public Utilities and by Biermayer may reflect a slight increase in prevalence between 2006 and 2008, but more likely reflects a slight difference in questioning, i.e. the Seattle study includes showers that have two heads *supplied by different pipes* whereas the study reported by Biermayer does not.

We therefore conclude that the available evidence, which is weak, shows that around 5-10% of showers are of the "panel" or "spa" type with two or more heads supplied from one pipe, and that another 5-10% have two or more heads supplied from different pipes, for a total of around 15% of the new construction market.

5.3.2 Accuracy of Rated Flow Rate Values

Flow Rate testing conducted by Robert Mowris and Associates for the California Energy Commission (Mowris and Associates 2010) found that the measured flow rate of many shower heads at 80 psig exceeded their rated flow rate. In some cases the flow exceeded the maximum Federally-allowed flow rate of 2.5gpm. This raises the question of whether a reduction in the allowed rated flow rate would actually result in a reduction in flow rates in practice, and thus in energy and water savings.

Figure 6 shows the average measured flow rate for each rated flow rate (blue dot), along with the standard deviation of flow rate among the shower heads tested (error bars). It shows that on average there is an almost perfect 1:1 ratio, i.e. that a 1 gpm reduction in rated flow corresponds to a 1 gpm reduction in measured flow, although there is a lot of variation between one shower head and another.

This result suggests that there is no systematic attempt on the part of manufacturers to claim lower flow rates than their products actually deliver, i.e. that the large variations for individual shower heads likely exist for technical reasons such as variations in production quality or differences in method or calibration between flow measurements.

Therefore, a given reduction in the allowed shower head flow rate in Title 24 would likely result in that same reduction being achieved in practice.

