

Impact Measurements for a Low-Flow Showerhead Program

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PG&E (Pacific Gas and Electric Company) recently completed an evaluation of its Energy-Saver Showerhead Coupon Program. The goal of this program is to conserve energy, both natural gas and electricity, by reducing water heating demand. The program is designed to encourage customers to replace an inefficient showerhead--i.e., flow rate greater than 2.75 gallons per minute--with a low-flow showerhead--2.75 gallons per minute or less--sooner than they would have otherwise.

The objectives of the evaluation of the Energy-Saver Showerhead Coupon Program were twofold:

- Determine a net-to-gross ratio of effective showerheads to total rebated showerheads.
- Verify components of the energy savings calculation, including length of showerhead use and flow rate.

Based on a telephone survey of participants, while 67 percent of rebated showerheads had been installed and not subsequently removed, only 31 percent of the rebated showerheads proved to be effective (i.e., yielding net energy savings). Although such self-reported results have a large error band, this was still lower than expected. Of the remaining showerheads, one percent were used outside the utility service area, 18 percent were not installed, 2 percent were installed but subsequently removed, 17 percent replaced a showerhead that already had an efficient flow rate, and 32 percent of the new showerheads replaced preexisting showerheads that were at the end of their useful life (i.e., free riders).

Counterbalancing the net-to-gross result, respondents in the survey also reported that the length of daily use per program showerhead was 12.9 minutes. This is about 40 percent longer than the amount previously estimated. Based on shower duration alone, PG&E could be claiming 40 percent more energy savings.

Background

PG&E (Pacific Gas and Electric Company) recently completed an evaluation of its Energy-Saver Showerhead Coupon Program. The goal of this program is to conserve energy, both natural gas and electricity, by reducing water heating demand. The program is designed to encourage customers to replace an inefficient showerhead--i.e., flow rate greater than 2.75 gallons per minute--with a low-flow showerhead--2.75 gallons per minute or less--sooner than they would have otherwise.

In 1991, PG&E redeemed coupons for about 521,600 low-flow showerheads. PG&E paid a \$4 rebate on each showerhead for up to four showerheads per coupon. Customers received the rebate at the time of purchase from retailers. Retailers submitted coupons monthly to PG&E for reimbursement.

PG&E currently assumes that 75 percent of all rebated showerheads actually meet the program's basic effectiveness criteria. That is, the rebated showerhead was installed and not removed, the rebated showerhead's flow rate was less than the flow rate of the showerhead it replaced, and the preexisting showerhead was replaced before the end of its useful life.

PG&E further assumes that a low-flow showerhead can save 22.8 therms per year on a natural gas water heater or 524 kilowatt hours per year on an electric water heater. Approximately 90 percent of PG&E's residential customers have a natural gas water heater, and the other ten percent have an electric water heater.

The objectives of the evaluation of the Energy-Saver Showerhead Coupon Program, performed by HBRS, Inc., were twofold:

- Determine a net-to-gross ratio of effective showerheads to total rebated showerheads.
- Verify components of the energy savings calculation, including length of showerhead use and flow rate.

The results of the evaluation are being used to conduct post-program measurement of the impacts of the retail coupon program. The results also suggest recommendations for revisions to the current assumptions used by PG&E for estimating the energy savings from the low-flow showerheads purchased through the program. To accomplish these objectives, the evaluation includes quantitative and qualitative data collection efforts with program participants and nonparticipants. Two data collection methods were employed: telephone surveys and on-site measurements.

Methodology and Sampling Design

The first data collection approach was customer telephone surveys. These survey data are used to address evaluation questions concerning showerhead installation and persistence, factors affecting a program net-to-gross ratio, factors related to estimation of energy savings per showerhead, and issues regarding satisfaction with the low-flow showerheads. The second approach involved on-site data collection to better understand how actual showerhead use conditions vary from the standard conditions assumed in PG&E's energy savings calculations. Some of these water use conditions can only be reliably measured using an on-site data collection method.

Telephone Survey Sampling and Data Collection

A critical element of this telephone survey was the sampling of program participants. Because PG&E is interested in separate information for gas *versus* electric water heat customers, the sample was designed so that 350 surveys would be completed with gas water heat participants and 150 surveys would be completed with electric water heat participants. Sampling and data collection with nonparticipants was employed to study the showerhead purchases of customers who did not participate in the program.

