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Potential Water and Energy Savings from Showerheads

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1.0 SUMMARY

This paper estimates the benefits and costs of six water reduction scenarios. Benefits and costs of showerhead scenarios are ranked in this paper by an estimated water reduction percentage. To prioritize potential water and energy saving scenarios regarding showerheads, six scenarios were analyzed for their potential water and energy savings and the associated dollar savings to the consumer. The scenarios and their ranking are listed in Table 1 below.

Table 1: Ranking of Showerhead Scenarios (1)

Rank	Scenario	Percent savings of water(1)
1	Counteract the trend toward using multiple showerheads' body spas, etc.	25%
2	Reduce average showering time by 1 minute	17%
3	Change all showerheads that meet code to below code (from 2.5 to 2.0 gpm)	15%
4	Change all showerheads that exceed code to meet code	7%
5	Reduce number of showerheads tampered with (modified to increase the flow)	1%
6	Reduce tub spout leakage	<1%

(1) Percent of baseline showerhead water use

2.0 OBJECTIVE

This report's objective is to conduct an overview assessment of showerhead water savings potential to establish research priorities. The primary objectives are to rank anticipated energy, water and sewer benefits and costs for market transformation.

3.0 INTRODUCTION

Reducing the water and energy consumption of residential and commercial showerheads has potential even though a maximum water flow is already stipulated in Federal Regulations[1]. Anecdotal evidence suggests several opportunities for savings:

- In practice not all showerheads being sold are in compliance with the Federal Standard.
- Trends in shower design are headed toward having multiple showerheads.

[1] U.S. Dept. of Energy, Final Rule: "Energy Conservation Programs for Consumer Products: Test Procedures and Certification and Enforcement Requirements for Plumbing Products; and Certification and Enforcement Requirements for Residential Appliances," *Federal Register* (63 FR 13308), March 18, 1998. http://www.eere.energy.gov/buildings/appliance_standards/residential/pdfs/plmrul.pdf

- Showerheads may be available that perform well and use less than the maximum allowed flow rate.
- After purchasing showerheads, some consumers tamper with them to increase water flow.
- Tub spouts that leak when water is diverted to the showerhead waste water.

Water utilities and other stakeholders have shown an interest in testing and research to reduce showerhead water use and coincident energy consumption.

This report quantifies water and energy savings of the six scenarios outlined in Table 1 and listed below.

1. Counteract the trend toward using multiple showerheads, body spas, etc.
2. Change all showerheads that meet code to operate below code (from 2.5 gpm to 2.0 gpm).
3. Reduce average showering time by 1 minute.
4. Change all showerheads that exceed code to meet code.
5. Reduce number of showerheads tampered with (modified to increase flow).
6. Reduce leakage from tub spouts when a diverter sends water to the showerhead.

Although the potential water and energy savings are quantified for each scenario based on participation rates of 100%, the primary focus of this report is to rank potential approaches to reducing showerhead water consumption in order to prioritize showerhead water conservation programs.

In a separate document, *Proposal for Showerhead Testing and Evaluation*, LBNL is proposing research to support programs aimed at reducing the water consumption and attendant energy consumption of poorly performing showerheads. These savings would pertain primarily to residences, but savings also could pertain to commercial and public facilities such as hotels, sports facilities and schools.

3.1 Problem

Although federal regulations require showerheads to be water-efficient, not all models provide a satisfactory shower. Because consumers may modify or remove low-flow features, even the most efficient showerheads may end up saving no water at all. Experiences with poorly performing showerheads may also act as a deterrent to the replacement of inefficient showerheads with new efficient showerheads. Water efficient toilets also suffered initially from poor performance, but now reliable and realistic test methods are used to identify the better-performing models.[2]. Given this information, consumers can replace inefficient toilets with efficient models that provide satisfactory performance. In addition, water utility sponsored programs could recommend or specify the better performing toilets in rebate programs.