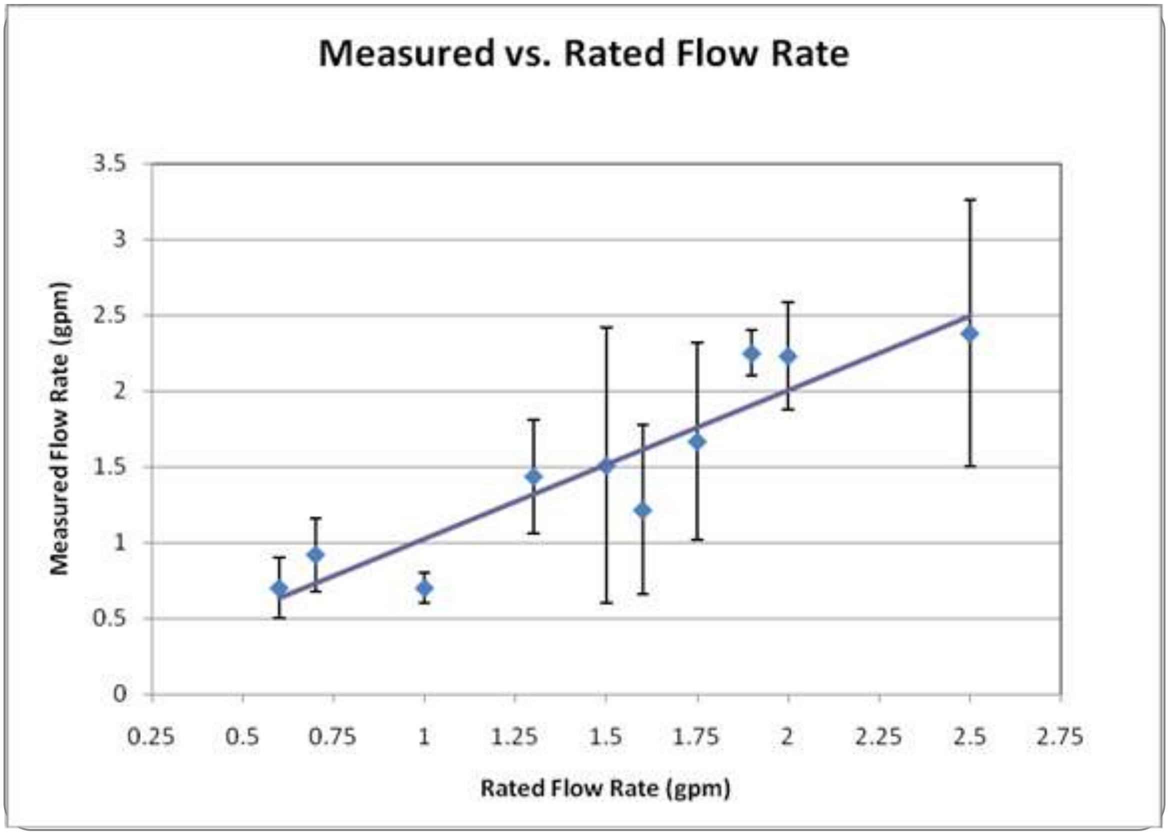

Figure 6. Measured vs. Rated Flow Rates for Shower Heads

5.4 Availability and Pricing Survey

Manufacturers of shower heads are numerous and offer wide range of products. Typical shower fixtures are distinguished by the style and flow rate; each fixture series is available in a few different trim options—nickel, brass etc—which provides customers with an overwhelming array of choices. Figure 7 is the result of HMG conducted survey of shower fixture sales reps and provides a summary of market information gathered for the pricing study. The survey included 22 manufacturers and 116 models with a 2.2 gpm average flow rate.

Brand Name	Number of different models sold	Minimum Fixture Flow rate (gpm)	Maximum Fixture Flow rate (gpm)	Brand Name	Number of different models sold	Minimum Fixture Flow rate (gpm)	Maximum Fixture Flow rate (gpm)
Alsons	5	1.6	2.2	La Toscana	2	2.5	2.5
American Standard	2	1.5	2.0	Moen	12	2.2	2.5
Brass Craft	1	2.5	2.5	Pasco	2	1.5	2.5
CP	1	1.5	1.5	Pegasus	8	2.5	2.5
Danze	1	2.5	2.5	Premier	1	2.5	2.5
Delta	16	1.5	2.4	Price Pfister	9	2.2	2.5
Downpour	1	2.5	2.5	Proflow	1	2.5	2.5
Ecoflow	1	1.5	1.5	ProPlus	1	2.5	2.5
Grohe	8	1.5	2.0	Speakman	7	1.5	2.3
HansGrohe	2	1.5	2.0	Sprite	1	2.5	2.5
Kohler	27	1.75	2.4	Waterpik	7	2.5	2.5

Figure 7. Market summary of shower fixtures

We found, anecdotally, that the larger manufacturers provide a wide range of models designed to meet the federal 2.5 gpm standard flow rate but few or no lower-flow models (e.g., Delta, Grohe/HansGrohe, Kohler, Moen, Price Pfister). Conversely, many smaller volume manufacturers sell ultra low flow fixtures only (e.g, Alsons, CP, Ecoflow and Pasco).

Figure 8 shows that the majority of products sold meet the federal standard nominal flow rate requirement of 2.5gpm, rather than a lower flow rate.

Flow Rate (gpm)	Number of models
1.50	10
1.60	2
1.75	3
2.00	3
2.20	3
2.50	98

Figure 8. Fixture Quantities by Flow Rate

Although the market is flush with fixtures that meet current federal standards, and moving the market towards lower flow fixtures would require a change in manufacturing, this shift should not push undue costs onto manufacturers, because lower flow shower heads mostly use the same components are regular shower heads (though modified to deliver less water).

Figure 9 shows fixture purchase price is not dependent on rated flow rate. The fixtures that make up the 2.5 gpm category include a wide range of styles and finishes to cover basic, intermediate and luxury customer preferences. Due to the broad range of products offered at 2.5 gpm, the fixtures available at rated 2.5 gpm flow rate have an average price that is considerably higher than the most basic fixture. Conversely, there are few lower-flow shower heads offered with expensive finishes, which explains their lower average price.

From conversations with experts and manufacturers we have learned that flow rate is determined by the diameter of the spray nozzles, which is not price-dependent. Together, this information suggests that that manufactures will not suffer increased manufacturing costs to satisfy a code change requiring lower nominal flow rate fixtures.