Participant Sampling Plan. A sample of participants was systematically drawn from the retail coupons redeemed during 1991. The participant sample was *proportionally* stratified; that is, the sample is proportionate to the 1991 population of total coupon redemptions by time period (typically month of coupon redemption during 1991) and by PG&E division. PG&E's storage system facilitated this proportionate selection of sampled coupons. The customer's zip code from each coupon and the number of showerheads purchased for each coupon had been entered into a program data base. Because the customer's zip code had been entered, participation was available from the data base by PG&E division. The PG&E data base provided a count of the total number of coupons redeemed during the study time period, as well as the number of coupons in each of PG&E's 25 divisions.

The sampling plan specified the selection of a total of 3,000 coupons from the 25 PG&E divisions in order to provide a sufficient number of starting sample points for the telephone surveys. This large sample size requirement was due to the necessity of completing surveys with 150 electric water heat participants (across PG&E's service territory, approximately only 10 percent of residential customers have electric water heat). However, this facet of the sample design necessitated calculation of weights for analyses that combined gas and electric water heat participants.

In order to calculate these weights, estimates of the proportionate sample sizes of gas, electric, and other water heat types were needed for each division. The proportionate sample size is defined as the number of customers who should have been chosen from each water heat fuel category to correctly represent the population of participating customers. The weighting factors are calculated by dividing the proportionate sample sizes by the actual number of surveys completed. The percentages of water heat fuel type by division were not known for program participants. They were, however, known for the entire residential population by division. The weighting factor calculations in this study employed this known percentage of all residential customers in each water heat fuel category. These percentages vary across each of PG&E's divisions and are reported in the PG&E Residential Appliance Saturation Study (RASS) data.

Nonparticipant Sampling Plan. The nonparticipant sample was drawn from a systematic sample of PG&E residential customers, which was provided by PG&E. At the time PG&E's sample was drawn, the residential population was approximately 3,635,167 customers. This random sample of 4,000 residential customers was

stratified by the six PG&E regions. The nonparticipant sample plan for this study specified selection of approximately 1,000 customers from PG&E's larger sample with the expectation of completing the nonparticipant telephone survey with 10 to 20 percent, depending upon survey response rates and the fraction of contacted customers who had acquired a showerhead within the past year.

The calculation of sample weights for the nonparticipant group (the random sample of PG&E residential customers) are provided for each PG&E region, and were calculated by dividing the proportionate sample size by the actual number sampled.

Survey Data Collection. The participant telephone survey was conducted from December 20, 1991, through February 17, 1992. Initially, interviewers attempted to conduct interviews with all contacted participants. However, after the goal of completing interviews with 350 gas water heat participants was achieved, the interviewers began using a short screening telephone call to identify the type of water heat fuel reported by the customer. This screening interview also inquired about the installation status of low-flow showerheads purchased by the respondent using the retail coupon.

Participants who indicated during the telephone screener that they had electric water heat were then asked to complete the full survey (identical to the survey completed by the gas water heat participants). A total of 995 customers completed the screener; 511 completed the full telephone survey. An overall response rate of 56 percent was attained across both participant survey instruments (full survey and screener).

The nonparticipant (random sample of residential customers) telephone survey was also conducted during the same weeks. Customers received a screening telephone call to determine whether they had acquired a showerhead during the past year (1991). If a customer reported acquiring a showerhead, the interviewer attempted to complete a full survey with the customer. An overall response rate of 59 percent was reached across a valid sample of 974 customers (115 full surveys and 461 screeners).

On-Site Sampling and Data Collection

Among the most important parameters in estimating energy savings achieved per installed program showerhead are the pre- and post-installation flow rates in gallons per minute. Also important is the temperature rise, or difference between the residence's inlet (cold) water temperature and the (outlet) water heater setting. These

measurements require on-site data collection with both program participants and nonparticipants.

In this study, the nonparticipant on-site data were required for estimating the pre-installation flow rate condition, while the participant data yielded post-installation (of the program low-flow showerhead) flow rates, as well as verification of installation. When these pre- and post-installation flow rates are combined, the change in flow rate attributable to the program showerhead can be inferred. The change in flow rate is a key determinant of the gallons of water required for showers and the consequent energy required to heat the water.

Sampling for On-Site Data Collection with Participants and Nonparticipants. On-site data collection was completed with 161 program participant residences and 160 nonparticipant residences, randomly sampled from four PG&E divisions. Four divisions were chosen out of 25 in order to minimize the costs associated with widely dispersed samples. Approximately 80 on-site inspections were conducted in each of the four PG&E divisions (Diablo, San Francisco, Stockton, and Mission).