A comparable method is needed to evaluate showerhead performance and develop a database of efficient, effective showerheads. Simply listing low- and high-flow

[2] http://www.cuwcc.org/Uploads/product/MaP-Final-Report.pdf

showerheads is unlikely to be helpful, because some consumers might believe that the high-flow showerheads provide a better shower experience. The database must rate the performance of showerheads that comply with federal regulations, so that consumers will be encouraged to purchase the better-performing models, and will not try to defeat the flow-restricting parts. This database must then be maintained and continue to provide updated information through a web site or other means easily accessible to the public.

3.2 Potential Water Savings

The amount of water used by showers nationwide could be reduced in several ways if information were available regarding both the water efficiency and performance of showerheads.

- Results of testing showerheads can provide an enforcement function, whereby showerheads that exceed the federal standard for water flow (2.5 gallons per minute [gpm]) are identified and removed from the market.
- Showerheads that use even less than 2.5 gpm and also provide a good shower experience can be identified and promoted.
- Providing consumers with information about which showerheads they are most likely to find satisfactory will encourage them to switch to effective low-flow showerheads and discourage them from installing non-compliant showerheads. Identifying low-flow showerheads that provide an adequate shower also may prevent consumers from purchasing multi-head shower fixtures.
- Additional research into ways to encourage consumers to turn off the water while lathering also could save water.
- Perceived or real safety considerations may prevent utilities from promoting very low flow showerheads and therefore, these issues must be researched.

Studies have reported the savings from replacing pre-regulation showerheads with federally regulated low-flow showerheads. One cannot, however, simply calculate the difference in flow rate between a standard showerhead and a low-flow showerhead as measured in a laboratory, because field measurements show that showerheads are not always run at maximum flow rate. In addition, studies have reached conflicting conclusions about whether shower duration is affected by switching to a low-flow showerhead.

4.0 ANALYSIS

This section describes the basis for the analysis of the six showerhead scenarios identified for study.

4.1 Data and Assumptions

Data and assumptions are described in Table 2, below.

Table 2: Data and Assumptions

Parameter	Value	Comment	Source
U.S. population	290 million	Census 2000 (estimate for 2002)	U.S. Census[i]
Persons per household	2.59	Census year 2000	U.S. Census[ii]
Showers per day	0.75	Combined baths and showers	REUW[iii], p. xxvii
Average shower duration	8 minutes	Actual average = 8.2 minutes	REUW, p. 99
Throttling factor (1)	2/3	2/3rds of rated flow; varies with flow rate	Vickers[iv]
Shower flow rate – gallons per minute (current standard)	2.5 gpm	Current federal regulation for maximum flow at 80 psig	DOE[v]
Percent of showerheads with flow rates that exceed the code	24%	Study showed 24.4% showered exclusively above the low flow range	REUW, p. 134
Estimated percent of showerheads tampered with	6%	Survey for a retail coupon program showed 6% low-flow showerheads removed or not used	PG&E, p. I-12[vi]
Percent of households having low flow showerheads	76%	Based on a study that showed 24.4% showered exclusively above the low flow range	REUW, p. 134
Tub spout leakage	See Table 3	Based on CEC regulations, March 2001 and March 2003.	CEC[vii]
Percent of all showers having a tub spout	62%	Showers were part of a combined shower-bathtub fixture	REUW, p. 99
Average shower flow rate	2.2 gpm	Baseline (pre-retrofit) value from Seattle study in 2000	Seattle[viii]
Percent multiple-head showerheads	15%	Based on percent of showerheads that are "cascading"	Homeworldbusiness.com [ix]
Flow of multiple-head showerheads	5 gpm	An estimated average based on a range of advertised luxury showerheads; more data needed	
Cost to install low-flow showerheads through a utility program	$12 - $30		Vickers, p. 95
Lifetime of showerhead	10-15 years		Vickers, p. 100
Electricity Rate	$.0906 per kWh	Representative average unit costs of residential energy (2005)	DOE[x]
Natural Gas Rate	$ 1.092 /Therm	Representative average unit costs of residential energy (2005)	DOE
Water & Wastewater Rate	$2.48 per 1000 gallons	Average value used in DOE clothes washer rulemaking, 2000. Includes water and sewage charges	DOE, CW TSD 2000, Appendix F
Percent of water heaters using gas	58%	Assuming all water heaters are either gas or electric	TSD DOE rulemaking[xi]

(1) The throttling factor adjusts the rated flow to account for pressures at less than 80 psig, and for limiting the flow by throttling back (closing) the control valve to the shower. This may be done to adjust the water temperature.