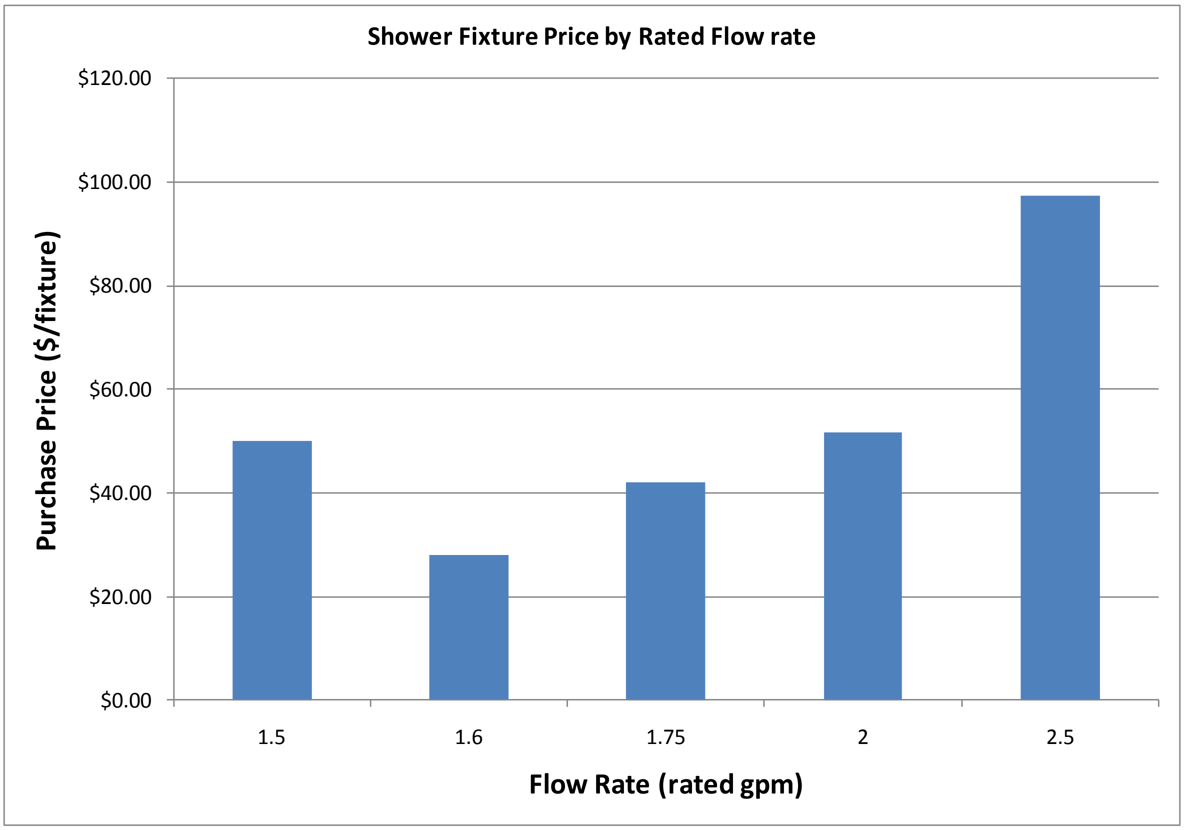

Figure 9. Fixture price by flow rate

5.5 Energy Savings

This section summarizes the projected energy and water savings from reducing the shower head flow rate and prohibiting multi-head showers in Title 24.

Although it would be intuitive to assume that lower flow rates result in less water consumption *per shower event,* we conducted an analysis to test this hypothesis. The resulting relationship between flow rate and shower volume can then be applied to both the lower flow shower heads and multi-head shower measures, to calculate savings.

Figure 10 shows the results of three studies comparing typical shower volume (i.e. the total amount of water consumed per shower taken) for various fixture flow rates. The East Bay Municipal Utility District (EBMUD) study and Residential End Use Water Survey (REUWS) data trends corroborate one another to yield a useful approximation of the relationship between fixture flow rate and shower volume: Larger fixture flow rates reduce average shower duration, but the decreased shower time does not outweigh the increase in fixture flow rate—i.e. lower flow showers (and shower with fewer heads) use less water *per shower taken*.

