



Single Family 2007 Showerhead Kit Impact Evaluation

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Seattle City Light

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Introduction

Impact Evaluation of the 2007 Showerhead Kit Program

In 2007, a partnership of Puget Sound utilities acted to rejuvenate the energy-efficient showerhead program that they offered during 1992-1994. In the Seattle City Light service area, the prior Home Water Savers Program had distributed conservation Kits to over 130,000 customers living in single-family and duplex homes. These Kits contained a showerhead rated at 2.5 gallons per minute (gpm) and a bathroom faucet aerator rated at 1.5 gpm. *In situ* research conducted during 1993 found that a variety of proposed program showerheads in fact flowed at 1.8 gpm. The median residual measure lifetime was estimated to be fifteen years. About 83,000 of the single-family and duplex homes acted to install the Kit showerheads, generating electricity savings of about 26,000 megawatt-hours (MWh) per year, or 386,000 MWh over the life of the measure.

The program offered in 2007 was designed to install new showerheads with equivalent efficiency in a like number of Seattle homes, with the intention to extend the life of conservation savings over another fifteen years, through the year 2022.

Background

Reducing hot water consumption in single family homes is a mutual goal of Seattle City Light and partnering water utilities in King County, Washington. In order to better quantify this savings potential, City Light sponsored updated research in 2006-2007 on hot water use by bathroom water fixtures in single-family homes. The research goal was to enable program planners to update parameters drawn from several water and energy metering studies conducted in the mid-1990s, in order the better to estimate hot water savings potentials from high efficiency showerheads and bathroom faucet aerators.

The measurement study investigated water and energy-related flows in a representative sample of 71 homes having 151 bathrooms. The sample was selected from a broad range of homes based on property assessment characteristics such as year built and geographic location, so that results from the study could be extrapolated to the utility service area. The study acquired *in situ* flow rate measurements before and after installation of new efficient products, as well as observation of other water system and appliance characteristics such as water pressure, hot water temperature, and hot water wait times.

This study arose out of the need to re-assess the state of showerhead and faucet aerator flow efficiencies in the Puget Sound area. Fifteen years had passed since a major market intervention and subsequent revisions to plumbing codes and standards. The current baseline was unknown; meanwhile area utilities were planning to mount new programs to improve and secure efficiencies in bathroom water and energy use, and needed updated information.

Prior detailed metering and survey research in the early 1990s (see References) clearly established known factors for calculating programmatic energy savings, including the persons per household, number of daily showers per person, average shower length, proportion of shower water from the hot tap, and the water temperature rise (water heater outlet minus inlet).

However, over time since the mass showerhead distribution programs of 1992-1994, uncertainty had been building about various unknown factors. These include the median measure lifetime of 1992 showerheads (originally estimated at fifteen years), subsequent replacement by changing market products, the impact of the 2.5 gpm plumbing code (1994), and the current baseline average flow rates for bathroom fixtures.

Therefore in 2006, Seattle City Light managed an observational study of bathroom water fixtures in single-family homes. The study was designed and conducted jointly with Seattle Public Utilities to update parameters from the dated water and energy metering studies (PSE & BPA 1994; BPA & SCL 1994; Warwick & Bailey 1993; Warwick 1995). Critical new on-site data were acquired to replace baseline parameters first measured fifteen years previously.

In 1992, existing baseline showerheads flowed at 3.0 gpm (SD=1.3) at full throttle and 2.5 gpm (SD=0.9) at user settings. Pressure-compensating program showerheads that had a maximum rated flow of 2.5 gpm were found by metering research to actually flow at 1.8 gpm (SD=0.3), at both full throttle and user settings *in situ* (PSE & BPA 1994; BPA & SCL 1994).¹ During the intervening years, state plumbing codes and federal standards have brought most retail market showerheads down to a rating of 2.5 gpm or less.

Seattle City Light (a municipal electric utility) undertook this study to prepare for and justify a distribution in 2007 of new pressure-compensating showerheads rated 2.0 gpm, in partnership with long-time utility collaborators in the Puget Sound area: Puget Sound Energy (investor-owned electricity/gas), the Saving Water Partnership (a group of eighteen water utilities from through Seattle and King County) which includes Seattle Public Utilities (municipal water/sewer), and the Cascade Water Alliance (an association of eight cities and water districts in the Puget Sound Region). The new program was planned to secure a continued advantage over 1992 baseline conditions, and extend the life of efficient-flow showerheads for another fifteen years .

Based on the new field measurement data and research parameters established by prior research, it is possible to estimate energy and water savings that would likely occur from installation of more efficient showerheads and aerators in the utility service area.

¹ Note that Seattle Public Utilities in 1991-1992 conducted quality control product testing in a laboratory setting. They found that the main program product, manufactured by BrassCraft, had a full-throttle flow of 2.3-2.5 gpm. (Personal communication, Al Dietemann, Seattle Public Utilities: Water Conservation.) The 2006 study found eleven of these BrassCraft and *in situ* measured full throttle flows at 1.97 gpm, on average. Research by the Bonneville Power Administration and Pacific Northwest Laboratory in 1993-1995 demonstrated that *in situ* flows are lower than and not always correlated with laboratory flow tests.

2007 Saving Water Partnership Program

In 2007, Seattle City Light and partnering utilities offered program Kits containing new beyond-plumbing-code showerhead and faucet aerator to all customers dwelling in single-family homes and duplexes throughout the service area.

During June and early July, a solicitation brochure was sent to customers describing the offer, and containing a response postcard. Follow-up reminder postcards were sent to non-responding customers during July and August. During mid-October, a second reminder postcard was sent to customers who did not respond to either the initial offer or the first reminder. This second mailing represented a subset of prior mailings. It was able to generate a few more percentage points of customer participants, and also helped lower the number of customers claiming they had never heard about the showerhead offer.

Through December 31, 2007, boxed program Kits were mailed to households that either returned the response postcard from the brochure or that called the utility after hearing about the program on radio and television advertisements. The fulfillment house vendor maintained a tracking system for all mailings and receipts, and staffed a telephone hotline to take calls from customers. The boxed Kit contained one showerhead, one bathroom faucet aerator, a strip of Teflon plumbing tape, and informational literature. Customers were able to request a second showerhead, by mail or by phone.

The Kit showerhead (models ES-740W-2.0 and ES-735WO) were supplied by New Resources Group. This showerhead is rated to flow at 2.0 gallons per minute or less. It is also known as the Shower Pro Massage 2.0 GPM model, with chrome plated brass on/off button. This showerhead is built around a Neoperl 2.0 GPM maximum pressure compensating, non-removable flow controller. The overall dimensions are 3 3/4" x 2 5/8". The Shower Pro Massage features massage, combo, gentle rain, and soap-up/off spray patterns. It is made of high impact ABS, and chrome plated brass.

The Kit faucet aerator (model TS-100-1.0), was also supplied by New Resources Group. This aerator is designed to flow at 1.0 gallons per minute. The aerator is pressure compensating to deliver 90% of the rated flow from 30 –90 psi. The rosette spray delivers multiple small streams that have the rinsing force of gallons more. The domed, molded micro screen filters out waterborne debris and extends aerator life for maximum savings. It features a laminar flow; no air is introduced into the stream.

Program Goals

According to the program proposal (see Appendix A), a successful program would meet the following goals (renumbered here in logical time sequence).

1. Complete program implementation within four months of program launch.
2. Ensure that 40% of all single family residential customers install one or two showerheads.
3. Ensure that 20% of all single family residential customers install one or two faucet aerators.

