PUGET SOUND ENERGY
The Energy To Do Great Things

2010 Gas Storage Water Heater Evaluation Documents

Contents:

This document contains both the final **2010 Gas Storage Water Heater Evaluation** and the Puget Sound Energy (PSE) **Evaluation Report Response** (ERR) to this evaluation. PSE program managers are required to complete an ERR upon completion of an evaluation of their program. The ERR addresses and documents pertinent adjustments in program metrics or processes subsequent to the evaluation.

Impact Evaluation of the PSE Efficient Hot Water Heater Program

Program Years 2005 - 2007

Madison, Wisconsin, June 16, 2010

Table of Contents

Table of Contents

List of Exhibits:

1. Executive Summary

This report provides an impact evaluation of the Puget Sound Energy (PSE) Efficient Hot Water Heater Program for the years 2005 through 2007.

1.1 Program Summary

The PSE Efficient Hot Water Heater Program provides incentives to PSE customers to install an ENERGY STAR® water heater with a minimum efficiency factor (EF) of .62. PSE estimates that the increase in efficiency provides savings of 18 therms annually. The program markets itself through the PSE website and relies on contractors informing customers of the availability of rebate for the installation of a more efficient water heater.

Over the three years evaluated in this report, the program rebated over 4,500 water heaters. The vast majority of water heaters installed were at the minimum efficiency threshold for the program. The majority of units had a tank size of 50 gallons giving the program as a whole, an average tank size of 48.2 gallons.

1.2 Evaluation Overview

This evaluation uses a billing analysis approach to estimate savings for the efficient water heater program. A billing analysis approach allows us to base our savings estimates on observerd consumption data on customer bills.

As a preface to the billing analysis approach we develop preliminary engineering estimates of programs saving. This exercise provides a useful reference point with respect to expected savings. More importantly, it provides a useful introduction into the framework within which savings are estimated with a billing analysis approach.

In addition to estimates of unit savings, we also estimate a free ridership percentage. This is an estimate of what percent of the participant savings would have happened in the absence of the program.

1.3 Results and Conclusions

This impact evaluation derived savings estimates for the PSE water heater program in multiple ways. The findings all point to expected savings well below the program estimate of 18 therms. The combined effect of all of these results points to a maximum expected savings of 10 therms. Table 6-1 summarizes the results reported for this evaluation.

Table 1-1
Savings Estimates Summary

Result	Savings
Preliminary Engineering	15.1
Preliminary Engineering, net of Free Riders	4.8
Billing Analysis, point estimate	0
Billing Analysis, 76 Percent Confidence	<=10

Preliminary engineering estimates indicate maximum potential savings of 15.1 therms given the level of baseload gas consumption observed in the samples. Any increase in baseline efficiency level above standard, minimum efficiency or any increase in post installation demand for hot water (take-back), both expected outcomes, would lower this estimate.

KEMA developed an estimate of free ridership percentage designed to be applied to a standard baseline estimate of savings. The survey based result indicates that 68 percent of the savings generated by the program would have happened without the program. The free ridership estimate can be applied to the preliminary estimate of savings because which is savings estimate based on a standard efficiency baseline. It provides an estimate of net savings of only 4.8 therms.

The billing analysis approach compared participant to non-participant savings related to the installation of a new water heater. The difference represents an estimate of participant savings relative to the observed non-participant baseline installation. This is the most relevant estimate of savings for a program of this type. The estimate of savings is effectively zero. Despite a relatively low precision due to small non-participant sample size we can still say with 75 percent confidence that the interval below ten therms includes the true estimate of savings. Alternatively, we can say there is only a 25 percent chance that the range above 10 therms includes the true savings.

This billing analysis estimate takes into account the natural installation efficiency level in the PSE population. It does not, however, take into account the self selection of likely installers of efficient units into the program. Accounting for this kind of free ridership would further lower this estimate of savings.

These estimates of savings provide consistent evidence that the expected savings for the PSE water heater program is well below the program estimate of 18 therms. The billing analysis approach, the most direct measure of savings, indicates a maximum reasonable estimate of annual savings at 10 therms.

1.4 Recommendations

1.4.1 Program Recommendations

The results reported here for the PSE Efficient Water Heater Program provide some evidence that PSE is operating in an increasingly transformed water heater market in PSE territory. Survey data indicates that most contractors discuss energy efficient options with their customers and that a large number of both participant and non-participants start the water heater buying process looking for an energy efficient unit. Combine this with a relative low incremental cost for the ENERGY STAR® units, the already existing strong brand recognition for the ENERGY STAR® products in general, and the modest rebate and you have many of the necessary conditions for a high free ridership for program participants and a high level of naturally-occurring baseline efficiency for non-participants.

As further evidence that the market has adapted to the program parameters, the program tracking indicates that almost all participants installed the minimum qualifying efficiency when they took part in the program. A program that offered higher incentives and required a unit with a higher level of efficiency would generate program attributable savings and push market players to include still higher efficiency units in the selection of water heaters they offer.

1.4.2 Evaluation Improvements

Billing data is a challenging form of data to work with. For a water heater evaluation, the challenge is increased because expect water heater savings are small enough that they can be lost in the natural variation in the data. PSE may have the capability to provide daily bill data for evaluations of this sort. These data will improve the modeling that decomposes consumption into baseload and heating load. They will also give a much better picture of data anomalies

allowing for a cleaner analysis. Making these data available for evaluations as soon as feasible is the single most important step PSE can take to the evaluations of its programs.

2. Introduction

This report provides an impact evaluation of the Puget Sound Energy (PSE) Efficient Hot Water Heater Program for the years 2005 through 2007.