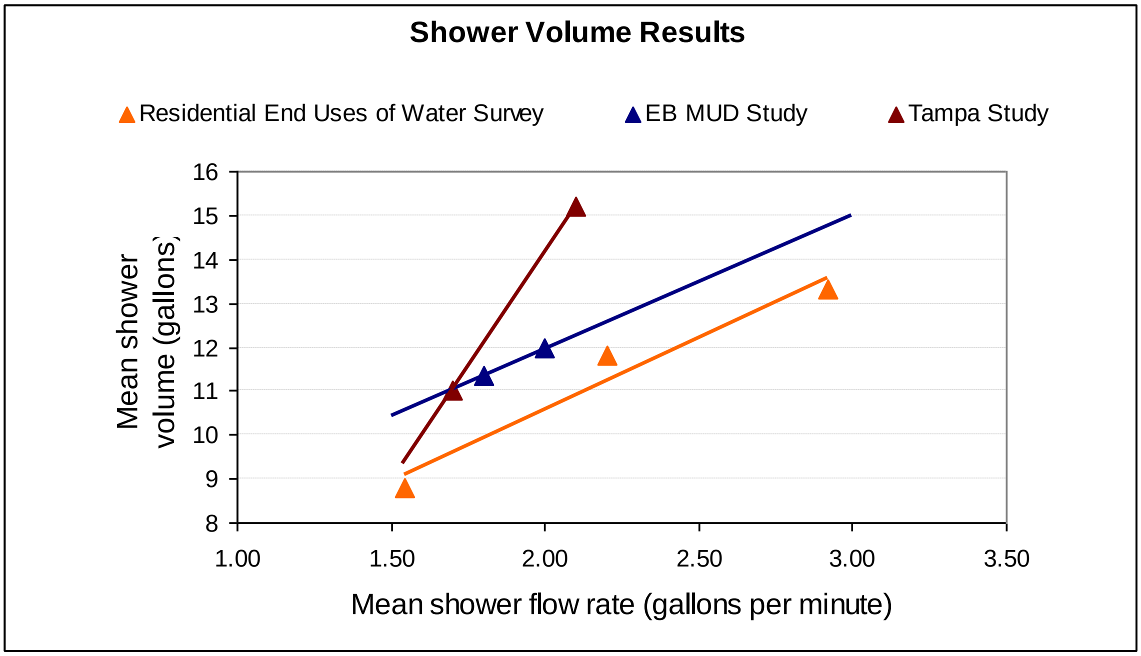

Figure 10. Shower Volume Study Outcome Comparison

5.5.1 Multi-Head Shower Fixtures

Seattle Public Utilities, 2006 Residential Water Conservation Benchmarking Survey and Attribution/Consumption Analysis, submitted by Dethman & Tangora LLC, Seattle[1], found 15% of respondents reported having showers with multiple heads or nozzles. Among those who had showers with multiple heads or nozzles, 47% reported they had two nozzles, 24% had three nozzles, and 20% had four or more nozzles. The average number of nozzles per multi-head shower was 2.6, which at a flow rate of 2.5gpm (standard) per nozzle gives an upper bound of 6.5gpm on the average flow rates of multi-head showers. Additional nozzles are typically 1.5 gpm, which would give an estimate of 4.9 gpm for average flow rate of multi-head showers, but we know from reviewing product literature that some multi-head showers use a lot more than four nozzles, so we have assumed that the 6.5 gpm estimate is likely to be more reasonable.

Based on published manufacturers' flow rates, and on a skewed triangular distribution of flow rates up to 10gpm (the highest flow rate found under testing by the California Energy Commission (p.9-19), Biermayer concludes that the mean flow rate for multi-head showers is likely to be around 5.5gpm. These data—Biermeyer and Seattle Public Utilities studies—provide fairly consistent fixture flow rate data points.

1 http://savingwater.org/docs/2006Regional Survey.pdf

The trend lines shown in Figure 10 for the REUWS study and the EBMUD study can be applied to the findings of Seattle Public Utilities and Biermayer results—6.5 and 5.5gpm average multi-head shower fixture flow rate, respectively—to produce annual water and energy consumption above federal standard maximum flow rate (2.5gpm). The conclusions are reported in Figure 11.

(All data reported is on per capita basis)	Average Fixture Flow rate (gpm)	Shower Use (gal/day)	Water use above Federal Std (gal/yr)	Potential Savings (therms/yr/shower head)
Seattle Public Utilities	6.5	25.7	9381	82
Biermeyer	5.5	22.6	8249	73
REUWS (Non-Low Flow houses)	2.9	13.3	4855	43

Figure 11. Comparison of Three Different Estimates of Multi-Head Shower Energy and Water Savings

Note that the Energy savings (therms/yr) are derived from the following assumptions:

- Ground water temperature = 60^0F
- Hot Water Supply temperature = 105^0F
- Average water heater energy factor = 0.57
- Density of water = 8.35 lbs/gal

The calculations do not include "structural waste" which is assumed to be the same for all showers. Structural waste is slightly increased by a hotter supply temperature (which may be required for high flow showers), but is mostly related to hot water supply pipe length and diameter, which we have assumed are the same irrespective of shower type. This is because bathrooms are typically supplied by a ¾" hot water pipe, which is sufficient for both single head and multi-head showers.