4. Obtain over an 85% customer satisfaction level with both the products and the delivery method, as measured by post-program survey.
5. Achieve consequent water and energy savings at a total cost of under \$11 per customer installation. *(Note: A full economic analysis was not performed for this impact evaluation.)*

Program Performance

The program was launched with brochure mailings in the first week of June. The program was intended to deliver Kits through September. An additional reminder mailing was subsequently scheduled for October, and the decision taken to continue fulfilling customer requests through the end of December 2007. This seven-month period exceeds the four-month period established by Goal 1.

Program planners had thought that a short four-month, high-intensity program would stimulate more urgency among customers, while reducing marketing and administrative costs. However, the additional three months did not significantly increase program costs.

Table 1: Proportion of Solicitation Brochures Mailed in 2007, by SWP Program Partner

Partners: Water Heat Fuel:	Seattle City Light	Saving Water Partnership	Cascade Water Alliance	Puget Sound Energy	Total SWP Kit Program
Brochure Schedule	June 6, 13, 20	June 6, 13, 20; October 16	July 3	July 3	
Postcard Schedule	July 10, 18	July 10, 18	August 7	August 7	
Brochure Mailings	174,079	135,261	76,637	8,294	394,271
Postcard Mailings	133,658	62,468	63,306	6,956	266,388
Second Brochures	0	58,340	0	0	58,340
Kit Requests	54,666	24,754	18,400	2,537	100,357
Response Rate	31%	32%	24%	31%	30%

The overall response of program customers to the solicitation brochure was 30%, varying little from the overall rate among Seattle City Light customers (31%). Survey research conducted in 2008 with program participants (see 2008 Survey Results) found that 90% of households installed one or more high-efficiency showerheads, and that 82% of Kit showerheads were installed. The resulting effect is that 27% (30% x 90%) of all single-family and duplex households installed program showerheads. This level of participation is markedly below the target level of 40%, established in Goal 2.

Program planners, consulted after program completion, commented that the original goal of 40% was probably too optimistic. Marketing experts consulted were surprised that 27% of customers had participated, since most “free” mail-out type promotional programs obtain far fewer participants. They considered a 27% installation rate to be excellent. On the other hand, Seattle City Light has mounted “conservation kit”

programs with compact fluorescent light bulbs, using a similar approach, and obtained a response of 57%. It would be instructive to compare the similarities and differences between the approaches and results of these two types of mail-out program.

In terms of persistence in the showerhead kit approach, before the mailing of reminder postcards or second brochures, the initial response level reached 69% of the eventual response. This underscores the importance of monitoring response and sending follow-up reminders to non-respondents. As post-program survey research showed, the pre-reminder response rate, compared to the final rate, was 74% for Seattle City Light customers, 72% for Cascade Water Alliance, 58% for Seattle Public Utilities, and 53% for Puget Sound Energy.

The same survey research found that 60% of households installed one or more high-efficiency faucet aerators. The resulting effect is that 18% (30% x 60%) of all single-family and duplex households installed program aerators. This level of participation is slightly below the target level of 20%, established in Goal 3.

The post-program survey research also established customer satisfaction levels with the Kit products. It found that 92% of customers were satisfied (69% “very satisfied”) with the efficient showerheads, and 90% felt the new showerhead was equal to or better than the one being replaced (62% “better than the old one”). It also found that 90% of customers were satisfied (61% “very satisfied”) with the efficient faucet aerators. Thus it appears that the program achieved Goal 4, to obtain over an 85% customer satisfaction level with both Kit products.

The survey research did not address customer satisfaction with the program delivery method.

Table 2: Proportion of Delivered Kits, by SWP Program Partner

Partners:	Seattle City Light	Saving Water Partnership	Cascade Water Alliance	CWA Skyway Tukwila	Puget Sound Energy	Total SWP Kit Program
Water Heat Fuel:						
Gas	21,678	15,968	12,753	411	1,358	52,168
Electric	28,614	6,373	3,084	769	1,026	39,866
Subtotal	50,292	22,341	15,837	1,180	2,384	92,034
Check box not marked	4,376	2,389	1,275	108	175	8,323
Total	54,668	24,730	17,112	1,288	2,559	100,357
Proportion of Program	54%	25%	17%	1%	3%	100%

Between June and December 2007, Kits were requested by 54,668 households in the Seattle City Light service area. These represented over half (54%) of overall program participants. On the response postcard, participants were asked to indicate their water heat fuel. Slightly over half of the Seattle City Light households served (28,614) stated they use electricity to heat their water, and slightly fewer than half (21,678) use gas as the water heat fuel; the remaining 4,376 did not answer this question.

In the group of Kit program participants identified as Seattle City Light customers, 57% stated they heat their water with electricity and 43% with gas. By comparison, the 2000 Residential Customer Characteristics Survey (Geist 2001) states that 65% of City Light single-family homes heated their water with electricity and 35% with natural gas.

As shown in the table above, among the 92,034 households indicating their water heat fuel, 31% of program Kits were delivered to the 28,614 Seattle City Light customers heating their water with electricity. Of the 100,357 total Kits delivered, 29% went to Seattle City Light electric water heat customers.

In terms of customer satisfaction, the participating utilities and contractors received very few complaints from customers, either about defective products or delivery issues. Self-installation was not an issue; most customers were able to install themselves, or find a family member or friend to install the products for them. The staff members of the participating utilities were very pleased with the program results. As proof of this, a combined utility multifamily showerhead program was subsequently conducted.

2008 Survey Results

In early 2008, Seattle City Light collaborated with Puget Sound Energy to field a post-program survey with participating customers.

Most of the results presented here are from the combined sample of 684 respondents, 312 identified as Puget Sound Energy gas customers and 348 identified as Seattle City Light electric customers.

A sample of this size generally provides an error of no more than $\pm 4\%$ at proportions approaching 50%•50%, $\pm 3\%$ at proportions of 20%•80%, and $\pm 2\%$ at proportions of 10%•90%.

Here are some highlights from the survey results.

..... Q: What type of fuel heats your water?

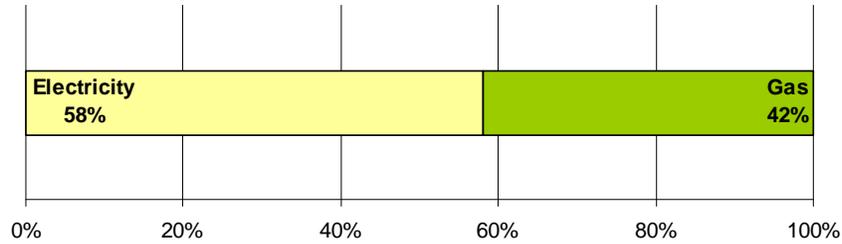
Table 3: Water Heat Fuel

Response	Count	Percent
Electricity	377	58%
Gas	273	42%
Heat Pump	2	0%
Subtotal	652	100%
Missing	32	
Total	684	

The 2008 post-program survey's combined sample did not distinguish Puget Sound Energy gas customers located outside from those inside the Seattle City Light service area. Hence, the following information is drawn from the combined samples for the

two utilities. In the combined sample, 58% of survey participants heat their water with electricity and 42% with natural gas.