2.1 Program Summary

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Over the three years evaluated in this report, the program rebated over 4,500 water heaters. The vast majority of water heaters installed were at the minimum efficiency threshold for the program. The majority of units had a tank size of 50 gallons giving the program as a whole, an average tank size of 48.2 gallons.

2.2 Evaluation Overview

This evaluation uses a billing analysis approach to estimate savings for the efficient water heater program. A billing analysis approach allows us to base our savings estimates on observer consumption data on customer bills.

As a preface to the billing analysis approach we develop preliminary engineering estimates of programs saving. This exercise provides a useful reference point with respect to expected savings. More importantly, it provides a useful introduction into the framework within which savings are estimated with a billing analysis approach.

In addition to estimates of unit savings, we also estimate a free ridership percentage. This is an estimate of what percent of the participant savings would have happened in the absence of the program.

All three of these aspects of the evaluation are explained in depth in section 3, the Analysis Approach section. Section 4 introduces all the data used for the analysis. Included in this section is a discussion of how the participant and non-participant samples were developed. Section 5 provides the results of the analysis. Section 6 provides conclusions. There are four

appendices: technical methodology, participant and non-participant survey instruments and a full set of survey results.

3. Analysis Approach

This section provides an overview of the methods used to develop preliminary engineering estimates and the billing analysis approach estimates. These two approaches are linked by a common underlying framework. The preliminary engineering estimates are included both to provide a reference point with respect to savings and to illustrate the analysis framework. This section also presents the methodology for calculating the free ridership percentage.

A more complete explanation of the billing analysis methodology is provided in Appendix A.

3.1 Preliminary Engineering-Based Savings Estimates

The first step KEMA took for this evaluation was to establish a preliminary engineering-base estimate of savings. These estimates are similar to PSE program tracking savings estimates, and they provide a clear context within which additional evaluation steps take place. In particular, the structure of the underlying engineering equation is central to the evaluation process. The relatively simple application of assumptions that produce the preliminary savings estimate provide a useful starting place from which to build the rest of the analysis. The final estimates of savings incorporate real world data and address a variety of issues raised by the preliminary savings estimates.

For a tank-type water heater program, a preliminary estimate of potential savings can be calculated with assumptions regarding water heater efficiency and consumption. If we assume that the demand for hot water does not change as a result of the newly installed water heater, energy savings is a only a function of the change in efficiency from a baseline unit to the to the efficient model.

3.1.1 Engineering Equation

The engineering equation for calculating gas savings from a water heater efficiency gain is:

$$Gas\ Savings = ((EF_q - EF_b)/EF_q)\ X\ Baseline\ Water\ Heater\ Consumption$$

Where

EF_q = *Energy factor of the qualifying energy efficient water heater.*

EF_b = *Energy factor of the baseline water heater*

The water heater program, provided by Puget Sound Energy, promotes the installation of a gas water heater with a minimum efficiency of .62. For participants in the program, the average

installed water heater efficiency over the 2005 to 2007 program years was slightly above the minimum acceptable level for the program, at EF=0 .622. This efficiency is used for the energy factor for the qualifying unit.

3.1.2 Input Assumptions

Baseline efficiency represents the level of efficiency that would have been installed by participants in the absence of the program. This information is unknown for participants so it is common to use federal or state efficiency standards for calculations of energy savings. Standard efficiency represents an estimate of the minimum acceptable efficiency that would have been installed outside of the program. Federal standards set in 2004 mandated minimum efficiencies of EF= .575 for water heaters. For the purpose of the preliminary savings estimate, this efficiency is used for the baseline energy factor of water heaters installed between 2005 and 2007 in the PSE service territory that were not installed with the assistance of PSE's water heater program.

In this equation, baseline water heater consumption represents the annual therms used to meet hot water demand by a water heater at the baseline efficiency level. The US Energy Information Administration provides an estimate of water heat consumption for the Pacific West at 240 therms[1]. This estimate represents average consumption at the average existing water heater efficiency level, not the appropriate baseline level of efficiency. Average existing water heater efficiency will be below the standard. Also, this estimate is not specific to the Pacific Northwest.

The billing data collected for the sample of participants provides a more refined. The participant billing data provide an estimate of pre-installation gas baseload (including other non-space heat consumption like cooking) for the sample of participants. It is estimated at only 232 therms. This indicates that the EIA estimate of water heater load may be too high for the relevant population of program participants. In fact, based on the EIA ratio of water heater to baseload consumption, this would put participant pre-program water heat consumption as low as 159 therms[2]. For the preliminary savings estimate, we will split the difference and use 200 therms as the estimate of baseline water consumption for units with standard efficiency.

[1] Energy Information Administration, Office of Energy Markets and End Use, Forms EIA-457 A, B, C of the 2005.

[2] EIA water heater consumption is 69 percent of the EIA non-heating load for the Pacific West.

A preliminary engineering based energy savings estimate, using the baseline federal standard efficiency (EF=0.575), a high efficiency water heater rated at EF=0.622, a water heat load of 200 therms, and the energy calculation methods described above, produces potential savings of 15.1 therms.

3.2 Billing Analysis Approach

The preliminary energy savings calculation explained above provides a simplified, first pass at estimated program savings. A full evaluation is necessary because many of the assumptions underlying the calculation can be substantially different in reality. Changes in these assumptions can result in very different calculated savings.

3.2.1 Addressing Input Assumptions

For the preliminary savings estimate, only the efficiency of the installed unit is known for certain because the program collected these data. Two important assumptions need to be considered:

1. What level of water heater efficiency would have been installed in the absence of the program; that is, baseline efficiency.