5.5.2 Lower Flow Shower Fixtures

There are many studies conducted at various times over the last 20 years that use either primary or secondary evidence for reductions in energy consumption due to the installation of shower heads with lower flow rates. The results of those studies are summarized in Figure 12. Note that the first study (REUWS) measured all flow rates and durations as found, whereas the other studies measured flow rates and durations before and after retrofit of a conserving shower head.

All the studies HMG reviewed compared shower durations and sometimes shower volume at two or more flow rates. It is important when assessing these studies to note whether the results quote the *rated* or the *in situ* flow rate (second column in Figure 12), because the *rated* flow rate is the rated maximum flow rate of the shower head (at 80psi), whereas *in situ* flow rate is the actual flow rate of the shower as measured in the house (typically at less than 80psi). All the figures quoted for shower duration are measured durations, rather than self-reported duration. HMG did not report results for studies that measured only self-reported shower durations, because there is not sufficient basis to have confidence in self-reported duration accuracy.

Study	Measurement	Shower volume per capita per day (gallons)	Showers per day	Shower duration (minutes)	Average flow rate (gpm)	Sample size
Residential End Uses of Water Study 1999	"Mixed" houses	11.8	0.67	8.0	2.2	712
	"Low flow" houses	8.8	0.67	8.5	1.6	177
East Bay MUD Study 2003	Before retrofit, mean flow rate in situ 2.0gpm	12.0	0.65	8.9	2.0	33
	After retrofit with rated 2.5gpm shower, 1.8gpm in situ	11.4	0.74	8.2	1.8	33
Tampa Study 2004	Before retrofit, mean flow rate in situ 2.1gpm	15.2	0.92	8.0	2.1	49
	After retrofit with rated average 1.86gpm shower, 1.7gpm in situ	11.0	0.82	7.8	1.7	49
Tachibana and Schuldt 2008	Before retrofit, mean flow rate in situ 2.5gpm	Not measured	Not measured	Not measured	2.5[1]	139
	After retrofit with rated 2.0gpm shower, 1.8gpm in situ	Not measured	Not measured	Not measured	1.8	139

Figure 12. Shower flow rates and volumes from reviewed studies

The four studies summarized in Figure 12 show the results of reducing nominal shower fixture flow rate. Figure 13 compares the measured changes in nominal fixture flow rate and observed shower volume changes. The magnitude of savings differs between the studies, but the data clearly shows a correlation between flow rate reduction and energy savings.

1 Flow rate was measured with throttle open

Study	Flow Rate Reduction, relative to Federal 2.5gpm standard	Shower water savings relative to Federal 2.5 gpm standards (gal/day)	Energy savings (therms/yr/shower head)
REUWS	0.6	3	9.6
EBMUD	0.2	0.6	1.9
Tampa	0.4	4.2	13.5
Tachibana and Schuldt	0.7	2.2*	7.1
Weighted Average (based on sample sizes)	**0.6**	**2.6**	**8.6**

Figure 13. Per capita energy and water savings documented by various studies (* denotes calculated value)

To calculate cost savings from lower flow shower heads and eliminating multi-head showers, hourly (8760) estimates for energy use were multiplied by the CEC's hourly values for Time Dependent Valuation 2008[1] (TDV $/kBTU) to obtain hourly estimates for the value of the energy saved. TDV$ and kWh values were summed over 8760 hours to quantify annual savings. TDV$ are in present value dollars.

The rated flow rate and the measured flow rates differ slightly as reported by Robert Mowris & Associates (RMA); Figure 14 and Figure 15 show the annual water and energy savings for various fixture flow rates (based on measured flow rates also known as *in situ* flow rate). Annual water consumption is calculated using the relationship developed in Figure 10 (average of the EBMUD and REUWS studies trends) between shower volume and showerhead flow rate.