Figure 1: Water Heat Fuel



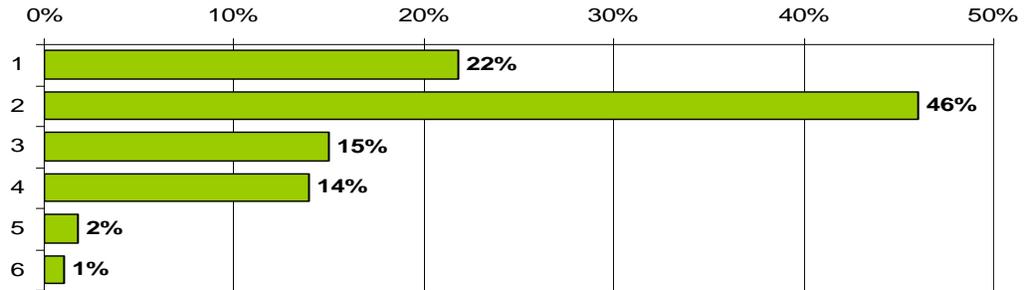
The post-program survey results match those from the group of Kit program participants identified as Seattle City Light customers, of whom 57% stated they heat their water with electricity and 43% with gas. By comparison, the 2000 Residential Customer Characteristics Survey (Geist 2001) states that 65% of City Light single-family homes heated their water with electricity and 35% with natural gas.

..... Q: How many people live in your home?

Table 4: Number of Home Occupants

Response	Count	Percent
1	144	22%
2	304	46%
3	99	15%
4	92	14%
5	12	2%
6	7	1%
7 or more	2	0%
Subtotal	660	100%
Missing	24	
Total	684	

In the post-program survey’s combined sample, the majority of homes (46%) have two occupants, followed in frequency by single-occupant homes (22%). The other 32% of homes are made up of three occupants (15%), four occupants (14%), five occupants (2%), or six-plus occupants (1%).

Figure 2: Number of Home Occupants

By comparison, the 2000 Residential Customer Characteristics Survey described the occupancy of single-family homes as follows. The majority (42%) had two occupants, followed in frequency by single-occupant homes (19%). The other 39% of homes were made up of three occupants (18%), four occupants (14%), five occupants (4%), or six-plus occupants (3%).

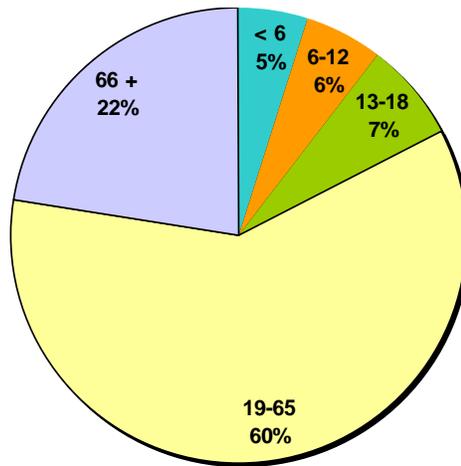
..... Q: How many are in these age ranges?

Table 5: Age of Home Occupants

Response	Count	Percent
Under 6 years	76	5%
6-12 years	86	6%
13-18 years	104	7%
19-65 years	914	60%
66 and older	341	22%
Total	1521	100%
Mean	2.3	

The age composition of the combined sample of single-family homes can be described as follows. The majority of occupants (60%) were in the 19-65 adult age range, followed in frequency by occupants who were 66 years or older (22%). Children made up 17% of occupants, in the age ranges below school age (5% aged < 6 years), of elementary school age (6% aged 6-12), and in the teen years (7% aged 13-18).

Figure 3: Age of Home Occupants



The single-occupancy homes were split evenly between occupants below age 65 (55%) and occupants aged 66 years or more (46%). The double-occupancy homes were also mainly occupied by adults, being comprised of 60% adults below 65 years of age and 38% adults aged 66 years or more. Among the double-occupancy homes in the respondent sample, only 2% of these occupants were children 18 years or younger. Most of the children (77%) represented in the survey sample lived in homes with three or four occupants; 17% lived in homes with five or more occupants.

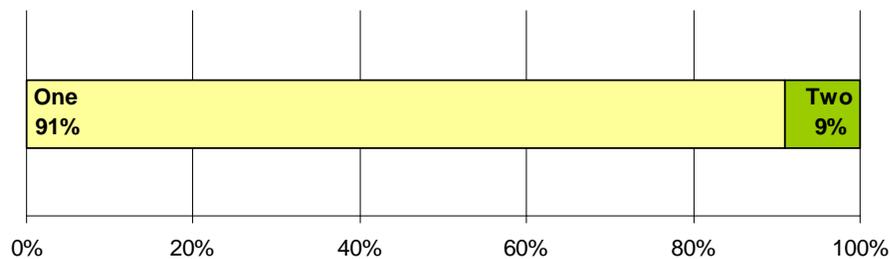
..... Q: How many showerheads did you request?

Table 6 Number of Showerheads Requested

Response	Count	Percent
One	623	91%
Two	61	9%
Total	684	100%

In the combined sample, the majority of respondents state that they requested one showerhead, while a minority requested two.

Figure 4: Number of Showerheads Requested



This finding contrasts with records kept of program distributions, which show that 2.3% of requests from Seattle City Light (electric) and Puget Sound Energy (gas) customers were for a second Kit. This finding also contrasts with program planning projections that one-third of customers responding to the solicitation would request a second Kit.

Q: Did you receive the new showerhead(s) that you requested?

Table 7: Were Requested Showerheads Received?

Response	Count	Percent
Yes	636	93%
No	45	7%
Subtotal	681	100%
Missing	3	
Total	684	

At the time the survey was fielded, it appears that 7% of respondents believed that their household had not received the product(s) requested. The distributor reports that Kits were sent to all households requesting them. The 7% answering “No” to this question may thus represent respondents unaware of the actions of another household member, those that have forgotten requesting or receiving a Kit, or products received that may not have conformed to the request, as well as cases where mail may have gone astray in either direction.

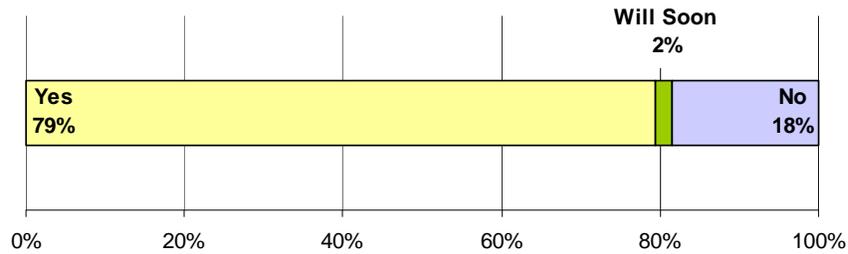
..... Q: Have you had a chance to install your showerhead(s) yet?

Table 8: Have Showerheads Been Installed Yet?

Response	Count	Percent
Yes	543	79%
Will Soon	15	2%
No	126	18%
Total	684	100%

In the combined sample, the majority (79%) of respondents state that their household had already installed a Kit showerhead, and another small group (2%) indicated in written comments that they would be installing one (or more) very soon after receiving the survey. The remainder (18%) had not installed any Kit showerhead.

Figure 5: Have Showerheads Been Installed Yet?



For the purpose of calculating energy savings from the program, the parameter representing the household rate of efficient showerhead implementation shall be set to 82%.

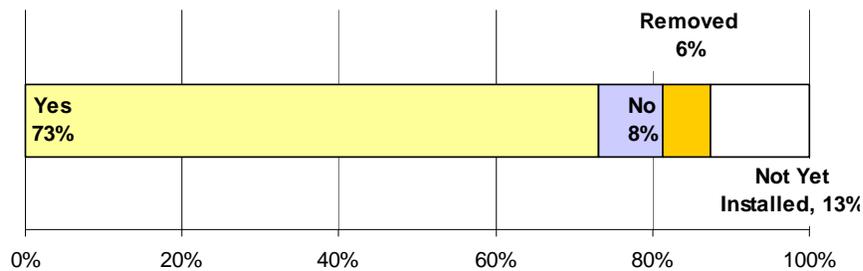
..... Q: Is one of your new showerheads installed in the shower *used most often*?