2. Does demand for hot water increase after the installation of the more efficient, program-qualified water heater. This is relative to demand for hot water from the water heater that would have been installed without assistance from the program; that is, take-back.

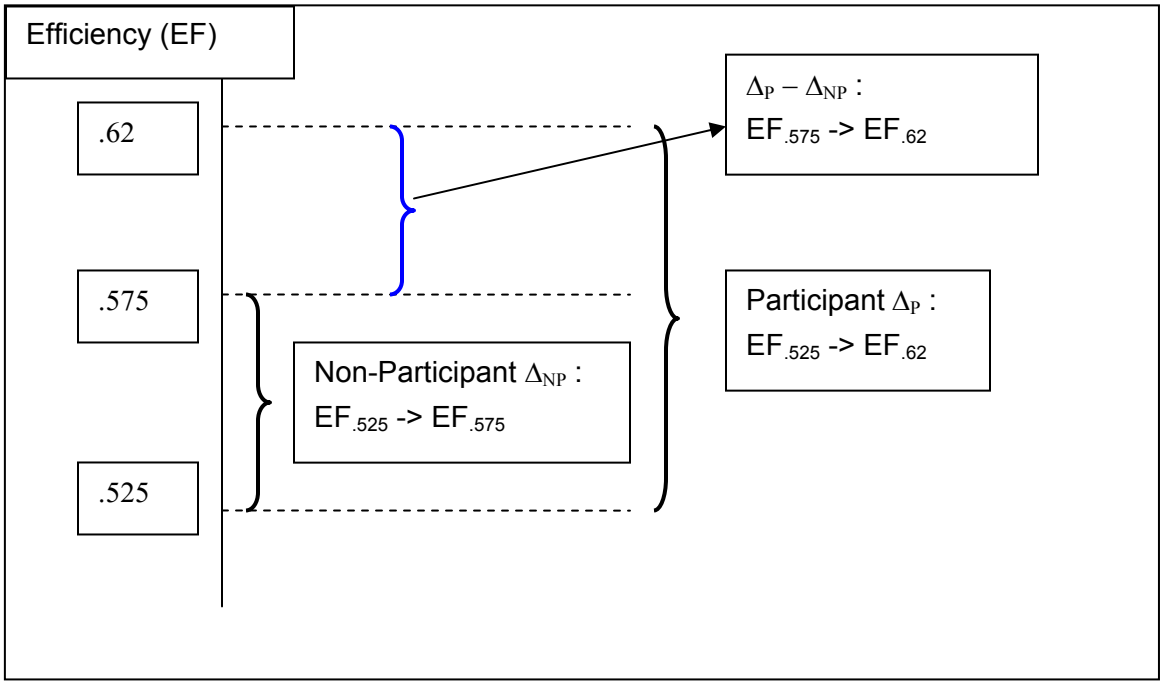
Neither of the above assumptions can be observed or measured directly. Furthermore, in both cases, it's reasonable to assume that the distribution of possible input values for these assumptions would tend to move savings estimates down. Because standard efficiency is a minimum allowable efficiency level, for instance, baseline efficiency can only be at that level or higher. With regards to take-back, economic theory tells us that demand for hot water is more likely to increase with decrease in effective price (higher efficiency) than to go the other way.

Therefore, we analyze the change in customer bills from before and after installing new water heater to estimate savings based on observed consumption. We compare the change in consumption for program participants with the change in consumption for non-participants who installed a new water heater but did not get a rebate from the PSE efficient water heater program. The results derived from the bill data will account for any differences in baseline and demand for hot water that could affect the level of savings.

3.2.2 Analysis Framework

Figure 3-1 provides an illustration of how participant and non-participant consumption can be compared to estimate the savings for program participants. To simplify this example we continue to work with the same basic assumptions that underlie the preliminary estimate of savings. In addition to the assumption that non-participants install standard efficiency, there is the assumption that the existing units are at EF=.525, the minimum standard efficiency during the decade prior to 2004.

Figure 3-1
Billing analysis Approach Example



The figure has three elements:

Participant delta, Δ_p -- The change in consumption in participant bills reflects the change in efficiency from their existing unit which is assumed to be at an EF of .525 to their new unit, which is at an EF=0.62. This difference is spanned by the large bracket.

Non-participant delta, Δ_{np} -- The change in consumption in non-participant bills reflects the change in efficiency from their existing unit (EF of .525) to the efficiency of their new unit, which we continue assumed is standard efficiency of EF = 0.575. This difference is spanned by the lower left bracket.

Participant savings relative to baseline, $\Delta_P - \Delta_{NP}$ -- the difference between the participant and non-participant differences represents the change in consumption between the program qualifying level of efficiency and the level of efficiency at which non-participants installed. Still maintaining the simplifying assumption that non-participants install at exactly standard efficiency, the efficiency difference is .575 to .62.

Table 3-1 provides the therms for each delta. The estimate of participant savings net of non-participant savings is the same as the preliminary estimate of savings calculated earlier.

Table 3-1
Preliminary results in Billing Analysis context

Group	Baseline Usage	Percent	Difference in Therms
Participant EF_b -> EF_q	219	16%	34.2
Non-participant EF_b -> Ef_s	219	9%	19.0
Participant, Net EF_s -> EF_q	200	8%	15.1

Figure 3-1 lays out the strategy for using billing data to estimate program savings.