[1] HMG applied CEC authorized 2008 TDV multipliers for cost effectiveness. When 2011 TDV multipliers are available, the calculation will be updated.

Rated Flow Rate	Measured Flow Rate	Single Family	Multi-Family
Gal/min	Gal/min	Annual Water Consumption (gal/household)	
0.60	0.64	4,678	3,074
0.70	0.74	5,397	3,547
1.00	1.03	7,553	4,963
1.30	1.32	9,709	6,380
1.50	1.52	11,146	7,324
1.60	1.62	11,865	7,797
1.75	1.77	12,942	8,505
1.90	1.91	14,020	9,213
2.00	**2.01**	**14,739**	**9,686**
Baseline (2.5 gpm)	2.50	18,332	12,047

Figure 14. Annual water consumption

Figure 15 shows energy consumption for various flow rates (not just the proposed 2.0 gpm flow rate), for comparison, and to facilitate future discussion of alternative flow rate values.

Rated Flow Rate	Single Family	Multi-Family	Single Family	Multi-family
Gal/min	Annual Energy Consumption (Therms/household)		Annual Energy Savings—2.0 gpm relative to 2.5 gpm (therms/household)	
0.60	23.3	15.3	68.0	44.7
0.70	26.9	17.7	64.4	42.3
1.00	37.6	24.7	53.7	35.3
1.30	48.3	31.8	42.9	28.2
1.50	55.5	36.5	35.8	23.5
1.60	59.1	38.8	32.2	21.2
1.75	64.5	42.4	26.8	17.6
1.90	69.8	45.9	21.5	14.1
2.00	**73.4**	**48.2**	**17.9**	**11.8**
2.5	91.3	60.0	N/A	N/A

Figure 15. Annual energy consumption

5.6 Cost-Effectiveness

This section describes the cost-effectiveness of changing Title 24 to require showers in new construction and retrofit projects to flow at 2.0 gpm or less (irrespective of the number of shower heads connected).

2.0 gpm was chosen based on the high number of shower heads available at or below that flow rate, and based on the fact that the Federal WaterSense program has adopted 2.0 as its voluntary requirement. The results from the user satisfaction survey suggest that a lower flow rate would be possible, and a logical choice for a lower flow rate would be 1.5 gpm, given that our market survey showed at least ten different models of shower head being sold at that flow rate.

The present value of the total savings over the measure life is shown in Figure 16. The measure life is 30 years in residential space (single family, and low-rise multi-family), based on the life of the mixing valve rather than the shower head itself. The life cycle cost (ΔLCC) is the difference between the savings estimate and the installed cost for shower fixtures.

Based on HMG's pricing survey, there is no clear correlation between flow rate and purchase price of shower heads. Therefore by mandating lower flow fixtures, Title 24 will reduce water and energy consumption without increasing the purchase price or installation cost burden on consumers. The ΔLCC value is positive and the measure is cost-effective over its projected lifetime.

Savings calculations are based on the following set of equations. Water consumption is calculated based on data collected from the literature review. The amount of energy required to heat a gallon of water is calculated based on operating assumptions of a domestic hot water boiler (cold water supply temperature 60^0F, hot water supply temperature 105^0F, boiler efficiency 75%). Combining these two quantities (water consumption and energy required to heat water) provides an estimate of energy consumption. By taking the difference between the energy consumption of 2.5 gpm and 2.0 gpm showerheads we calculate the energy and water savings per dwelling unit. Finally statewide savings are calculated using the CEC new construction forecast data (Figure 18).

$$Water\ Consumption\ \frac{Gallons}{year * unit} = \frac{Gallons}{minute}^{1} * \frac{Minutes}{Shower}^{2} * \frac{Shower}{Person * year}^{3} * \frac{Person}{Unit}^{4}$$

Where:

1. Gallons/minute is evaluated for a range of measured flow rates based on correlation in Figure 10

Minutes/shower is taken from a thorough literature review of the studies documented in Section 5.5

Shower/person/year is based on the literature review that provided data on showers/person/day * 365 days/year

Person/unit is derived from the Residential Appliance Saturation Survey (RASS) – 2.5 for single family, 3.5 for multi-family

$$Energy\ Consumption\ \frac{Therms}{year * unit} = Water\ consumption\ \frac{Gallons}{year * unit} * \frac{Therms}{Gallon}^{1}$$