4.2 Baseline Water and Energy Consumption

The following calculations indicate that showers consume 2.9 billion gallons, or approximately 9,000 acre-feet, of water every day in the United States. Daily showerhead water consumption is estimated as follows.

[1] *Person-showers per day = (population) x (showers per day per person)*
Where:
Population = 290 million
Showers per person per day = 0.75

[2] *Gallons per shower = (shower flow, gpm) x (length of shower, min.) x (throttling factor)*
Where:
Shower flow rate = 2.5 gpm
Length of shower = 8 minutes
Throttling factor = 2/3

Person-showers per day are multiplied with gallons per shower to obtain the estimate of 2.9 billion gallons of water used daily in showering.

4.3 Scenarios Ranked by Water-Saving Potential

The following sections describe the ranking of the six showerhead scenarios.

The gallons of water saved per day for the entire United States is calculated for each scenario. Energy savings generally will be proportional to water savings.

4.3.1 Scenario 1: Counteract the trend toward using multiple showerheads, body spas, etc.

Definitions of Terms:
Definitions of terms are provided in Appendix D.

Discussion: A recent trend in shower design for both residential and hotel applications is to "upgrade" to multiple showerheads controlled by one on-off lever. Some have interpreted such systems as not conforming to the flow regulations for showerheads [www.pwmag.com, 9/03/2002, Julius Ballanco]. A related trend is to have more than one showerhead per shower, each with its own control valve presumably operating within the regulatory code.

A review of manufacturer and industry Web sites reveals that some showerhead systems are advertised as supplying as much as 10 gpm of flow. Other shower systems produce a waterfall or rain-type of effect, or have a series of water jets mounted on a vertical wall. Through these and other systems that use a pump to recirculate large amounts of water, shower producers can now advertise a shower experience that is equivalent to standing up in a whirlpool.

Existing Studies: Consumer preferences have been analyzed in proprietary studies by manufacturers (such as Moen [www.pmmag.com, 6-03-2002]); hotels (Westin and Holiday Inn Express); and utility companies. Moen found that 66% of respondents wanted more water flow, and 60% wanted more force. Westin tested more that 150 showerheads before deciding to install custom-designed showers having two heads. The Holiday Inn tested showerheads with more that 7,000 guests, who rated them based on water pressure, spray coverage, and flexibility of spray settings [www.ihgplc.com].

A utility-sponsored test revealed that many showerheads, which the manufacturer had labeled as low flow, in reality had an adjustment knob that enabled the user to "dial up" the flow rate to far above 2.5 gpm. In addition, more than 75% of tested showerheads exceeded the manufacturer's labeled flow rate at the 80 psig test condition. These showerheads, obtained from installations, may have been tampered with by the consumer or installer [www.costcontainmentengr.com].

Data Needs: Little data is available regarding multiple showerhead or body spa systems. It may be inappropriate to assume that two showerheads use twice as much water as one. There is likely to be a wide variation in water use depending on the available water pressure and design of the showerheads. Also unknown is whether these shower systems encourage a longer shower time or if the capacity of the water heater to provide hot water limits the duration of the shower. Sales and marketing data on showerheads can be purchased from marketing companies such as the NPD Group [www.npd.com].

Assumptions: In analyzing the effects of enacting this scenario we use cascading showerheads as a proxy for high-flow showerheads systems. In 1999, cascading showerheads had a 5% market share, which increased to 15% by 2004. [http://www.homeworldbusiness.com, *Sprite Has Filters for Cascading Showerhead*, May 10, 2004]. Other assumptions include:

- Without efforts to counteract the trend toward multiple-showerhead systems, 15% of showerheads will be replaced by high-flow showerheads.
- Convert number of showerheads to number of showers (assume a one-to-one correlation).
- Based on a sampling of Web site data, these high-flow showerhead systems use on average twice the maximum allowed water flow, or 5 gpm.
- A high-flow showerhead replaces a showerhead having an actual (not rated) flow of 2.2 gpm.
- The water savings calculated below represent a yearly savings after sales equilibrium has been reached, i.e., after the lifetime of a showerhead. The lifetime of a low-flow showerhead is 10 to 15 years.