The four divisions were selected on the basis of four criteria for representativeness: (1) preliminary results for installation rate obtained from the telephone survey; (2) residence structure type; (3) level of program participation; and (4) low-flow showerhead program activity levels of water utility districts in each division. For each criterion, the on-site sampling plan sought a balance, or mix, across the PG&E divisions. For example, two of the four divisions selected had program showerhead installation rates (from the telephone survey preliminary results) that were very close to the average installation rate across all divisions; one division had an above-average installation rate, and one had a below-average rate.

The criterion regarding low-flow showerhead programming activities by local water utility districts (which are separate from PG&E's efforts) was considered important for two reasons. First, there is wide variability in water conservation efforts across water districts within PG&E's service territory. Second, since the nonparticipant showerhead flow rate measurements were used as a surrogate for the participants' pre-installation flow rate, the study sought to avoid potential bias in these "preprogram" flow rate measurements that could have resulted by selecting only residences within water districts with atypically aggressive water conservation programs.

As with the telephone survey data, weights were calculated for analyses using the on-site data. Weighting factors were calculated for each of the four divisions by dividing

the proportionate sample sizes (based on program participation by division) by the actual number of on-sites completed in each division. Calculation of nonparticipant weights for the on-site data followed the same logic, using the population of residential households within each of the four divisions to determine the proportionate sample size for each division.

On-Site Data Collection. Following selection of the samples, participants and nonparticipants were contacted by telephone to determine whether they would be willing to agree to a site visit for collection of data relevant to water heating energy savings. In order to minimize participant sample bias associated with non-installation of showerheads (i.e., a selection-by-treatment interaction effect), we recruited participants without acknowledging their showerhead coupon redemption.

As indicated above, several of the parameters for energy-savings calculations could only be measured on-site. This data collection therefore included the following measurements: (1) flow rate for all showerheads in the residence, full throttle and as adjusted by resident; (2) household cold water (inlet) temperature; (3) household hot water (outlet) temperature; and (4) verification of the installation of the program low-flow showerhead among participants. Additional data concerning hot water usage was also collected to supplement the telephone survey data.

Results

Results Related to Calculation of a Program Net-To-Gross Ratio

The central issue related to the estimation of a net-to-gross ratio for the Energy-Saver Showerhead Coupon Program is: What would the distribution of showerhead efficiency levels (flow rates) be in the absence of the retail coupon program? The on-site observations for participants and nonparticipants provide estimates for flow rates. Among the important measurement questions incorporated in the participant telephone survey data collection are:

- What is the rate of showerhead installation and persistence?
- What type of showerhead did the program low-flow showerhead replace?
- Is the showerhead currently installed?
- How did the program coupon influence the timing of customers' purchase decisions?

Installation Rate and Persistence of Program Showerheads. Both of the evaluation data collection approaches--telephone surveys and on-site observations--focused on installation rate measurement objectives. The installation rate can be defined as the fraction of low-flow showerheads distributed through the retail coupon program that are currently installed in homes in PG&E's service territory. An additional objective of the study was to calculate the average elapsed time between date of purchase (obtained from the redeemed coupon and/or survey data) and installation of the fixture.

According to the telephone survey data, 6 percent of the program-sponsored showerheads were installed but subsequently removed (and no longer in use), and 27 percent had not been installed. The balance (67 percent) were installed, but not all of these meet the program's criteria for effectiveness. There was some difference in reported installation status by electric (68 percent) *versus* gas water heat participants (58 percent).

The on-site data collection among program participants was also used to measure installation rate. These results are shown in Table 1, and indicate that 6 percent of the showerheads obtained through the coupon program by the on-site participants were installed but subsequently removed, about 57 percent had not been installed, and 37 percent were currently installed.

At least one factor related to the cases used in the calculation of the installation rates may help explain some of the disparity between the installation rate obtained from the telephone survey and the on-site installation rate. In the on-site participant survey, all sampled customers were considered to be participants, whether they remembered participating or not. In the participant telephone survey, on the other hand, the full interview was not conducted with those customers who did not remember participating. Installation rates, therefore, may be somewhat different for these two samples, resulting in lower-than-expected rates for the on-site sample and higher-than-expected rates for the telephone survey sample.