3.2.3 Input Assumption Outcomes

It is useful to do a kind of sensitivity analysis on the assumptions underlying the preliminary estimate of savings using Figure 3-1. In both cases, if the assumptions are wrong, there is a higher probability the inputs would move in one direction rather than the other. This has clear implications for whether savings are likely to be higher or lower than the preliminary estimates indicate.

The assumption of minimum standard efficiency as a baseline is more likely to be too low than too high. Code-level efficiency is a minimum standard. Water heaters with efficiencies below EF=.575 could still be in the market because they remained in inventory more than a year after the change of standard. While this may be the case is some instances, it is very unlikely enough lower efficiency units would be installed to move the average baseline below the .575 level.

On the other hand, non-participants might install at a level higher than standard efficiency. This would increase the difference in consumption between their existing unit and their replacement unit. This would, in turn, increase the “baseline” to which participant change in consumption is compared, shrinking the estimate of participant savings relative to non-participants. It is a

common concern that the natural replacement efficiency level is higher than minimum code-based standards, thus decreasing the resulting savings.

A second observed concern for programs is take-back. For this program, because of the higher efficiency of participant water heaters, a gallon of hot water is less expensive for participants than it was prior to participation in the program. Economic theory explains that the decrease in price should increase participant demand for hot water. An example would be a participant who says, “now that I have an energy efficient water heater, I can afford to take the longer showers I love”. Take-back of some level is expected for a program like this.

In the participant bills, this increase in demand will counteract the effect of the increased efficiency on consumption. For any given level of efficiency-related savings, an increase in demand will lower those savings. Once again the effect will be to decrease the resulting estimate of savings.[3]

Looking at the assumptions underlying the preliminary estimate of savings, it appears likely that these savings estimates may be inflated. The billing analysis results will reflect the actual savings, taking into consideration both baseline and take-back.

3.2.4 Framework Assumptions

For the billing analysis framework to be effective, the non-participant group has to be considered a good comparison group for the participants. Non-participants should be similar with respect to baseline demand for hot water and baseline efficiency level. In addition, with regards to the purchase of the new water heater, we must consider non-participants a reasonable indication of what participants would have done in the absence of the program.

3.2.4.1 Efficiency and Demand

When using billing data measuring consumption, it is impossible to separate demand and efficiency. We observe consumption levels but we do not generally know existing unit efficiencies let along demand for hot water. Higher demand for hot water with higher efficiency would be indistinguishable from lower demand with lower efficiency.

[3] The figure is scaled in efficiency so does not directly illustrate an increase in demand for hot water after installation. With respect to consumption, an increase in demand has the same effect as lowering the efficiency. Ultimately, take back has the effect of lowering expected savings.

In general, that participants and non-participants are similar is challenged by the idea of self-selection. This theory tells us that the characteristics of participants (observed or unobserved) can be correlated with aspects of the household and water heater that affect consumption or water heater efficiency. By the very fact of having chosen to take part in the program, participants are different than non-participants. This can lead to selection bias.

Unfortunately, the offending characteristics may be observed or unobserved. This means that, while we can control for house size, for instance, there may be some other unobserved characteristic that is correlated with a characteristic important to the estimation of savings like baseline efficiency or demand and that difference could lead to biased estimates.

Techniques have been developed that claim to address self-selection bias but whether they solve the problem is debated among practitioners. Despite this, it is the accepted approach to control for as many characteristics and otherwise assume that self-selection bias will be small could affect the results in either direction. That is what we will do for this evaluation.

A sensitivity analysis across varying demand and efficiency scenarios indicates that results are more sensitive to the relationship between participant and non-participant existing unit efficiencies. In the billing analysis framework, variation in demand for hot water will have an approximately proportional effect on savings. Differences in existing unit efficiency have a much more dramatic effect on results. This is a fortunate result for this evaluation, as a difference in existing unit efficiency between the two populations would appear less likely than differences in hot water demand.

3.2.4.2 Appropriateness of Baseline

There is always a great deal of discussion in the program evaluation field regarding gross versus net savings. The primary savings result provided for this evaluation fall in between these two approaches. Our approach is not similar to the most common definition of gross savings because the baseline is not minimum standard efficiency. On the other hand, the results provided here are not fully net savings estimates either. The non-participant based baseline does reflect the non-participant willingness to install greater than minimum standard efficiency without a rebate. The final savings result does not, however, account for participants who would have installed relatively higher average efficiency without the rebate. We would expect this kind of marginal free ridership behavior among participants.

3.2.5 Site-level Modeling

The specific modeling approach used for this analysis we refer to as two-stage site-level modeling. In the first stage, we develop individual site-level models of heating and base load. This model disaggregates gas consumption into baseload and temperature correlated loads for each home in the sample. A primary purpose of this kind of modeling is to develop an overall estimate of normalized annual consumption. In this case, because the water heater load is primarily in the base load, the model results is left in disaggregate form, providing a separate estimate of baseload along with heating load.

Separate models were performed for the pre- and post-installation periods providing separate estimates of average base load for the two periods. The difference was calculated for each household.

Using the household level deltas from the site level modeling, we estimated a second stage regression equation to capture the average effect of installation on gas consumption for participants, non-participants. Finally, a combined model provides estimates of the difference between the change in consumption between participants and non-participants which represents the program's effect. This modeling approach replicates with observed gas consumption data, the analysis framework shown in Figure 3-1.

A full technical discussion of the approach is in Appendix A.

3.3 Free Ridership

For this evaluation, KEMA has developed an estimate of free ridership for participants in the efficient water heater program. The free ridership percentage represents the percentage of the savings estimate that is not attributable to the program. A free ridership estimate of this sort is most appropriate applied to an estimate of savings based on savings relative to standard efficiency. With this approach, the standard efficiency baseline represents the minimum level of efficiency and includes no considerations of any non-program related tendency to install greater than standard level efficiency. Applying the free ridership to savings calculated in this fashion assures that there is not double counting of the customer behaviors that lower attribution to the program.