Calculations:

[3] Potential Water Savings =

(population)(showers per capita per day) (gpm reduction)(% replaced by high-flow showerheads)(shower duration)

= (290,000,000)(0.75)(5 - 2.2 gpm)(15%)(8 min.)

= **731 million gallons per day**

4.3.2 Scenario 2: Reduce average shower time by 1 minute

Discussion: In this scenario we postulate that the length of a shower might be reduced by one minute if the showerhead gave a more satisfying shower. For example, anecdotal reports indicate that consumers spend more time rinsing long hair when using a poorly designed low flow showerhead. Selection of better performing showerheads could be aided by having an unbiased database with showerhead performance data or by distribution of better showerheads in utility rebate or give-away programs.

Assumptions: In analyzing the effects of enacting this scenario we assume that consumers who have better-performing showerheads will spend one minute less for each shower. We further assume the flow rate of the showerhead remains the same, and the improved performance of the showerhead is a function only of its design. The assumptions include:

- Shower time is reduced from 8 to 7 minutes.
- The improved showerhead provides an average flow rate of 2.2 gpm.

Calculations:

[5] Potential Water Savings =

(population)(showers per day per capita)(flow rate)(reduction in shower time)
= (290,000,000)(0.75)(2.2 gpm)(1 min.)
= 479 million gallons per day

4.3.3 Scenario 3: Change all showerheads that meet code to operate below code (from 2.5 to 2.0 gpm)

Discussion: In this scenario, all showerheads that meet current code would be replaced by showerheads having an even lower flow. In the calculations below, savings reflect converting all at-code showerheads to lower-flow showerheads.

Assumptions: One cannot, however, simply calculate the difference in flow rate between a standard showerhead and a low-flow showerhead as measured in a laboratory, because field measurements show that showerheads are not always run at maximum flow rate. A throttling factor is used to correct for this difference. In addition, consumers who have lower-flow showerheads may take longer showers. In the estimate of savings shown here, shower duration is assumed to remain constant. The following additional assumptions are made:

- 76% of the population has a 2.5-gpm rated showerhead.
- Only the 2.5-gpm showerheads will be converted to 2.0 gpm.
- The throttling factor is 2/3. This means that consumers do not open the water valves completely, and therefore use less than the rated showerhead flow.

Calculations:

[4] Potential Water Savings =

(population)(showers per capita per day)(% of pop. having a 2.5-gpm rated showerhead)(delta flow)(throttling)(shower duration)
= (290,000,000)(0.75)(76%)(2.5 - 2.0 gpm)(2/3)(8 min.)

= **441 million gallons per day**

4.3.4 Scenario 4: Change all showerheads that exceed code to meet code

Discussion: This Scenario assumes that all showerheads that currently operate above code are replaced by showerheads having a flow rate that meets code (2.5 gallons per minute).

Assumptions:

- Assume 3.25 gpm average non-compliant rate of flow.
- 2.5 gpm is the compliant rate of flow.
- Assume 2/3 throttling factor from rated flow.
- Savings in flow for each showerhead changed to be compliant = (3.25 - 2.5 gpm)(2/3) = 0.5 gpm

Calculations:

[6] **Savings per shower =** *(0.5 gpm)(8 min.) = 4 gallons per shower)*

[7] **Potential Water Savings =**
(percent above code)(population)(showers per capita per day) (gallons per shower)
(24%)(290,000,000)(0.75)(4 gal)
= 209 million gallons per day

4.3.5 Scenario 5: Reduce number of showerheads tampered with (modified to increase water flow)

Discussion: This Scenario assumes that some low-flow (compliant) showerheads were installed but later removed or modified so that flow rate exceeds code. One might assume that consumers tamper with their showerheads when performance is unsatisfactory. Adequate information on showerhead performance would assist consumers in purchasing water-efficient showerheads that operate satisfactorily. The dominant 'tampering' practice is the removal of the flow restrictor where that is possible; in some cases manufacturers explain in their literature how to remove flow restrictors to get higher flow rates.