Where:

1. $\frac{Therms}{Gallon} = \frac{1}{100{,}000} * 8.3\frac{lbs}{Gallon} * 1\frac{BTU}{lbs*F} * \ 105^0F - 65^0F \ * \frac{1}{75\%}$
2. And 75% is the average boiler efficiency used for gas fired water heaters.

$$Statewide\ Technical\ Potential\ \frac{Therms}{year} = Energy\ Consumption\ \frac{Therms}{year * unit} * CEC\ Forecast\ \ Units$$

Figure 16 shows the energy savings which is the difference between energy consumption calculated from the preceding equations as compared to the 2.5 gpm baseline energy consumption.

Rated Flow Rate	First Year Energy Savings (Therms/year)		Total TDV Savings (2008 TDV $)	Annual Energy Savings*[1]
	Single Family	Multi-Family	Single + Multi-Family	Single + Multi-Family
0.6	6,351,416	1,196,028	413	$4,901,756
0.7	6,017,131	1,133,079	391	$4,643,769
1.0	5,014,276	944,233	326	$3,869,808
1.3	4,011,420	755,386	261	$3,095,846
1.5	3,342,850	629,488	217	$2,579,872
1.6	3,008,565	566,540	196	$2,321,885
1.75	2,507,138	472,116	163	$1,934,904
1.9	2,005,710	377,693	130	$1,547,923
2.0	**1,671,425**	**314,744**	**109**	**$1,289,936**

Figure 16. Projected energy savings (therms and dollars)

Results indicate that TDV savings for single family and multi-family residential space are positive for all flow rate reductions. Savings estimate are based on measured flow rates-RMA found that fixtures rated to flow at 2.5 gpm typically flow at 2.38 gpm-which yields a more accurate estimate than using rated flow rates. As plumbing fixtures become more advanced,

[1] Calculated savings use a conservative rate of $0.90/therm.

EIA gives California Res avg price = 0.918 $/therm (9.43 $/1000 cu ft, 1000 cu ft = 10.27 therms)
http://www.eia.gov/pub/oil_gas/natural_gas/data_publications/natural_gas_annual/current/pdf/nga09.pdf
http://www.eia.doe.gov/tools/faqs/faq.cfm?id=45&t=7

PG&E in San Francisco = 1.02670 $/therm
http://www.pge.com/tariffs/tm2/pdf/GAS_SCHEDS_G-1.pdf

SoCal Gas in LA = 0.95374 $/therm (customer meter charge and baseline rate)
http://www.socalgas.com/regulatory/tariffs/tm2/pdf/GR.pdf?webSyncID=271e43b9-6345-61d4-655b-66884d0baed5&sessionGUID=b10b2bc6-da6c-3585-1930-0d38eac5acbb.

typical shower equipment includes pressure compensating valves (making measured flow rates more closely aligned with rated flow rates); thus HMG applied the measured flow rate averages for various fixtures from the PIER report (CEC 2010).

The proposed reduction is from 2.5 to 2.0 gpm, but a reduction from rated 2.5 gpm to *any* lower rated flow rate would meet the cost effectiveness requirements of the Warren Alquist act; Figure 9 shows that purchase price does not depend on flow rate—there is no increased cost of purchasing or manufacturing lower flow rate showerheads—and Figure 16 documents the projected savings due to a reduction to2.0 gpm.

The statewide technical potential energy and water savings of this measure are shown in Figure 17. The statewide figures are based on CEC residential new construction forecasts, the most recent update came in March, 2008 which projects the number of single-family and multi-family households built each year for the next decade. Figure 18 in the Appendix shows a consistent increase in households built (1.6% per year for SF, 1.0% for MF). Based on these projected new households, HMG forecasts the statewide savings (water and energy) for a mandatory code change with a 30-year measure life.

The value of the gas saved is projected to be roughly $1.3 million statewide annually (assuming 100% compliance). Additionally, a reduction in flow rate from 2.5 gpm to 2.0 gpm would save roughly 500 million gallons of water statewide annually (assuming 100% compliance), or 15 billion gallons of water over the 30-year effective life of the measure.