Table 9: Is a New Showerhead Installed in Shower Used Most Often?

Response	Count	Percent	Count	Percent	Count	Percent
Yes	497	73%	497	84%	497	90%
No	55	8%	55	9%	55	10%
Removed	42	6%	42	7%	—	—
Not Yet Installed	85	13%	—	—	—	—
Subtotal	679	100%	597	100%	557	100%
Missing	5		90		132	
Total	684		684		684	

In the combined sample, the majority (73%) of respondents state that they had installed a Kit showerhead in the shower location used most often. A small group of households (6%) had installed a Kit showerhead but removed it again, for reasons detailed separately in written comments. Another small group of respondents indicate that their household did not install a Kit showerhead in the most-used location. The remainder (13%) had not yet installed a Kit showerhead.

Figure 6: Is a New Showerhead Installed in Shower Used Most Often?



When the denominator excludes households not yet installing a Kit showerhead, then among those households where it was attempted, a larger majority (84%) successfully installed and retained at least one Kit showerhead in the shower location used most often, while a small number (9%) installed and retained in a less-used location all showerheads received from the program. A minority (7%) attempted installation and then removed again all showerheads received from the program.

And, finally, when households are restricted to those where a Kit showerhead was successfully installed and retained in at least one location (excluding removals), a clear majority (90%) installed at least one product in the most-used location.

The statements above are made at the household-level. A separate analysis addresses the number of showerheads themselves, keeping in mind that 9% of households received a second Kit from the program.

In this analysis, responses are filtered to represent only those 543 cases where at least one showerhead was installed. As stated above and seen in the table below, 90% of these households installed one of the new showerheads in the location used most often, the primary location, while 10% of the households did not.

Table 10: Proportion of Households Installing Showerhead(s)

How many showerheads did you request?	Is one of your new showerheads installed in the shower used most often?		
	Yes	No	Total
One	439	47	486
Two	52	5	57
Total	491	52	543
Percent	90%	10%	100%

The 543 households implementing program products installed a total of 600 showerheads, averaging 1.1 showerheads per household. Among these households, 52 received two showerheads, installing one in the primary location and the other in a secondary location. Another five households received two showerheads, installing both in secondary locations. Thus the number of showerheads installed in secondary locations numbered 47 among households receiving one, and 62 among households receiving two. And, as seen in the table below, 82% of the installed showerheads went into the in the location used most often, the primary location, while 18% of the showerheads went into a less-used location.

Table 11: Proportion of Delivered Showerheads that Were Installed

How many showerheads did you request?	Is one of your new showerheads installed in the shower used most often?		
	Yes	No	Total
One	439	47	486
Two	52	62	114
Total	491	109	600
Percent	82%	18%	100%

For the purpose of calculating energy savings from the program, the parameters representing the location of showerhead installations shall be set to 82% in the primary location and 18% in secondary locations.

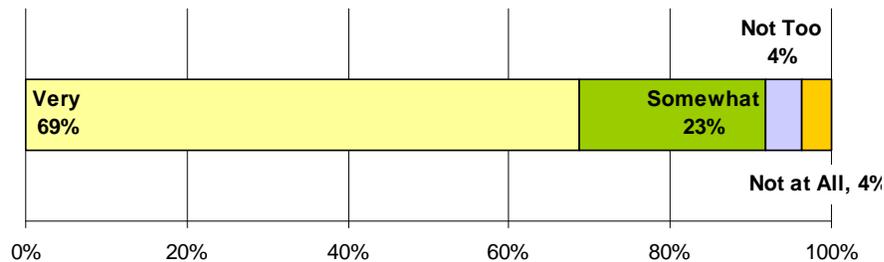
..... Q: How satisfied are you with the spray pattern and the amount of water that comes out of your new showerhead?

Table 12: Satisfaction with Showerhead Spray Pattern and Water Amount

Response	Count	Percent	Count	Percent
Very	400	60%	400	60%
Somewhat	135	20%	135	20%
Not Too	26	4%	26	4%
Not at All	22	3%	22	3%
Not Yet Installed	85	13%	—	—
Subtotal	668	100%	583	
Missing	16		101	
Total	684		684	

The vast majority of survey respondents who had installed a showerhead (92%) were satisfied with the program showerhead: 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%).

Figure 7: Satisfaction with Showerhead Spray Pattern and Water Amount



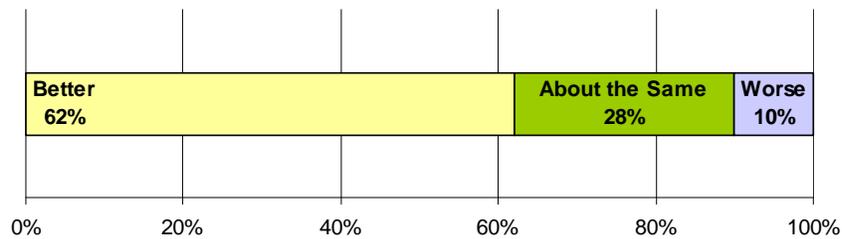
..... Q: How do you like the new showerhead compared to your old one?

Table 13: Satisfaction with New Showerhead Compared to Old

Response	Count	Percent	Count	Percent
Better	363	54%	363	62%
About the Same	162	24%	162	28%
Worse	59	9%	59	10%
Not Yet Installed	85	13%	—	—
Subtotal	669	100%	584	100%
Missing	15		100	
Total	684		684	

The vast majority of survey respondents (90%) of respondents felt that the new showerhead 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 showerhead was “worse than the old one” (10%).

Figure 8: Satisfaction with New Showerhead Compared to Old



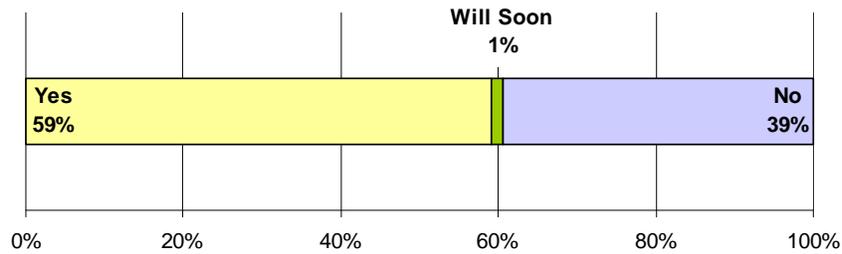
..... Q: Have you had a chance to install your faucet aerator yet?

Table 14: Has Faucet Aerator Been Installed Yet?

Response	Count	Percent
Yes	405	59%
Will Soon	10	1%
No	269	39%
Total	684	100%

In the combined sample, many (59%) of respondents state that their household had already installed a Kit faucet aerator, and another small group (1%) indicated in written comments that they would be installing one (ore more) very soon after receiving the survey. The remainder (39%) had not installed any Kit faucet aerator .

Figure 9: Has Faucet Aerator Been Installed Yet?



For the purpose of calculating energy savings from the program, the parameter representing the household rate of efficient faucet aerator implementation shall be set to 60%.