Assumptions: It is impossible to determine how many showerheads have been tampered with. We use a number from a Pacific Gas and Electric Company (PG&E) study that found that 6% of showerheads that were part of a replacement program were removed or not used.

Calculations:

[8] **Potential Water Savings =**
(% tampered)(population)(showers per capita per day)(delta flow)(throttle factor)(shower duration)
= (0.06)(290,000,000)(0.75)(3.0 - 2.5 gpm)(2/3)(8 min.)
= **35 million gallons per day**

4.3.6 Scenario 6: Reduce tub spout leakage

Discussion: Showers that are plumbed as part of a bathtub typically start with water flowing through the spout. Water is then diverted to the showerhead via a lever connected to the tub spout. Although most of the water is diverted to the showerhead, throughout the shower some water escapes through the tub spout. Leakage through the tub spout reduces the amount of water available to the showerhead, reducing showerhead performance. In this calculation we assume that the total flow (through the showerhead and tub spout) is increased by the amount of water leaking through the tub spout. Due to the water lost through the tub spout a consumer may also take longer showers, or increase the water temperature. The California Energy Commission (CEC) established regulations stipulating the maximum allowable tub spout leakage, as shown in Table 3 below.

Table 3: Allowable Tub Spout Leakage in California

Effective Date	Allowable Leakage when New	Allowable Leakage after 15,000 Cycles
March 2001	0.1 gpm	0.3 gpm
March 2003	0.01 gpm	0.05 gpm

Assumptions:

- Showers having a tub spout diverter represent 62% percent of all showers.
- New tub spouts follow California requirements, over a lifetime leaking an average of 0.03 gpm (between the allowable leakage when new and after 15,000 cycles).
- Baseline leakage nationwide can be represented by an average of California's old requirements (0.1 gpm when new and 0.3 gpm after 15,000 cycles), or 0.2 gpm.
- Although the percentage of tub spouts nationwide that conform to California's March 2003 specifications is unknown, we assume that 10% do not conform.
- The lifetime of tub spouts and replacement period are unknown, but it is assumed that they are replaced every 12.5 years, the same value assumed for showerheads.

Calculations:

[9] **Δ** *leakage = (0.2 - 0.03 gpm) = 0.17 gpm*

[10] Potential Water Savings =
(% not conforming with CEC)(population)(shower per day per person)
(% showers with tub spout)(delta tub spout leakage)(shower duration)
= (10%)(290,000,000)(0.75)(62%)(0.17 gpm)(8 min.)
= 18 million gallons per day

5.0 POTENTIAL ENERGY SAVINGS

In a simplified analysis, it can be reasonably assumed that the energy savings are proportional to the water savings. This requires the assumption that any change in flow rate does not affect the temperature setting that the consumer uses. In this analysis we assume that 42% of water heaters are electric and have a recovery efficiency of 98%, and that 58% of water heaters are natural gas-fired and have a recovery efficiency of 75%. Other assumptions are a cold water inlet temperature of 60˚F and a shower temperature of 105˚F.

Calculations:

Energy required for electrically heated water =

[(1 gal.)(8.3 lbs/gal)(1 Btu/lb/˚F)(105˚F - 60˚F)] / (0.98)
= 381Btu/gallon
= 0.112 kWh/gallon
= 112,000 kWh per million gals

Energy required for gas-heated water=

[(1 gal.)(8.3 lbs/gal)(1 Btu/lb/˚F)(105˚F - 60˚F)] / (0.75)
= 498 Btu/gallon
= 4980 Therms per million gals

Table 4 (in section 8 below) shows the energy savings based on all electric water heaters (essentially the energy content of the water). The monetary benefits shown are based on the nationwide mix of gas and electric water heaters and their respective efficiencies.

6.0 COST OF PROGRAMS

Labor and material costs for installing low-flow showerheads in a utility-sponsored direct installation or audit program ranged from $12 to $30 per installation[xii]. The time needed is 30 to 45 minutes. Programs that provide showerheads by mail or allow them to be picked up are less costly.

Implementation costs of showerhead programs vary on the specific program designs. While all of these methods listed below cost in the range of $7 to $30 per household, the customer participation rates can vary greatly[xiii].