In addition, in the on-site surveys, the interviewed customer may not have been the one who redeemed the coupon. On-sites, by necessity, were conducted with the household member who was available at the time of the on-site visit. In the telephone interviews, an effort was made to contact the customer specially named on the coupon.

The participant telephone survey asked respondents about the status (and other details) of each of the low-flow showerheads they purchased with a program coupon, up

Table 1. Overall Installation Rates for Low-Flow Showerheads

Action	Percent of Sample (n=965)
From Telephone Survey:	
Installed	67% (n=644)
Removed, no longer in use	6 (n=55)
Never installed	27 (n=265)
	Percent of Sample (n=247)
From On-site Data Collection:	
Installed	37% (n=92)
Removed, no longer in use	6 (n=15)
Never installed	57 (n=140)

to four showerheads. Survey results indicate that participants were equally likely to purchase either one or two showerheads (41 percent reported purchasing one showerhead, 41 percent reported purchasing two). However, a small percentage of participants who lived in multi-unit dwellings reported purchasing five or more showerheads. When all surveyed participants are included, the average number of showerheads purchased was 1.9.

Participants were asked how long they had the low-flow showerhead before they installed it. Using participants' responses to this question, the average elapsed time was calculated across all sampled participants, by type of water heat (gas or electric), and by installation status. The overall average elapsed time between purchase and installation for showerheads currently installed was 1.0 weeks. On average, electric water heat participants took an additional two days to install the purchased showerhead (1.3 weeks *versus* 1.0 weeks for gas water heat participants).

For those participants who reported installing but subsequently removing a showerhead purchased with the retail coupon, the overall average elapsed time between

installation and removal was 5.8 weeks. A small difference was observed between gas and electric water heat participants, where gas water heat customers reported removing the showerhead in about 5.8 weeks, compared to 5.4 weeks for electric water heat participants.

Type and Status of the Preprogram Showerhead Fixture. A key issue for the calculation of a net-to-gross effectiveness ratio in the retail coupon program concerns the showerhead fixture that the program-subsidized low-flow showerhead replaces. To the extent that the new low-flow showerhead replaces an existing low-flow fixture, the net-to-gross ratio is reduced. The sampled participants provided information for each showerhead purchased through the program, including whether the replaced showerhead was low-flow (or had a restrictor) or regular flow. Seventeen percent of all rebated low-flow showerheads were reported to have replaced existing low-flow fixtures. It should be noted that self-reported information regarding the type, or efficiency level, of replaced equipment are likely to include more error than most other self-report data.

Reported Showerhead Purchase Behaviors Without the Program Coupon. The participant telephone survey data were also used to examine other aspects of program impact, including impacts on those customers who report that they would have bought a low-flow showerhead even without the coupon. The program can influence the *number* of showerheads purchased with the coupon (quantity effect), and the number of participants who report purchasing a showerhead *sooner* than they would have (timing effect). Also, information was obtained from those participants who reported that the coupon influenced the *efficiency* of the purchased showerhead (lower gallons-per-minute flow rate).

Combinations of participant responses to the timing and quantity questions yielded six levels of reported purchase behavior without the coupon, as shown in Table 2. These combinations are ordered in this table from "Would not have bought at any time" (maximum program effect on purchase behavior) to "Would have bought showerheads at same time and in same quantity" (minimum program effect). As presented in Table 2, 30 percent of the sampled respondents indicated that without the coupon they would not have purchased any low-flow showerheads at any time. This proportion did not vary by water heat fuel type. At the opposite end of this "program effect" spectrum, 42 percent of the surveyed participants reported that they would have bought the same quantity of low-flow showerheads at the same time. This minimum

Table 2. Reported Purchase Behaviors Without Program Coupon

	<u>Electric Water Heat Participants</u>	<u>Gas Water Heat Participants</u>	<u>Total</u>
Reported Purchase Behavior Without Coupon			
Would not have bought at any time	30%	29%	30%
Would have bought showerhead at same time but would have bought fewer	5	8	8
Would have bought showerheads at later time and fewer of them	4	4	4
Would have bought showerheads at later time but in same quantity	19	7	9
Don't know what effect lack of coupon would have on timing and/or quantity	8	7	7
Would have bought showerheads at same time and in same quantity	34	45	42
Percent Reporting that Coupon Influenced Choice of Showerhead	32%	27%	28%
Of Those Reporting that Coupon Influenced Their Choices, Respondent:			
Purchased lower-flow/more energy efficient showerhead(s) with the coupon	13%	27%	26%
Purchased showerhead(s) with on/off switch	21	30	28
Purchased showerhead with more features (other than on/off switch)	35	18	20
Other	38	36	36

program-effect result did vary by water heat fuel type, with 34 percent of electric water heat participants, compared to 45 percent of gas water heat participants, reporting that the program coupon had no effect on the timing or quantity of their purchase.