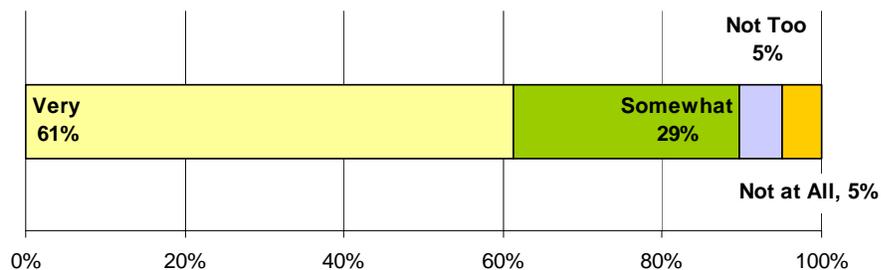
..... Q: How satisfied are you with the spray pattern and the amount of water that comes out of your new faucet aerator?

Table 15: Satisfaction with Faucet Aerator Spray Pattern and Water Amount

Response	Count	Percent	Count	Percent
Very	268	61%	268	61%
Somewhat	125	29%	125	29%
Not Too	23	5%	23	5%
Not at All	22	5%	22	5%
Not Yet Installed	0	0%	—	—
Subtotal	438	100%	438	100%
Missing	246		246	
Total	684		684	

The vast majority of survey respondents (90%) were satisfied with the program faucet aerator: most said “very satisfied” (61%) and nearly a third said “somewhat satisfied” (29%). Few respondents were dissatisfied: half of those said “not too satisfied” (5%) and the rest said “not at all satisfied” (5%).

Figure 10: Satisfaction with Faucet Aerator Spray Pattern and Water Amount



Discussion of Survey Results

The 2008 post-program survey research found that 90% of households installed at least one Kit product. Four months after delivery, 82% of showerheads mailed to customers were installed and still in place. Although this installation rate is lower than was expected during 2007 program planning (90%), the actual installation rate is higher than that assumed by the Regional Technical Forum (76%) in 2008 savings calculations.

Seattle City Light mounted a Conservation Kit Program in 2001 that followed a similar solicitation-reply program model used in the 2007 Program. The Conservation Kit contained two compact fluorescent light (CFL) bulbs, an efficient bathroom faucet aerator, and related products. This program option was based on the concept that requiring customers to take some action in order to receive the Kit would strengthen their knowledge of and commitment to the product. This sort of approach also was intended to improve the cost-effectiveness for the utility. Planners for the 2001 program assumed a 30% solicitation response rate, based on past experience of PacifiCorp in a give-away program, and their assumption for a similar program for Oregon residential customers.

PacifiCorp had also conducted two pilot programs in Walla Walla and Yakima, Washington, to compare the effectiveness of three approaches to distributing CFL products to residential customers. Whether directly mailing two products, directing mailing one product with a two-for-one store coupon, or mailing an offer for two products (as in the present Saving Water Partnership Program), customers responded to all three distribution methods by installing the products at a rate of more than 90%.

Many people have a tendency to postpone activities like installing a new household fixture. The 1992 Home Water Savers Program distributed a similar showerhead-and-aerator Kit. That Kit, however, was unsolicited, having been left in a doorknob hanger on the front door of every house in the city. This contrasts with the present program model, in which Kits were sent only to households from which a direct request for the Kit was received.

Following the 1992 program, a second survey was conducted one year after Kit distribution to assess longer-term installation and persistence rates. The earlier survey performed within the first five months after Kit distribution found that 52% of residents had installed the showerhead and 29% had installed the bathroom faucet aerator. By the one-year mark, it was found that 65% of residents installed and retained the Kit showerhead, while 40% had installed and retained the bathroom faucet aerator. An important finding of that evaluation was the lengthy delay between program distribution and self-installation of Kit products by many residents. A variety of barriers was responsible for non-installation.

In the 2008 post-program survey, the question remains whether additional installations should be expected from unused Kit products. Respondents indicated that 29% of showerheads that are not currently installed are “very likely” to be installed at some future point in time.

Survey results indicated that the percentage of showerheads placed in the most-used, primary location was higher than expected. While pre-program assumptions were that 75% would be placed in primary locations, survey results show that 82% were in fact placed there. The 2008 Regional Technical Forum calculations estimate that even fewer (67%) would be placed in primary locations.

The survey instrument included questions regarding installation of bathroom faucet aerators. The installation rate was quite a bit lower than that for showerheads. Only 59% of homes requesting a Kit installed an efficient faucet aerator. Of the 684 households, 35 reported not receiving an aerator, while only NN felt they had not received a showerhead. It appears that many respondents did not see the aerator in the package, or was unaware of the Kit receipt by another household member, or in fact the assembled Kit did lack an aerator in the package.

Overall, respondents were satisfied with the products provided in the Program Kit. Summarize.

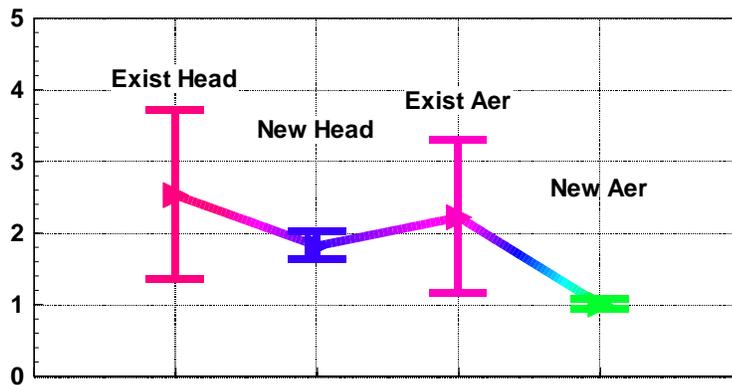
On-site Measurement Study

The measurements study was conducted in 2006 with a representative sample of Seattle sites. Due to the hilly nature of the city, with open water reservoirs, and hence varied site water pressures—along with the varied plumbing age in the housing stock, and consequent pipe corrosion—the sample was drawn from five neighborhood groupings and five construction periods. The final sample of 71 single-family homes contained 151 bathrooms.

The homes averaged 2.1 bathrooms each, slightly more than the city average of 1.6 recorded in the property assessment files. Nearly all bathrooms had one or more faucets, one toilet, and one shower (or tub/shower combination), but in a few cases consisted of just one faucet, or one shower, or one toilet. Two circulating pumps were found but one was disengaged. A slight majority (54%) of the homes used electricity to heat hot water, while the remainder (46%) used natural gas. The age of homes was representative of home ages in the city as a whole, with an average of 70 years. The average floor area was 1,857 square feet, about 400 square feet smaller than the city average (there were fewer “high-end” homes than exist in the city as a whole).

For the purpose of this analysis, attention is here focused on two sets of measurements: the *in situ* flow rates of showerheads and bathroom faucet aerators, both existing equipment and the new efficient replacement products proposed for the 2007 program. The figure below depicts the means and standard deviations for the pertinent measurements.