- Door-to-door canvas
- Mass Mailing
- Depot Pickup
- Rebates
- Kit Requests
- Special event giveaways (fairs, exhibits, etc.)

Alternately, some of the benefits may be achieved by an informational campaign or by testing and listing the performance of showerheads on a web site.

7.0 COST / BENEFIT DETERMINATION

Costs/benefits of enacting the six projects described above can be evaluated in terms of:

- the cost to the consumer of a better showerhead compared to the amount the consumer saves in water and energy costs

- the cost to a utility company of a research and education program or a showerhead replacement program compared to the value of the water conserved[3]

In the second case, a utility generally seeks to conserve water (or energy) because of a shortage. A cost/benefit analysis can be used to help decide which programs to implement first. Although general values are given for the cost of a program, the price difference between a poorly and better-performing showerhead (the basis on which the water and energy savings were determined) has not been established. In some cases a utility's cost might only involve constructing a database or enforcing code rather than initiating a replacement program. Nevertheless, the current analysis can shed light on the *potential* water, energy and cost savings, noting that it assumes a high rate of consumer participation in the measures described in the six scenarios.

8.0 RESULTS

Results in Table 4 below show the potential water and energy savings for a given showerhead water conservation goal, i.e., for each of the analyzed scenarios. Because the potential water savings are sensitive to specific parameters used in the calculations, they should be viewed as rough estimates. Sources of uncertainty include differences in results from various field studies and from a lack of data. For example, in the case of tub spouts, the leakage rates reported by manufacturers need to be verified by independent testing. Nevertheless, the values are useful for an initial ranking of potential showerhead conservation programs. Note that savings from different scenarios are not additive. Dollar savings are based on national averages for water and wastewater disposal costs. Water heating assumptions and fuel costs are based on the national data. As a point of reference, scenario 1 alone would save the amount of electricity equivalent to the energy consumption of a television or computer for every household in United States.

[3] the need to conserve water or energy due to a shortage is more likely the driving force and benefit to the utility

Table 4: Potential Savings for Each Showerhead Scenario(1)

Rank	Scenario	Percent (2) savings of water	Million gallons per day savings	Acre-feet per day	Energy Savings (3) Gigawatt hours per day (GWh)	Billions of dollars in Water and Energy Savings annually (4)	Dollars saved annually per affected household(4)
1	Counteract the trend toward using multiple showerheads body spas, etc.	25%	731	2240	81	$2.64	$157
2	Reduce average showering time by 1 minute	17%	479	1470	53	$1.73	$15(5)
3	Change all showerheads that meet code to below code (from 2.5 to 2.0 gpm)	15%	435	1330	49	$1.57	$19
4	Change all showerheads that exceed code to meet code	7%	209	641	23	$0.75	$28
5	Reduce number of showerheads tampered with (modified to increase the flow)	1%	35	110	4	$0.13	$19
6	Reduce tub spout leakage	<1%	18	60	2	$0.07	$10

(1) Values are rounded
(2) Percentage of baseline showerhead water use
(3) The energy savings shown here assumes electrically heated water.
(4) Assumes 42% electric water heaters, 58% gas water heaters and includes the cost of water.
(5) While option 2 saves more total gallons because it is applied to all households, the gallons saved per shower is greater for options 3,4 & 5, which explains the higher per household dollar savings.

9.0 RELATIONSHIP BETWEEN RESEARCH OBJECTIVE AND PROGRAMS

Water and energy savings are obtained from:

- Reducing the tampering or replacement of showerheads through increasing market share of superior performing and conserving showerheads
- Reversing the trend of consumers and hotels converting showers to use multiple showerheads, cascades, and spray panels
- Eliminating installation barriers to high efficiency showerheads due to perceived (or actual) safety considerations.

Figure 1 illustrates some of the connections between research, programs and results. Specific research and testing options are outlined in a separate LBNL document, *Proposal for Showerhead Testing and Evaluation*.