All surveyed participants were asked whether the PG&E coupon influenced which low-flow showerhead model(s) (efficiency level) they purchased. Overall, 72 percent reported that the coupon did not affect their low-flow showerhead model selection. However, among the 28 percent who indicated that the coupon did influence their

model selection, about one-fourth said they purchased a more energy-efficient showerhead with the coupon. Slightly more than one-fourth (28 percent) of these same participants said the coupon influenced them to purchase a showerhead with an on/off switch. Thirty-six percent of those who indicated that the coupon influenced their model selection noted "other" reasons, which included: purchase of showerheads of greater overall quality; satisfaction with the lower purchase cost because of the coupon; and that, without the coupon, they probably would not have purchased any showerhead(s).

Surveyed participants were also asked about other low-flow showerheads they had acquired outside the program. Five percent of all surveyed participants indicated that they had received other low-flow showerheads through PG&E, typically through another PG&E program. Fifteen percent of the respondents reported that they had received or purchased low-flow showerheads through vendors other than PG&E. Of those 15 percent of participants, one-fourth said they had acquired the low-flow showerhead through a water utility.

Calculation of a Net-to-Gross Ratio. Five of the self-reported factors described above were employed to calculate a net-to-gross ratio for the program; that is, the fraction of low-flow showerheads for which coupons were redeemed whose installation can be attributed to PG&E's coupon program. These factors were:

1. Was the showerhead installed?
2. Did the program showerhead replace a high-flow showerhead?
3. Is the showerhead currently installed?
4. Did the program affect the timing of the showerhead purchase?
5. Did the program affect the efficiency level (flow-rate) or features of showerhead?

Each of these criteria were applied sequentially to the total number of program showerheads for which sampled participants provided information (n = 965). Table 3 presents the results of these screening steps. The screening criteria with the greatest impact on the net-to-gross ratio are: the proportion of program showerheads initially installed; the proportion of these showerheads that replaced existing low-flow fixtures; and the program (coupon) effect on purchase behaviors. Thirty-one percent of the program showerheads represent the "net" impact of the program. This represents a significant reduction in net-to-gross ratio compared to the earlier program assumption of 75 percent.

Reported Showerhead Purchases by Nonparticipants. An alternative approach for net-to-gross measurement consists of collecting information from nonparticipants (the PG&E random residential sample) concerning showerhead purchases. In particular, the rate of purchase of low-flow showerheads among nonparticipating customers can be interpreted as the base rate of purchasing low-flow showerheads without the program.

Across the surveyed sample of nonparticipants who indicated that they had acquired a showerhead in 1991, 81 percent of the showerheads were either low-flow or had flow restrictors. Interpretation of this self-reported purchase data is not straightforward, however, since

Table 3. A Per-Showerhead Calculation of the Net-to-Gross Ratio: All Showerheads

<u>Screening Criteria</u>	<u>Percent Removed Through Screening</u>
Not installed	18%
Normal replacement	32
Replaced low-flow showerhead	17
Installed and removed	2
Target market	31

California state law requires that all showerheads that are for sale be low-flow.

The rate of showerhead acquisition can be observed in the response rates to surveys conducted with nonparticipants (across both screener and full survey). A total of 576 randomly sampled residential customers completed either the screener alone (n = 461) or the telephone survey (n = 115). Thus, among the 576 customers who were interviewed, 115 customers had acquired at least one showerhead (purchases actually totalled 193 showerheads). This suggests a customer-level showerhead acquisition rate of about 20 percent for the surveyed customers included in the random sample of residential customers.

Results Related to Estimation of Energy Savings Per Program Showerhead

The participant telephone survey data provide responses to questions concerning several key input parameters for the estimation of energy savings attributable to the program showerheads. Among the results presented in this section are participant self-reports of: number of showers taken per person per day, shower duration, and changes in shower usage since installation of the low-flow showerhead. Results from telephone surveys are presented separately for gas and electric hot water heat customers. Additional measurements directly related to per showerhead energy savings were collected during the on-site installation verifications. Among the most important on-site measurements obtained from both participants and nonparticipants were showerhead flow rates, inlet (cold) water and outlet (hot) water temperatures, and total daily showerhead usage (in minutes).