Figure 11: Flow Rate Means and Standard Deviations

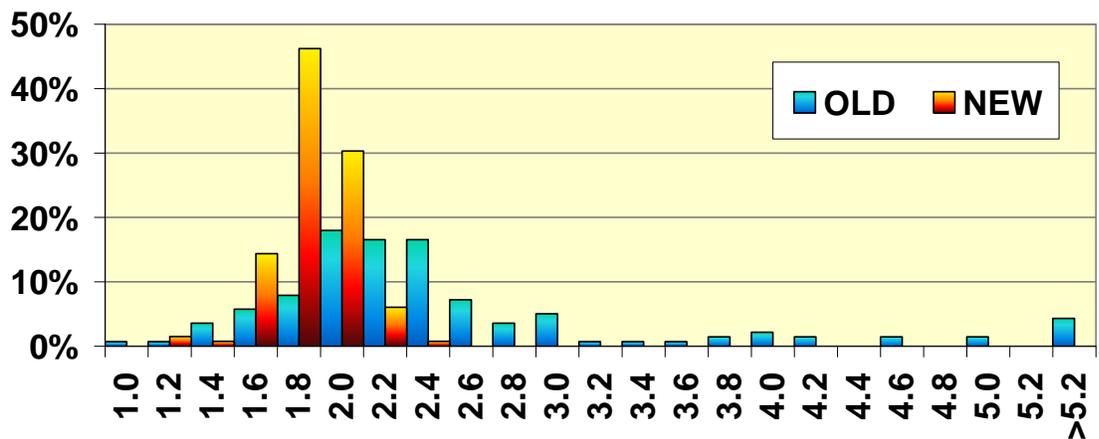


..... Showerhead Flow Rates

Marked Rating. Of the 144 showerheads, the majority (78%) were standard showerheads; however, a significant minority (22%) were hand-held types. No luxury showerheads were observed. Across the 87 showerheads where the existing flow rating was marked and could be identified, the largest portion of the showerheads (95%) was marked 2.5 gpm. Only one showerhead was rated lower than 2.5 gpm and only three were rated above 2.5 gpm.

The figure below shows the distribution of the measured pre-retrofit flow rates across the 139 existing showerheads where measurements were made. The figure shows that the largest portion of the measured flow rates was between 2.0 and 2.5 gpm. The second most common flow rate range was between 1.5 and 2.0 gpm. A total of 67% of the flow rate measurements were in the 1.5 to 2.5 gpm range.

Figure 12: Distribution of Showerhead Measured Pre-Retrofit Flow Rates (in gallons per minute)



Existing Flow Rate. The study measured the pre-retrofit full throttle flow rate for a total of 139 showerheads in 71 homes. The flow rate measurement could not be made at five shower arms because the water to the showerhead was shut off. The full throttle

flow rate across the 139 showerheads where measurements could be made ranged from 1.0 to 9.0 gpm. The mean flow rate (with a fairly broad standard deviation) was measured to be 2.53 gpm—slightly greater than the median flow rate of 2.20 gpm.

Replacement Flow Rate. The study measured the *in situ* post-retrofit full throttle flow rate for a total of 132 showerheads. Fewer measurements were made for the post-retrofit case because seven of the showerheads had ball joints that could not be retrofitted. The full throttle flow rate for the efficient showerheads (rated 2.0 gpm) ranged from 1.2 to 2.4 gpm. The largest portion (46%) was between 1.6 and 1.8 gpm, while another 30% were between 1.8 and 2.0 gpm. The mean flow rate (with a very narrow standard deviation) was measured to be 1.82 gpm—the same as the median flow rate. This observed value is lower than the marked rating for this showerhead (2.0 gpm).

Flow Change. The efficient showerhead reduced the flow rate in all but a few cases where it replaced an existing clogged showerhead or a showerhead with the same rating. On average the flow rate was reduced from a mean of 2.53 gpm to 1.82 gpm, resulting in water savings of 0.71 gpm.

The following table summarizes the salient parameters for energy savings analysis.

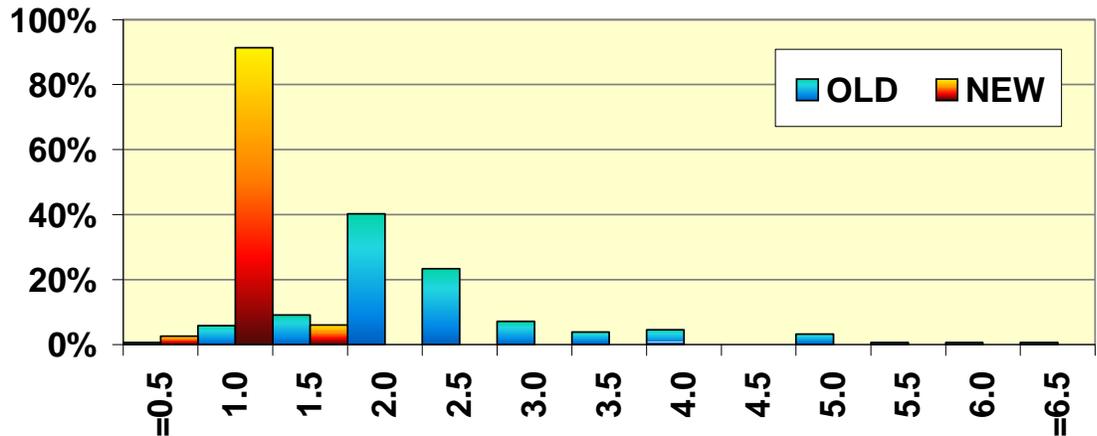
Table 16: Showerhead Flow Rates

	Median gpm	Mean gpm	S.D. gpm	No. at sites
Existing Showerhead	2.20	2.53	1.18	139 at 71
New Showerhead	1.80	1.82	0.19	132 at 67

..... Aerator Flow Rates

The figure below shows the distribution of the measured pre-retrofit flow rates across the 154 existing bathroom faucets where measurements were made. The figure shows that the largest portion of the measured flow rates (40%) was between 1.5 and 2.0 gpm. The second most common flow rate range was between 2.0 and 2.5 gpm. A total of 64% of the flow rate measurements were between 1.5 and 2.5 gpm. The replacement faucet aerator is designed to flow at 1.0 gpm, which was confirmed by the *in situ* measurements .

Figure 13: Distribution of Faucet Aerators Measured Pre-Retrofit Flow Rates (in gallons per minute)



Existing Flow Rate. The study measured the pre-retrofit full throttle flow rate for a total of 154 faucets in 71 homes. The full throttle flow rate ranged from 0.4 to 8.8 gpm. The mean flow rate was measured to be 2.2 gpm—slightly greater than the median flow rate of 2.0 gpm.

Replacement Flow Rate. The study measured the post-retrofit full throttle flow rate for a total of 116 faucets. Fewer measurements were made for the post-retrofit case because the efficient aerators would not fit on the faucets in 38 cases (25%). The flow rate of the efficient aerators (rated 1.0 gpm) ranged from 0.8 to 1.2 gpm. Of the 116 efficient aerators where measurements were made, the largest portion (91%) was between 0.8 and 1.0 gpm. The mean flow rate was measured to be 1.0 gpm—the same as the median flow rate. This value accords with the marked flow rate for this aerator.

Flow Change. The efficient aerator reduced the flow rate in all but a few cases where it replaced an existing clogged aerator. On average the full throttle flow rate was reduced from a mean of 2.2 gpm to 1.0 gpm, resulting in water savings of 1.2 gpm.

The following table summarizes the salient parameters for energy savings analysis.

Table 17: Faucet Aerator Flow Rates

	Median gpm	Mean gpm	S.D. gpm	No. at sites
Existing Aerator	2.0	2.2	1.1	154 at 71
New Aerator	1.0	1.0	0.1	116 at 56

Calculating Energy Savings from Showerhead and Aerator Replacements

The algorithm for estimating energy savings from showerhead replacements multiplies showerhead flow rate reduction (gallons/minute, adjusted from full-throttle to user-setting) by shower duration (minutes), shower water from hot tap (%), hot water temperature rise (°F), persons/household, showers/person/day, annual occupancy

(days), conversion factor for electric heat (8.29 Btu/°F/gallon/3413), heat element loss factor, and delivered products installed (%).