By contrast, the approach we use for our primary estimate of savings compares participant to non-participant savings. The measure of savings calculated in this way includes some, but not all, of customer behavior that represents free ridership. This approach should provide a very

conservative measure of free ridership, and has the advantage of not relying on the self-report based free ridership percentage. It is not appropriate to apply the free ridership estimate to this estimate of savings.

The self-report based free-ridership estimate, then, provides

- A free ridership estimate that could be applied to the preliminary estimate of savings, or
- Important general support for the savings estimate.

3.3.1 Self-report Free Ridership Approach

Free-ridership is based on participant survey results. It combines a measure of awareness free-ridership and incentive free-ridership. The two measures are combined weighted by the importance of the awareness and incentive in the decision process for the participants themselves. This approach is loosely adapted from approaches used for California evaluations.

The questions used to ascertain awareness and incentive free-ridership are provided in Table 3-2.

Table 3-2
Free Ridership Questions

Awareness	Q25 Before you started considering replacing your water heater, were you aware that some models were significantly more energy efficient than others?
	Q26 When working with your contractor, plumber or supplier to obtain your new water heater which statement was most true?
Incentive	Q27 On a 0 to 10 scale, with 0 being not at all likely and 10 being very likely, how likely is it that you would have purchased . . the same or an equally efficent water heater (a less efficient water heater) if you had not received a <rebate amount> rebate from Puget Sound Energy?
Awarenes vs Incentive Weight	Q28 Consider how important any awareness and education provided by PSE or by your contractor, plumber or supplier was to your decision compared to the <rebate amount> rebate from PSE: Choose the number between 0 and 10 that best describes the importance of each of these factors.

The equation used for putting together the free ridership components is

$$Final\ FR = FR_A*(1-w) + FR_I*w$$

Where

FR_A is awareness free ridership on a percentage basis

FR_I is incentive free ridership on a percentage basis

w is the awareness vs incentive weight

4. Data

For this evaluation, we analyzed the bills of random samples of program participants and non-participants. This section provides the details of how the samples were selected.

4.1 Billing Data

PSE provided billing data for all program participants and a random sample of over 100,000 non-participants. KEMA identified the subset of all billing data that was suitable for evaluation. There are a number of data issues that make an individual billing series unsuitable. They include bad read types, issues with read dates and long billing periods. Table 4-1 provides the account counts as we removed problematic billing series. While a substantial number of accounts are removed from analysis, they are removed from both the participant and non-participant populations. There is no reason to believe that the removal of these data negatively affects the evaluation. On the other hand, the inclusion of these accounts would introduce a great deal of additional variation into the final results.

Table 4-1
Billing Data Preparation

Account Status	Accounts Remaining	
	Participants	Non-participants
Billing data provided	3,925	106,738
Zero or nonuse removed	3,924	106,322
Missing readtypes - Indcates unusual billing data	3,918	106,006
Series with gaps greater than 3 days removed -- Removes series with longterm overlapping period that cannot be put on a monthly basis	3,324	78,388
Series with negative usage and billl periods > 100 days removed	2,940	60,170

4.2 Tracking Data

KEMA also identified the participants who were suitable for inclusion in the billing analysis. There were three issues to address in the tracking data:

- **Participants without savings.** A small number of entries in the participant database were assigned no savings. These accounts were left out of the analysis altogether

- **Multiple units installed.** Fewer than two percent of participants installed multiple units during the three years of program. These households can be difficult to integrate into a billing analysis framework. In addition, the goal of the analysis is to estimate the savings related to the replacement of a single water heater. For this reason, we did not include these units in our analysis sample. We did include them in our total counts of program units.
- **Occupancy Issues**. Billing analysis requires a minimum number of bill reads from before and after installation for the occupant who installed the new water heater. In addition, to complete a survey, the occupant needs to still reside at the same address. The combination of these two issues caused a substantial number of participant accounts to be removed from the analysis.

Table 4-2 provides the counts of accounts removed for the reasons discussed above.

Table 4-2
Participant Tracking Data Preparation

Account Status	Accounts Affected	Accounts Remaining (Entries)	Units
Tracking Count of Participants		4509	4560
zero or negative savings	14	4495	4546
Muliple WH installed, same day	51	4444	4444
Muliple WH installed, different days	21	4399	4399
Occupancy issue -- Too little pre-installation occupancy, change in occupant, etc	976	3423	3423

4.3 Weather Data

PSE maintains weather station data that map to all its customers. These data were provided to KEMA for this evaluation. The appropriate weather station data are merged with the billing data. The weather data, in daily degree day form are used in the modeling process to control for variability in consumption due to weather.

4.4 Survey Sample

The final sample frame was composed of all of the participants with both tracking and billing data that could be used in the analysis and as many of the non-participants with good billing

data as could be contacted within the budget for surveying. KEMA used a mail and internet based survey approach for both the participant and non-participant surveys. Performing the surveys in this way has several advantages:

- **KEMA controls aspects of the data gathering process otherwise in the hands of a survey house** – The recipients received a letter from KEMA on company letterhead, which immediately established the authenticity of the survey. Mail-in and internet survey options were made available at the respondents' choice. Data collected both on mail-in surveys and the internet surveys were collected by trained KEMA personnel.
- **The recipient controls the survey response process** -- The survey is completed at the convenience of the recipient. This allows recipients to take the necessary time to respond, take breaks, and/or gather additional information from other household members if necessary. We believe reading written survey questions increases recipient comprehension compared to telephone interviews performed by survey houses. We believe this results in higher quality survey response data and a higher response rates.
- **Cost --** Mail / Internet surveys can be completed at a cost comparable or below the cost of surveys performed by survey houses.