Reported Usage of Installed Low-Flow Program Showerheads by Participants. Information was collected in the telephone interview about each program

low-flow showerhead that participants purchased and installed (up to four showerheads). Responses obtained from the telephone surveys regarding usage of the program showerheads are presented in Table 4. Results of the on-site data collection for showerhead use, flow rates, and water temperatures are shown in Table 5.

Across all installed program showerheads included in the telephone survey data, the average reported number of showers taken per showerhead per day was 1.72. This quantity did not differ significantly by water heat fuel type. On average, 1.65 showers were taken per day for program showerheads installed in electric water heat residences and 1.74 showers were taken per day in gas water heat residences.

Interviewed participants were also asked about the total minutes each program showerhead was in use each day. Table 4 shows an average for total time of usage per showerhead of 12.91 minutes per day. This total usage was 40 percent higher than PG&E's existing assumption regarding usage per showerhead (9.2 minutes). Again, this figure did not vary significantly by type of water heat fuel. When the mean total minutes of use per day (per showerhead) are divided by the average number of showers per showerhead, the average *per shower* duration is 7.5 minutes.

Interviewed nonparticipants who had acquired showerheads during 1991 were also asked about showerhead

Table 4. Usage of Installed Low-Flow Program Showerhead

	<u>Electric Water Heat Participants</u>	<u>Gas Water Heat Participants</u>	<u>Overall</u>
Average Number of Showers Taken per Program Showerhead per Day	1.65	1.74	1.72
Average Total Minutes Program Showerhead Is In Use Each Day	13.22	12.83	12.91
On/Off Switch or Button on Showerhead			
No	62%	47%	49%
Yes	38	53	51
Length of Showers with Low-Flow Showerhead Compared to Old Showerhead			
Showers are same length	75%	71%	72%
Shorter showers	14	24	23
Longer showers	9	4	4
Don't use this shower	0	0	0
Don't know	2	1	1
Amount of Hot Water Used With Low-Flow Showerhead Compared to Old Showerhead, to Get Same Water Temperature			
More hot water	2%	6%	6%
Same amount of hot water	76	58	60
Less hot water	22	36	34
Changed Temperature Setting on Hot Water Heater Since Installing Low-Flow Showerhead(s)			
No	93%	92%	92%
Yes, hotter	1	1	1
Yes, colder	6	7	7

Table 5. On-site Data Collection Results Related to Estimation of Energy Savings

	<u>Participant Program Showerheads</u>	<u>Participant Nonprogram Showerheads</u>	<u>Nonparticipant Showerheads</u>
Average Number of Showers Per Showerhead per Day	1.65 (n=120)	1.47 (n=121)	1.20 (n=221)
Average Total Minutes Showerhead is in Use Each Day	12.65 (n=120)	12.11 (n=121)	10.44 (n=221)
Average Number of Showers Taken per Day per Person	.78 (n=263)	.84 (n=214)	.80 (n=333)
Average Length of Shower per Person (Minutes)	7.17 (n=257)	7.47 (n=213)	8.30 (n=332)
Flow Rate--Full Throttle (Gallons per Minute)	2.26 (n=126)	2.97 (n=116)	3.25 (n=208)
Flow Rate--Customer-Throttled	1.75 (n=126)	2.08 (n=115)	2.44 (n=206)
Cold Water (Inlet) Temperature (°Fahrenheit)	63.0° (n=161)		63.5° (n=139)
Hot Water (Outlet) Temperature (°Fahrenheit)	135.3° (n=161)		133.5° (n=139)

usage. Results for nonparticipants were quite similar to participants: they reported an average usage of 13.24 minutes per day per showerhead.

Another showerhead characteristic that can affect usage of hot water is the presence of an on/off switch or button on the low-flow showerhead. It is important to note that, overall, about one-half (51 percent) of the program showerheads had an on/off switch. Showerheads purchased by gas water heat participants were somewhat more likely to have this feature (Table 4).

Other important factors related to the hot water savings realized through program low-flow showerheads are any changes (since replacement of the old showerhead) in: typical shower duration, amount of hot water used to

obtain the desired water temperature, and changes in temperature settings to the customer's water heater. Table 4 presents additional findings by water heat fuel type for these possible changes.