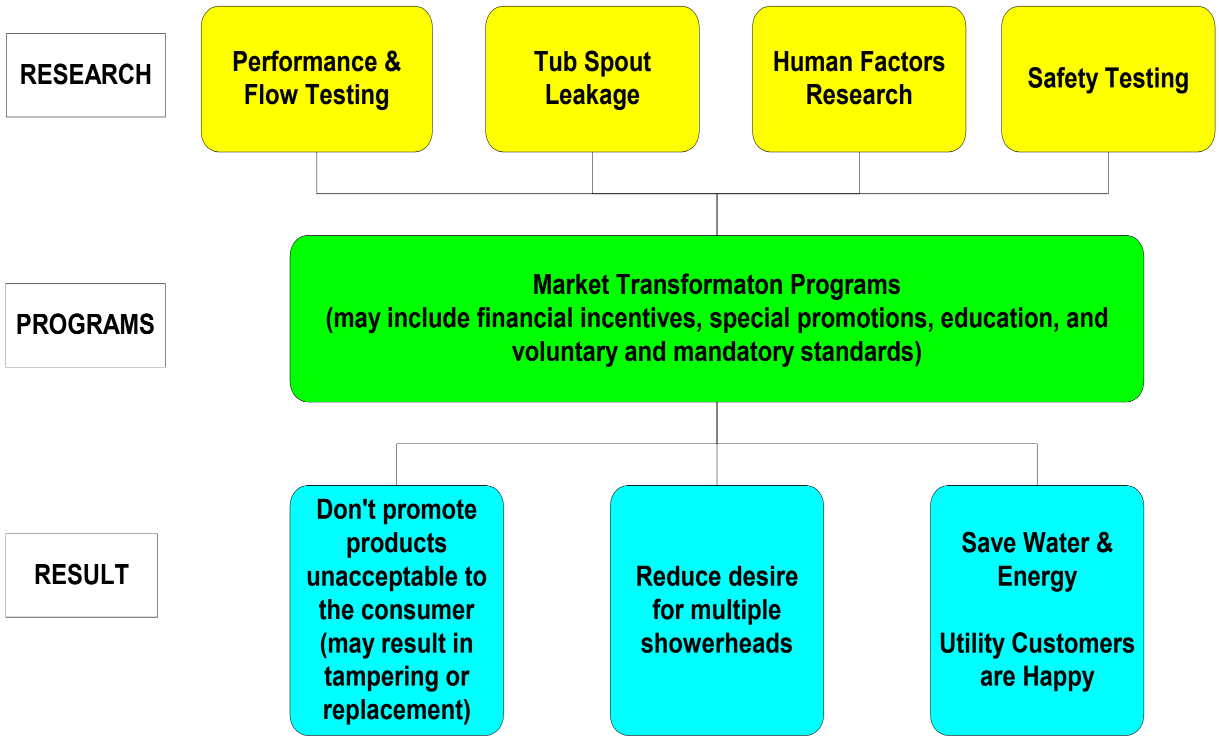


Figure 1: Linkages between Research, Conservation Programs and Results

APPENDICES

A. Current Regulations

U.S. Department of Energy (DOE) regulations specify that the test procedures for testing showerhead water use are as in ASME/ANSI Standard A112.18.1M-1996. As of January 1, 1994, the maximum water use allowed for any showerhead is 2.5 gallons per minute when measured at a flowing pressure of 80 pounds per square inch gauge.

ANSI/ASME standard A112.18.1M-1996, Section 7.4.4 on showerheads, states that "shower head volume controls, whether integral or separate, shall be designed so that they cannot completely shut off the water to the shower head." This requirement is intended to eliminate thermal shock when the shower is turned back on by the user. Some showerheads on the market have a partial shut off valve on the showerhead that reduces the flow considerably and is meant to be used to turn down the water flow while lathering.

The California Energy Commisssion (CEC) in addition to supporting Federal regulations, has additional leakage requirements for tub spouts.

B. Conversion Factors

Conversions	
1 acre-foot	326,000 gallons
1 kWh	3412 Btu/hr
1 Gigawatt hour (GWh)	One million kilowatt hours (kWh)

C. Additional Resources

Waste Not Want Not: The Potential for Urban Water Conservation in California, Gleick, P., Pacific Institute:
http://www.pacinst.org/reports/urban_usage/appendices.htm

The World's Water 2004-2005, Gleick, P., Island Press, 2004.