Key parameters carried over from prior research (PSE & BPA 1994; Warwick 1995; Geist 2001; Mayer et al. 2000) include the following: ratio of user-setting to full-throttle flow rate (0.83 existing, 0.95 replacement), 7.84 minutes average shower length, 68% of shower water derived from the hot tap, 75°F water temperature rise (tank outlet minus inlet °F), 2.51 persons per household, 350 days annualized occupancy, and a 98% adjustment for heat lost from the element through the tank connection.

Prior research has shown that the daily average number of showers per person is 0.55 in primary showerhead locations, 0.28 in secondary locations, and 0.64 regardless of shower location in the home (Brattesani & Okumo 1993; Brattesani & Tachibana 1994).

Program planning projections are that 90% of showerheads delivered by the program will be installed. This is based on a pilot study survey with 704 respondents, which found that 93% installed delivered showerheads (Hampton 2006). The new program plan also estimates that 67% of households will request a single showerhead, while 33% will request a second showerhead as well. Post-implementation survey research in 2008 will test that assumption and provide correcting factors for the last two parameters.

Following are the algorithms used to calculate household shower minutes per year, shower water saved in gallons per minute, and water heating energy in kilowatt-hours per gallon. Energy savings are calculated as the cross-product of these three factors.

Using values from the table below, the calculation of $D * S * P * Y$ produces an estimate of time spent showering in the typical household. Showering minutes per year are 3,788 in the most-used shower location, 1,928 in less-used shower locations, and 4,132 per household across all showering locations in the household (weighting for 82% of showers in primary and 18% of showers in secondary locations).

Table 18: Calculation of Time Spend Showering in the Typical Household

$D * S * P * Y =$	Household Showers, in Minutes per Year
D = 7.84	Average duration minutes / shower
S =	Daily average showers / person / day
0.55	• if installed in primary / most used location
0.28	• if installed in secondary / less used location
0.50	• if installed in an unspecified location
P = 2.51	Persons / household
Y = 350	Occupancy days / year

Using values from the table below, the calculation of $(VX * RX) - (VE * RE)$ produces an estimate of shower water saved by a showerhead retrofit in the typical household, going from an average shower flow rate of 2.53 gpm to an efficient flow

rate of 1.82 gpm. Regardless of shower location, the adjustment from full-throttle flow rate (as measured in the 2006 study) to a user-setting flow rate will save 0.40 gpm, on average.

When multiplied by the number of showering minutes per year, the result is water savings of 1,515 in the most-used shower location, 771 in less-used shower locations, and 1,653 per household across all showering locations in the household (weighting for 82% of showers in primary and 18% of showers in secondary locations).

Table 19: Calculation of Shower Water Saved by a Showerhead Retrofit in the Typical Household

$(V_X * R_X) - (V_E * R_E) =$	Shower Water Saved, in Gallons per Minute
V =	Observed full-throttle flow rate (gallons / minute)
2.53	<ul style="list-style-type: none"> X: if existing showerhead
1.82	<ul style="list-style-type: none"> E: if efficient replacement showerhead
R =	Ratio of user-setting to full-throttle flow rate
0.83	<ul style="list-style-type: none"> X: if existing showerhead
0.95	<ul style="list-style-type: none"> E: if efficient replacement showerhead

The last algorithm transmutes gallons of water saved (both hot and cold) into energy savings from heating the hot portion of the shower water. The calculation of $H * W * B / ((1-C) * K)$ produces an estimate of electricity savings at 0.126404 kWh per gallon; while the calculation of $H * W * B / (1-C)$ produces an estimate of natural gas savings at 431 British thermal units (Btu) per gallon. Gas savings need to be further adjusted downward, multiplying by 0.75, to reflect a lower direct heating efficiency of the typical gas domestic hot water tank. Gas savings may be restated in therms, dividing by Btus by 100,000.

Table 20: Calculation of Energy Savings from Heating Shower Water

$H * W * B / ((1-C) * K) =$	Water Heat Energy, in kWh per Gallon
H = 68%	Proportion of shower water from hot tap
W = 75	Hot water temperature rise (tank outlet °F minus inlet °F)
B = 8.29	Water heating energy (Btu/°F/gallon)
C = 2%	Heat lost from the element through the tank connection (steady state heat loss factor)
K = 3413	Electric energy (Btu / kWh)

When multiplied by the number of showering minutes per year and gallons of water saved per minute, the result is annual electricity savings of 192 kWh in the most-used (primary) shower location, and 98 kWh in less-used (secondary) shower locations. Annual natural gas savings are 4.9 therms in the most-used (primary) shower location, and 2.5 therms in less-used (secondary) shower locations.

Estimate of Program Energy Savings

The algorithms presented above use findings from the 2006 pre-program measurement study as well as parameters from prior research conducted during the 1990s. Thus the electricity and gas savings estimated from avoided water heat apply specifically to showerheads where the location is installation is known.

However, not all products delivered by the program were installed. And, for purposes of program accountability, it is desirable to estimate energy savings at the household level, since program tracking was conducted at the household level.

As found by the participant survey, 83% of delivered showerhead products were installed by participants. Thus, per installed showerhead the annual electricity savings are 159 kWh in the most-used (primary) shower location, and 81 kWh in less-used (secondary) shower locations. Annual natural gas savings are 4.1 therms in the most-used (primary) shower location, and 2.1 therms in less-used (secondary) shower locations.

And, as found by the participant survey, 82% of delivered showerhead products were installed by participants in the most-used showering location, while 18% of program showerheads were installed in less-used locations. Thus, per household the average annual electricity savings are 130 kWh in the most-used (primary) shower location, and 15 kWh in less-used (secondary) shower locations. The weighted average across showerhead locations produced 145 kWh per household participating in the program. Annual natural gas savings are 3.3 therms in the primary location, and 0.4 therms in secondary locations. The weighted average across showerhead locations produced 3.7 therms per household participating in the program.

So, for the purpose of calculating energy savings from the program, the number of households receiving program Kits should be multiplied by 145 kWh, or 3.7 therms. Annual water savings (cold plus hot) are estimated as 1,147 gallons per household. The following table provides the results for Seattle City Light.

Table 21: Water and Energy Savings in Seattle City Light Service Area

Water Heat Fuel:	Seattle City Light	Annual Water Savings	Units	Annual Energy Savings	Units
Electric	28,614	32,820,258	gals	4,149,030	kWh
Assigned to Electric	2,490	2,856,030	gals	361,050	kWh
Subtotal Electric	31,104	35,676,288	gals	4,510,080	kWh
Gas	21,678	24,864,666	gals	80,209	therms
Assigned to Gas	1,886	2,163,242	gals	6,978	therms
Subtotal Gas	23,564	27,027,908	gals	87,187	therms
Total	54,668	62,704,196	gals		

The 2007 Kit program therefore generated 4,510 MWh of annual electricity saving for Seattle City Light, and 87,187 therms of natural gas savings in the Seattle service area for Puget Sound Energy. With an expected lifetime of 15 years, these electricity

savings will mount to 67,651 MWh over the life of the measure. The load reduction per year for Seattle City Light will be 0.54 average megawatts (aMW). Over the expected lifetime of 15 years, these natural gas savings will mount to 1,307,805 therms over the life of the measure.