Almost three-fourths of the currently installed program showerheads are used for showers of the same duration as the old showerhead. Twenty-three percent of these showerheads are reportedly used for shorter showers compared to the old showerhead. Only 4 percent, on average, of these showerheads are used for longer showers. There were only small differences by water heat fuel type.

The amount of hot water used with the program low-flow showerheads was perceived to be somewhat *less* compared

to the old showerhead. Thirty-four percent of the currently installed program showerheads are perceived by customers to be using less hot water than the replaced showerhead, perhaps primarily attributable to the on/off switch feature present in about one-half of these low-flow showerheads. There was a tendency for gas water heat participants to perceive comparatively less hot water use than was perceived by electric water heat participants. For 60 percent of the program showerheads, it seemed that the same amount of hot water was used.

A small percentage of participants with currently installed program showerheads stated that they had changed the temperature setting on the water heaters since installing the showerhead (8 percent). Among those changing this setting, 7 out of 8 reported *reducing* the temperature setting.

On-Site Data Collection Results. Results obtained from the on-site data collection for showerhead usage, flow rates, and inlet/outlet water temperatures are presented in Table 5. The daily showerhead use and flow rate results are broken out by three showerhead categories: (1) program participant showerheads purchased with a coupon; (2) program participants' showerheads not acquired through the coupon program; and (3) nonparticipant showerheads. The inlet/outlet water temperature results are presented by participant *versus* nonparticipant households.

The on-site interviews included data collection specific to each showerhead in the household. For example, responses to the number of people using a shower fixture, the number of showers they take per day, and the average duration of these showers were all linked to specific shower fixtures. As shown in Table 5, an average number of 1.65 showers per day were taken with program showerheads. This compares to an average number of 1.47 showers per day with participants' nonprogram showerheads, and an average number of 1.20 showers per day among nonparticipant shower fixtures.

The total use of participants' program showerhead(s) per day was, on average, 12.65 minutes. This contrasts with 12.11 average daily minutes for participants' nonprogram showerhead(s) and 10.44 minutes for nonparticipants' showerhead(s).

A critical parameter to calculations of energy savings attributable to the program low-flow showerheads is the measurement of flow rates. As indicated above, the nonparticipant on-site data were used to estimate the pre-installation (i.e., preprogram) flow rate condition, while the participant data provide post-installation (of the

program low-flow showerhead) flow rates. When these pre- and post-installation flow rates are combined, the change in flow rate attributable to the program showerhead can be inferred. This change in flow rate is one of the most important determinants of program energy savings.

As with daily showerhead use, Table 5 presents flow rate results for three categories of showerhead fixtures: (1) program participant showerheads purchased with a coupon; (2) program participant showerheads not acquired through the coupon program; and (3) nonparticipant showerheads. In addition, two flow rate measurements were obtained. First, the shower water controls were set at full throttle (i.e., both hot and cold sources at maximum settings) for a flow rate measurement. Next, the flow rate was measured with the shower controls adjusted by the household member present for the on-site visit. Though clearly imperfect as a surrogate for the shower control adjustment made by *each* member of the household, it is a useful approximation.

The average flow rate for program participant showerheads purchased with a coupon was 2.26 gallons per minute (GPM) at full throttle. An average flow rate of 1.75 GPM was found for the customer-adjusted setting. In contrast, the average nonparticipant showerhead flow rates were 3.25 GPM at full throttle, and 2.44 GPM at the customer-adjusted (throttled) setting. The differences, then, between average participant program showerhead and nonparticipant showerhead flow rates are .99 GPM (full throttle) and .69 GPM (customer-throttled). It is the customer-throttled flow rate measurement that is used in calculation of program energy savings, since this is more likely to simulate actual hot water use.

Additional results in Table 5 indicate that participants' nonprogram showerhead flow rates are 2.97 GPM and 2.08 GPM for full throttle and customer-throttled, respectively. As expected, these average flow rates are higher than the participants' program showerhead rates, but lower than nonparticipants' average showerhead flow rates. It is likely that the average flow rate difference between participants' nonprogram showerheads and nonparticipants' showerheads represents a self-selection effect, i.e., a difference between program participants and nonparticipants that reveals a tendency toward previous conservation actions by participants. Another factor in this difference may relate to water characteristics and consequent clogging of showerhead fixtures. It may be that participants have to change fixtures more frequently than nonparticipants, resulting in lower flow rates for their nonprogram showerheads.