D. Definitions of Showerhead and Shower System Terms

Single head

This type of showerhead may have a single setting or more than one setting. Settings often include more and less focused sprays and a pulsating spray. The photo below shows the showerhead selected by Holiday Inn based on its performance in terms of coverage and pressure.

Single showerhead fixture –Kohler

Multiple-head Shower

These fixtures may have two or more spray nozzles connected to one pipe. They can easily replace a single head fixture.

Multiple showerhead fixture- source: http://www.neatitems.com/triple_showers.htm

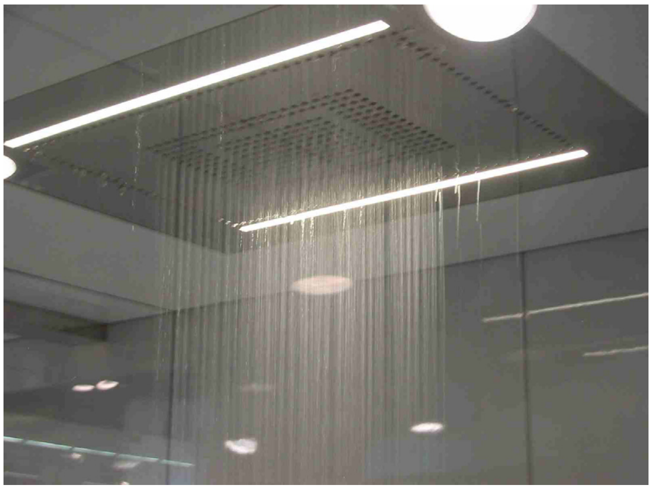
Cascading Showerhead
These are also referred to as "rainshower" and "downpour" type fixtures. They often are mounted overhead such that the water drops straight down. They typically give a softer spray and have diameters of 6 to 8 inches. They are less likely to have more than one spray setting. The model shown below has 80 spray nozzles.

Cascading showerhead- Consumer Reports, Hansgrohe Raindance

Shower Panel or Shower Tower
These are designed to spray water from more than one location having more than one showerhead. They may operate sequentially or as the photo shows below all at one time. Some are designed for the homeowner to replace an existing single pipe fixture and some are designed to be professionally installed with all piping behind the walls.

Shower panels – source https://my.estorenw.com

Rain Systems
As shown in the photograph below, rain systems simulate rain by allowing water to fall from an overhead fixture.



Rain system – source John Koeller

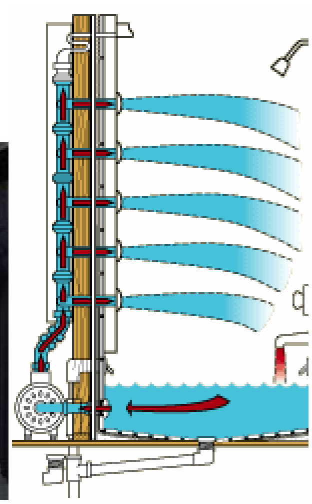
Body Spas
Body spas consist of multiple showerheads and are described by some as the vertical equivalent of a spa. The showerheads may be activated sequentially or intermittently.

The number of showerheads that are active can sometimes be controlled by the user via controls or may be set to automatically vary the spray pressure and temperature.

Body spas – sources: Kohler Body Spa Systems & Santa Cruz Sentinel, March 21, 2005

Recirculating System

In some cases the water in a body spa is recirculated and the shower system has its own heater and pump system. When used in this mode, it is not meant for cleaning. The recirclulating feature can typically be disabled to allow use as a shower.

Body spa with recirculation – source: Kohler Body Spa Systems web site

E. References

[i]U.S. Census Bureau: http://www.census.gov/popest/archives/2000s/vintage_2002/NA-EST2002-01.html, June, 2005

[ii]U.S. Census Bureau: http://quickfacts.census.gov/qfd/states/00000.html, August, 2004

[iii] Mayer P., DeOreo W., et. al. 1999. *Residential End Uses of Water*, American Water Works Association Research Foundation, p. xxvii

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