Table 4-3 provides the sample disposition for the participant and non-participant survey samples. The participant survey got a good response. Because the implementation dates for participants were known and were during the years 2005 through 2007 a relatively small percentage of accounts were lost due to date and modeling issues.

Table 4-3
Survey Sample Disposition

Account Status	Participants	Non-participants
Letters Mailed	2,568	6,432
Total Respondents	877	875
Replaced a water heater	877	174
Confident replacement date	797	158
Minimum of 9 pre and post installation readings, site-level model Rsquare > .7	722	74

The Non-participant response fell below expectations. The initial response rate was lower than expected. A portion of households that said they installed a water heater were unable to provide a reasonable date. As there is not tracking data for non-participants, this is essential. Finally, the final modeling approach required a minimum amount of post installation data and a disproportionate number of units were said to be installed in mid 2009 or later.

While the non-participant sample size is lower than might be desirable, the primary effect on the results is greater variability around the estimates of savings. The non-participant variability drives the combined results, meaning the ultimate estimate of participant savings has a relatively wide confidence interval. Importantly, though, despite this lower precision, it is still possible to come to reasonably strong conclusions about the savings generated by the program.

4.5 Sample Representation

The most important aspect of the analysis samples is whether the non-participant sample represents a similar population to the participants. The characteristics that are important are consumption and those household characteristics that relate to consumption. As discussed above, demand for hot water and efficiency of both existing and replacement units would be the ideal points of comparison, but these characteristics are either impossible to know (demand for hot water) or notoriously difficult to collect (non-participant water heater size or efficiency). Table 4-4 provides a comparison of the available and important characteristics for the two samples.

Table 4-4
Participant and Non-participant Characteristics

Characteristic	Participants (n=724)	Non-participants (n=76)
Pre-Installation Normalized Annual Consumption	941	929
Pre-Installation Annual Baseload Consumption	232	233
Square footage	2,193	2,226
Number of Occupants	2.41	2.42

The consumption and household statistics are all extremely close between the two samples. The differences are within three percent and none of them are statistically significant. Despite this, we will control for occupancy.

5. Results

5.1 Billing Analysis Results

The site-level modeling approach individually measures the change in consumption for participants and non-participants from before and after installation a new water heater. We estimate an average change in consumption for participants and non-participants and then compare them as discussed in section 3.2.5. To deal with the possible effects of the economic downturn we limited estimates of post installation consumption to 2009 bills for both participants and non-participants. This means both estimates include whatever change in consumption might have taken place as a result of the economic downturn. That is, both estimates of savings could be increased due to lower consumption motivated by the economic downturn, but the effect should be approximately the same for both participants and non-participants. Table 5-1 presents these results.

Table 5-1
Per Unit Savings Estimates from Billing Analysis

Group	Savings	Standard Error	Confidence Interval	
Participant	28.6	4.0	+/-	6.5
Non-participant	28.7	14.6	+/-	24.4
Participant, from Non-participant Baseline	-0.1	14.2	+/-	23.6

Both participants and non-participant showed similar reductions in consumption corresponding with the installation of the water heater at 28.6 and 28.7 respectively. Both estimates are individually statistically significant at a 90 percent confidence level. We're 90 percent confident that true participant savings fall between 21.2 and 35.2. We're 90 percent confident that non-participant savings fall between 4.4 and 53.1 therms. The wider confidence interval for the non-participants is a function of the smaller sample size.

The difference between participant and non-participant savings is less than a therm. This is the relevant estimate of savings for the program – participant savings relative to a non-participant baseline. This result is not statistically significantly different than zero. In this case, the statistical significance indicates that there is no reason to believe participant savings relative to non-participants were different than zero. There is another way to look at the results using the statistical distribution that is more useful. The distribution tells us that we can be 76 percent

confident that true participant savings relative to a non-participant baseline falls below 10 therms.

5.2 Free Ridership Results

5.2.1 Awareness Free Ridership

The free-ridership analysis starts with a two part assessment of participant awareness of energy efficient options. The first question relates to general knowledge of energy efficient options prior to starting the process of buying the water heater. Table 5-2 provides the results for this question from the survey. Only 13 percent of respondents who provided an answer to the question indicated they were not aware of differing levels of efficiency; 78 percent said they were aware of different levels of efficiency from some source. This free-ridership estimate is for the PSE water heater program, so the source of awareness, PSE or some other source, is not important to the free-ridership estimate. However, of those who were aware of different levels of efficiency, exactly half said they gained that knowledge from the PSE and half from some other source.

Table 5-2
Pre-Program Awareness Question

Q25 Before you started considering replacing your water heater, were you aware that some models were significantly more energy efficient than others?	N	Percent	Awareness
Don't know	72	8%	DK
No	116	13%	No
Yes, from sources OTHER than PSE	340	39%	Yes
Yes, through information from PSE	340	39%	Yes
All	868	100%	

The PSE efficient water heater program primarily works through contractors. Thus, the second part of the awareness measure, revolves around the role of the contractor in helping make the decision to go efficient. Table 5-3 shows the results of question 26 which sought to understand how contractors discussed the options for water heater purchasers. The largest fraction of participants, 33 percent, said they actually started the process looking for an efficient water heater. For the remainder, the majority said contractors discussed both standard and energy efficient water heaters, while 13 percent said their contractors only discussed energy efficient water heaters.