The differences between full throttle and customer-throttled flow rates varied slightly across the showerhead categories. The throttled adjustment represented a reduction in average flow rate of .51 GPM (23 percent) for participants' program showerheads, .89 GPM (30 percent) for participants' nonprogram showerheads, and .81 GPM (25 percent) for nonparticipants' showerheads. Current PG&E assumptions for the amount of throttled setting, obtained from the American Water Works Association, suggests a 33 percent adjustment from full throttle.

Water temperatures obtained from the on-site data collection were very similar across the sample participant and nonparticipant groups, and very close to the current PG&E assumptions. For participants, cold water (inlet) temperatures averaged 63.0 degrees (Fahrenheit), and hot water settings averaged 135.3 degrees. For nonparticipants, the average cold water temperature was 63.5 degrees, and the hot water averaged 133.5 degrees (all Fahrenheit).

Conclusions

Results from this research were used to conduct PG&E's post-program estimation of the impacts of the retail coupon program. PG&E estimates the program savings using engineering methods, with separate computations for the retail coupon and direct installation programs and for gas and electric water heating. The key parameters in the savings calculations can be grouped into two categories: (1) program-specific assumptions related to a net-to-gross ratio; and (2) engineering values for energy consumption of both normal and low-flow showerheads. Conclusions from this research that affect parameters in each of these categories are presented below.

Changes to Program Assumptions For A Net-To-Gross Ratio

The net-to-gross ratio for participants in the retail coupon program has been assumed by PG&E to be 75 percent. The reasoning for this parameter estimate is that some of these participants (about 25 percent) are expected to replace an existing energy saver showerhead with the low-flow showerhead obtained with the retail coupon.

As reported in the Results section, several factors related to a net-to-gross ratio were considered in this evaluation. These included telephone survey results regarding the location of the program showerhead (with respect to PG&E's service area), installation rate and persistence, type and condition of replaced showerhead, and program impacts on purchase behaviors. Predictably, the inclusion

of additional factors in a net-to-gross ratio calculation tended to depress this ratio significantly. This ratio was calculated at 31 percent based on the self-reported telephone interview data.

Presumably, self-reported installation, location, and showerhead replaced information are fairly accurate. To the degree that participants are good at introspecting about their likely purchase behaviors, results for the hypothetical questions about purchase behavior without the program are also useful and informative. However, one important limitation of the self-report approach is that participants may not be able to accurately judge their likely choices in the absence of the program. This is particularly a problem where the range of efficiency levels presented to customers in the retail market has been constrained, as it has in California for purchases of showerheads.

Changes to Engineering Assumptions for Per Showerhead Savings

The savings calculations used by PG&E identify several key parameters: shower flow rates, average shower frequency and duration, inlet and outlet water temperatures, etc. Values for many of these parameters were estimated in a nationwide survey of water fixture use sponsored by the U.S. Department of Housing and Urban Development and reported in 1984 by Brown and Caldwell. A number of these key assumptions are used in the handbooks of the American Water Works Association, and are cited by PG&E as the source for several parameter estimates used for energy saver showerhead savings calculations.

The research reported here employed two approaches: telephone surveys and on-site inspections. Results from both approaches were used to recommend changes to the existing program energy- savings calculations.

With respect to average per showerhead daily use, the results of the telephone surveys suggest that the current assumption of 9.2 minutes (per showerhead per day) is too low by about 40 percent. A value of 12.9 minutes per showerhead per day was indicated in the telephone survey results.

For the change in flow rate attributable to the program low-flow showerhead, PG&E is currently assuming a pre-to post-retrofit difference of 1.125 gallons per minute (GPM). Results from the on-site data collection conducted with participant and nonparticipant households indicates that this average difference is .69 GPM at a customer-throttled flow setting. This is a reduction from the assumed change in flow of about 39 percent. It should be noted, however, that the on-site flow rate results are not

based on representative samples of all participants and nonparticipants (as are the telephone survey data). They are based on purposive samples that employed criteria for selecting four PG&E divisions that would be as representative as possible. Households were then randomly selected within these four divisions.

This reduction in flow rate change is offset to some extent by increased shower durations compared to the current

PG&E assumption. As indicated above, the average per showerhead daily use as calculated from participants' telephone survey data was 12.9 minutes. The on-site results suggested very similar average per showerhead use, at 12.7 minutes per day. This acts to increase the gallons of water used per program showerhead and, thus, also increases the associated energy savings attributable to the low-flow showerhead.