Time Period	**Statewide Technical Potential Energy Savings (Million Therms)**		**Statewide Technical Potential Water Savings (Million Gallons)**	
	Single Family	**Multi-Family**	**Single Family**	**Multi-Family**
First Year	1.7	0.3	340	63
Measure Life	64	11	13,000	2,200

Figure 17. Statewide technical potential energy and water savings from reducing shower head flow rate to 2.0 gpm

6. Recommended Language for the Standards Document, ACM Manuals, and the Reference Appendices

This section describes the specific recommended language and contains enough detail to develop the draft standard in the next phase of work. We have used the language from the 2008 standard, and have used underlining to indicate new language and strikethroughs to show deleted language.

There is precedent for the following changes in Title 24 Part 6 to require lower flow showerheads. Setback thermostats function in much the same way as shower fixtures relative to the process equipment.

6.1 Sections to Change

We propose to change only section 113(c)7 because this applies to all occupancies (residential and non-residential), creating a common shower head standard for all buildings.

6.2 Summary of Proposed Changes

We believe that the proposed language accomplishes the following changes:

- Limits shower head flow rate to 2.0 gpm
- Discourages developers from adding higher flow rate showers after inspection, by requiring a shower head to be installed at the time of inspection.
- Tries to ensure that a maximum of 2.0gpm per person is being supplied by the shower
- Encourages parallel piping of showers
- Applies to all occupancies (residential and non-residential)

Note that, in line with the DOE's clarification of the definition of "shower head" within the Federal Code of Regulations[1], this revision to the Title 24 code language defines a "shower head" to include both single-head and multi-head showers that are supplied from a single pipe, i.e., multi-head showers are subject to the same flow rate limit as a single shower head.

6.2.1 Definitions

SECTION 101

SHOWER HEAD is a fixture for directing the spray of water in a shower. A shower head may incorporate one or more sprays, nozzles or openings. All components that are supplied standard together and function from one inlet (i.e., after the mixing valve) form a single shower head.

6.2.2 Mandatory requirements for all occupancies

SECTION 113(c)7 Shower Heads. A single shower head must be installed directly on each pipe that terminates at a shower . Shower heads must be placed no closer than four feet from

[1] "a showerhead may incorporate one or more sprays, nozzles or openings. All components that are supplied standard together and function from one inlet (i.e., after the mixing valve) form a single showerhead for purposes of the maximum water use standards under 42 U.S.C. 6295(j)(1)." See: http://www.gc.energy.gov/documents/Showerhead_Guidancel.pdf

each other, as measured directly from one shower head to the next. Shower heads must have a rated flow rate of no more than 2.0 gallons per minute at 80 psi. Each mixing valve must supply only one shower head. The piping connecting the shower head to the heater or recirculation loop must be no wider than ½ inch at any point.

EXCEPTION to Section 113(c)7: Showers that recirculate hot water from the drain to the shower head.

6.3 Material for Compliance Manuals

We will develop material for the compliance manuals in the final CASE report once the proposed code language has been approved by the California Energy Commission.

In this section, we will provide information that will be needed to develop the Residential and/or Nonresidential Compliance Manuals, including:

- Possible new compliance forms or changes to existing compliance forms.
- Examples of how the proposed Standards change applies to both common and outlying situations. Use the question and answer format used in the 2008 Residential and Nonresidential Compliance Manuals.
- Any explanatory text that should be included in the Manual.
- Any data tables needed to implement the measure.

7. Bibliography and Other Research

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8. Appendix

CEC new construction forecasts projected over the 30 year life of this measure:

Year	New Construction Single Family (# of households)	New Construction Multi-family (# of households)
2013	93,409	26,767
2014	94,913	27,038
2015	96,437	27,304
2016	97,938	27,534
2017	99,525	27,811
2018	101,153	28,101
2019	102,808	28,394
2020	104,489	28,690
2021	106,199	28,989
2022	107,936	29,292
2023	109,701	29,597
2024	111,496	29,906
2025	113,320	30,217
2026	115,173	30,533
2027	117,057	30,851
2028	118,972	31,173
2029	120,918	31,498
2030	122,896	31,826
2031	124,906	32,158
2032	126,949	32,493
2033	129,026	32,832
2034	131,137	33,175
2035	133,282	33,520
2036	135,462	33,870
2037	137,678	34,223
2038	139,930	34,580
2039	142,219	34,941
2040	144,545	35,305
2041	146,910	35,673
2042	149,313	36,045

Figure 18. CEC new construction forecasts