Table 5-3
Program Assistance Question

Q26 When working with your contractor, plumber or supplier to obtain your new water heater which statement was most true?	N	Percent	Program Assistance?
Don't Know	96	12%	DK
I started out looking for an energy efficient water heater	268	33%	No
My contractor, plumber or supplier discussed standard and energy efficient water heaters	263	32%	Yes
My contractor, plumber or supplier never discussed energy efficient water heaters	66	8%	No
My contractor, plumber or supplier only discussed energy efficient water heaters	104	13%	Yes
All	797	100%	

For the purpose of the awareness index, the essential question is whether contractors played a role in steering a participant to an efficient water heater. In this case, we will consider any contractor that discussed energy efficient water heaters (by themselves or along with standard water heaters) to have helped motivate the energy efficient purchase. On the other hand, we do not give the contractor any credit for motivating the purchase either when the participant started the purchase process looking for an energy efficient unit or did not discuss energy efficiency with the contractor. In this case, we leave the “don’t know” answers intact because there are certain combinations between the two questions that override a single “don’t know” answer.

Table 5-4 provides the awareness free ridership index. The index assigns free ridership levels between a low of 0.1 and a high 1.0 depending on the combination of Questions 25 and 26. The assignments attempt to be generous to the program with regard to giving credit for this aspect of the participation.

Table 5-4
Awareness Free Ridership

Awarenes (Q25)	Program Assistance (Q26)	N	Percent		Awareness Free Ridership
DK	DK	87	8.37		-
No	DK	39	3.75		0.1
No	Helped	54	5.19		0.1
No	No help	45	4.33		0.1
Yes	DK	70	6.73		0.5
Yes	Helped	374	35.96		0.5
Yes	No help	371	35.67		1

If participants indicated they had no awareness of the different levels of efficiency prior to starting the process, we assume the program deserves almost all the credit for motivating the energy efficient purchase. For all respondents who answered “No” on Questions 25, free ridership is a low 0.1.

If there was evidence of awareness prior to starting the process but, in addition, the contractor discussed energy efficiency, we still give 50 percent credit to the program on the awareness free ridership index. We even give 50 percent credit when the answer was “don’t know” on the second question.

Only for the participants who started out with awareness and there is no evidence the interaction with the contractor increased that interest, do we give the highest free ridership level of one. These assigned awareness levels aggregate to an average awareness free-ridership index of 0.67.

5.2.2 Incentive Free Ridership

The second part of the free ridership estimate relates to the importance of the incentive. To ascertain the importance of the incentive, we asked what they would have done if they had not received the incentive. We asked the question in two different ways to avoid bias with regards to the structure of the question. Table 5-5 provides the separate results and the overall incentive free ridership estimate.

Table 5-5
Incentive Free Ridership

Incentive Free Ridership	N	0 to 10 Average
On a 0 to 10 scale, with 0 being not at all likely and 10 being very likely, how likely is it that you would have purchased . . if you had not received a <rebate amount> rebate from Puget Sound Energy?		
the same or an equally efficient water heater (10=FR)	427	8.2
a less efficient water heater (0=FR)	443	3.2
Average Incentive Free Ridership (10=FR)	870	7.5

The question was structured identically for all participants. They both asked the likelihood of an action in the absence of the incentive. However, half were asked if they would have done the same thing without an incentive while the other half was asked if they would have done something less efficient without the efficient. A participant that would have been very likely (10) to purchase the same efficiency was a free rider. A participant would have been very unlikely (0) to purchase a less efficient unit was a free rider. The overall average incentive free ridership

puts both questions on the same scale where 10 is free rider. The result is an average incentive free-ridership estimate of 7.5; or in percentage terms, 75 percent.

5.2.3 Combined Free Ridership

The awareness and incentive free-ridership estimates are combined using a weighting that reflects the relative importance on each factor according to the participants themselves. The question asks the relative importance of awareness or incentive for motivating the choice of an efficient unit. Table 5-6 provides the question, how the answers were structured and the results.

Table 5-6
Relative Importance of Awareness vs. Rebate

Consider how important any awareness and education provided by PSE or by your contractor, plumber or supplier was to your decision compared to the <rebate amount> rebate from PSE: Choose the number between 0 and 10 that best describes the importance of each of these factors.	N	ColPctN
0 - The awareness and education was everything	101	15%
1	33	5%
2	46	7%
3	66	10%
4	53	8%
5 - The awareness/education and the rebate were equally important	230	35%
6	33	5%
7	24	3%
8	32	4%
9	13	2%
10 - The rebate was everything	15	2%
Average awareness-rebate weight		3.8

The average result was 3.8 indicating that the awareness portion of the process was more important than the incentive. For the purpose of weighting the awareness and incentive free ridership estimates, this means awareness free ridership estimate receives a weight of 0.62 compared to a weight of 0.38 for the incentive free ridership estimate.

The final, combined estimate of free ridership is 68 percent. This indicates that 68 percent of participant savings from a standard efficiency baseline would have taken place in the absence of the program. It is appropriate to apply this free ridership estimate to the preliminary savings estimate of 15.1 therms. This gives an estimate of net savings of 4.8 therms.

5.2.4 Non Participant Survey Results

For this evaluation, the free-ridership calculation will stand alone as an indication of free-ridership for the program rather than being applied to savings estimate. This is because the savings estimate calculated for this evaluation already accounts for non-participant purchase of greater than standard efficiency units. The application of the free-ridership would potentially double count that tendency to purchase greater than standard efficiency water heaters.