Table 22: Water and Energy Savings from the Combined Program

Water Heat Fuel:	Total Kit Program	Annual Water Savings	Units	Annual Energy Savings	Units
Electric	39,866	45,762,302	gals	5,780,570	kWh
Assigned to Electric	3,605	4,134,935	gals	522,725	kWh
Subtotal Electric	43,471	49,861,237	gals	6,303,295	kWh
Gas	52,168	59,836,696	gals	193,022	therms
Assigned to Gas	4,718	5,411,546	gals	17,457	therms
Subtotal Gas	56,886	65,248,242	gals	210,478	therms
Total	100,357	115,109,479	gals		

As for the overall Saving Water Partnership program, it generated 6,303 MWh of annual electricity saving for the Puget Sound Area, and 210,478 therms of natural gas savings for Puget Sound Energy. With an expected lifetime of 15 years, the electricity savings will mount to 94,549 MWh over the life of the measure. The load reduction per year for the Puget Sound Area will be 0.76 average megawatts (aMW). Over the expected lifetime of 15 years, these natural gas savings for Puget Sound Energy will mount to 3,157,170 therms.

Bathroom faucet aerators, saving 1.2 gpm, will provide an additional 46 kWh per confirmed installation, or 27 kWh per household, where 59% installed a Kit aerator.

Summary of Outcomes

In summary, then, these were the goals and outcomes of the 2007 Showerhead Kit Program.

Goal 1. Complete program implementation within four (4) months of program launch.

Outcome 1: Program completed within seven (7) months.
GOAL MET.

Goal 2. Ensure that 40% of all single family residential customers install one or two showerheads.

Outcome 2: The showerhead installation rate was 27% of single family customers.
GOAL NOT MET

Goal 3. Ensure that 20% of all single family residential customers install one or two faucet aerators.

Outcome 3: The faucet aerator installation rate was 27% of single family customers.

GOAL MET.

Goal 4. Obtain over an 85% customer satisfaction level with both the products and the delivery method, as measured by post-program survey.

Outcome 4: The satisfaction rates were 92% for showerheads and 90% for faucet aerators.

GOAL MET

Goal 5. Achieve consequent water and energy savings at a total cost of under \$11 per customer installation.

Outcome 5: Energy savings were close to early estimates, resulting in a cost under \$11 per customer (according to program operators).

GOAL MET.

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Appendix A: Program Plan

Saving Water Partnership Program Proposal for a Beyond Plumbing Code Showerhead & Aerator Replacement Program

..... Framework

This proposal is to offer a distribution program for showerheads and bathroom faucet aerators, targeted to the single-family residential sector. A program in the early 1990s distributed 2.5 gpm showerheads and 1.5 gpm aerators to many of these same customers. Those water saving devices are now reaching the end of their projected life (about 15 years). This proposed program would enable customers to replace those products with more efficient ones (2.0 gpm or less for showerheads and 1 gpm for aerators). Additional customers who did not participate in the past program would also be likely participants.

Two similar pilot projects were completed in 2005 to test customer interest and installation of the beyond code devices. The results of these pilots have been used to estimate participation and savings goals of the proposed regional program.

..... Program Goals

Widespread regional installation of residential showerheads and aerators that go beyond current plumbing code requirements offers significant water and energy saving. A successful program would meet the following goals:

- 40% of all single family residential customers install one or two showerheads
- 20% of all single family residential customers install one or two aerators
- Achieve these water and energy savings at a total cost of under \$11 per customer installation
- Obtain over an 85% customer satisfaction level with both the products and the delivery method as measured by post-program survey.
- Program implementation is completed within four months of program launch.

..... Participation/Savings Estimates and Budget

The estimates for participation and savings potential are based primarily on program experience and research. The research includes the 2000 Seattle Home Water Conservation Study, information from Seattle City Light regarding aerator installation penetration rates, and results of the 2005 Showerhead Pilot distribution.

A low and high range of program participation, savings, and budget are provided, along with target figures. The largest uncertainty between the referenced research and target program figures is with the participation (response) rate. While the Showerhead

Pilot had a participation rate of 21%, our data results shows that a reminder mailing and more prominent marketing can push the participation rate to 40% .

..... Partnerships

Since showerheads and aerators save energy as well as water, partnerships with the energy utilities and cost sharing with them is part of program planning. It is anticipated that Seattle Public Utility could share up to 50% of the total cost of the program with Seattle City Light, Puget Sound Energy, and Cascade Water Alliance. Coordination with other water providers and agencies in the region will be made to determine if they are interested and able to be funding partners in a regional effort.

..... Program Delivery

Based on the success of the pilot projects and recent experience with direct mail offers by Seattle City Light and Puget Sound Energy, the direct mail delivery method is proposed. All potential program participants will be mailed a solicitation explaining the program. The mailing will have a tear off section for interested customers to mail back with their request for fixture(s). Based on the information furnished by the applicant on the product request form, a conservation Kit will be mailed.

..... Timeline

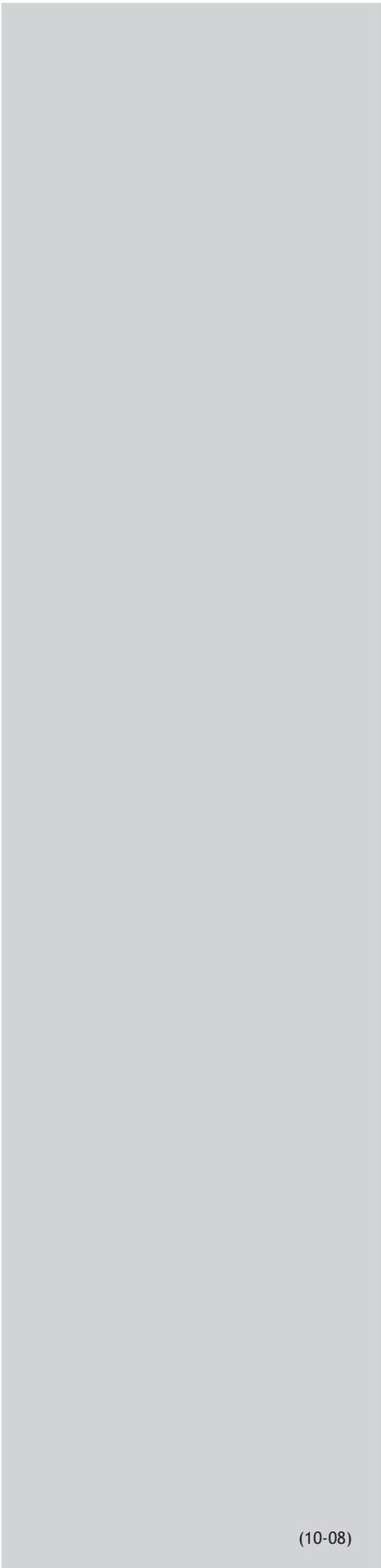
The program will be implemented in summer and fall of 2007. It is likely that program solicitation mailings will be staggered to enable the fulfillment house to better handle the work and to avoid delays in product delivery. A four-month timeline is proposed from initial mailing through substantial completion, defined as delivery of 95% of product.

..... Analysis and Evaluation

Satisfaction surveys will be done with a representative sample of customers. A post-program analysis will be conducted of actual cost, installation rates, and savings. A monitoring and data collection element, including a customer satisfaction and installation survey, will be part of the program plan.

..... Eligibility

Including all single family residential customers of Seattle Public Utilities (SPU), Puget Sound Energy (PSE), Seattle City Light (SCL), and Cascade Water Alliance (CWA) residing within the territory of each partner, this would exclude customers of Renton Water District, Kent Water District and Federal Way Water district. Not eligible are customers in the multi-family residential sector (apartments and condominiums). These customers are being reached by a separate multifamily bathroom fixture replacement program .



Seattle City Light