Given the result that participants effectively provide no additional savings over what non-participants are installing, it is important to look at what non-participant said about their water heater purchase. Where appropriate, we asked the same questions of non-participants as those for participants.

The first awareness question was asked of both groups, and the results were almost identical. Table 5-7 provides the two groups' results side by side. Awareness of different levels of efficiency was statistically identical between the two groups.

Table 5-7
First Awareness Question Results for Non-participants and Participants

Q25 Before you started considering replacing your water heater (see Q7, above), were you aware that some models were significantly more energy efficient than others?	Non participants		Participants	
	N	Percent	N	Percent
Don't know	13	8%	72	8%
No	20	12%	116	13%
Yes, from sources OTHER than PSE	68	43%	340	39%
Yes, through information from PSE	57	36%	340	39%
All	158	100%	868	100%

We also asked non-participants about their interactions with contractors. Table 5-8 gives the non-participant results beside the participant results. The expectation would be that non-participants received less information or guidance with respect to energy efficiency, especially as contractors could use the program incentive as a selling point. In fact, this is the case. The non-participants group of purchasers who were never told about energy efficient water heaters is more than twice as large on a percentage basis as the participant group. Fewer non-participants received information on both efficient and standard units than participants as well.

Table 5-8
Second Awareness Question Results for Non-participants and Participants

Q26 When working with your contractor, plumber or supplier to obtain your new water heater which statement was most true?	Non-participants		Participants	
	N	Percent	N	Percent
Don't know	14	9%	96	12%
I started out looking for an energy efficient water heater	49	33%	268	33%
My contractor, plumber or supplier discussed standard and energy efficient water heaters	37	25%	263	32%
My contractor, plumber or supplier never discussed energy efficient water heaters	27	18%	66	8%
My contractor, plumber or supplier only discussed energy efficient water heaters	18	12%	104	13%
All	145	100%	797	100%

The remaining results in the table are more important. Interestingly, a similar percentage of households were talked to about energy efficient water heaters exclusively. This does not necessarily indicate that these non-participant household bought energy efficient water heaters but it does indicate that there are either contractors who only offer energy efficient water heaters or that these non-participants went for an efficient unit without much consideration of a standard unit. This is supported by the final and most surprising result from this question. An identical percentage of non-participants said they “started out looking for an energy efficient water heater”. This result indicates that a constant third of the population starts out looking for an energy efficient water heater. Once again, this does not necessarily mean the non-participants ultimately purchased an efficient unit. However, it does point to a surprisingly high level of interest in energy efficiency even by those who do not ultimately take advantage of the program’s incentives.

The remaining question did not parallel the participant survey questions. We asked non-participants directly what kind of unit they purchased. The results in Table 5-9 indicate that greater than 50 percent believed they purchased an efficient water heater, either a tankless or

energy star version[4]. Responses to this kind of question may not be entirely reliable. Respondents may say, for instance, that they installed an Energy Star unit even if they did not. The results, however, leave open the possibility that a relatively large percent of non-participants purchased efficient water heater.

Table 5-9
Kind of Unit Purchased by Non-participants

Q27. When you purchased the water heater, did you buy . . .	N	Percent
A tankless water heater	14	10%
An ENERGY STAR© tank-type water heater	55	42%
Other or Don't know	28	21%
Some other kind of gas water heater	33	25%
All	130	100%

In combination, these non-participant survey results provide concrete evidence that the natural baseline efficiency for Puget Sound may be substantially above standard efficiency.

[4] The non-participant sample was designed to exclude participants from the PSE tankless water heater rebate program as well as the efficient (tank-type) water heater program under evaluation here.

6. Conclusion

This impact evaluation derived savings estimates for the PSE water heater program in multiple ways. The findings all point to expected savings well below the program estimate of 18 therms. The combined effect of all of these results points to a maximum expected savings of 10 therms. Table 6-1 summarizes the results reported for this evaluation.

Table 6-1
Savings Estimates Summary

Result	Savings
Preliminary Engineering	15.1
Preliminary Engineering, net of Free Riders	4.8
Billing Analysis, point estimate	0
Billing Analysis, 76 Percent Confidence	<=10

Preliminary engineering estimates indicate maximum potential savings of 15.1 therms given the level of baseload gas consumption observed in the samples. Any increase in baseline efficiency level above standard, minimum efficiency or any increase in post installation demand for hot water (take-back), both expected outcomes, would lower this estimate.

KEMA developed an estimate of free ridership percentage designed to be applied to a standard baseline estimate of savings. The survey based result indicates that 68 percent of the savings generated by the program would have happened without the program. The free ridership estimate can be applied to the preliminary estimate of savings because which is savings estimate based on a standard efficiency baseline. It provides an estimate of net savings of only 4.8 therms.

The billing analysis approach compared participant to non-participant savings related to the installation of a new water heater. The difference represents an estimate of participant savings relative to the observed non-participant baseline installation. This is the most relevant estimate of savings for a program of this type. The estimate of savings is effectively zero. Despite a relatively low precision due to small non-participant sample size, we can still say with greater than 75 percent confidence that the interval below ten therms includes the true estimate of savings. Alternatively, we can say there is only a 25 percent chance that the range above 10 therms includes the true savings.

This billing analysis estimate takes into account the natural installation efficiency level in the PSE population. It does not, however, take into account the self selection of likely installers of efficient units into the program. Accounting for this kind of free ridership would further lower this estimate of savings.

These estimates of savings provide consistent evidence that the expected savings for the PSE water heater program is well below the program estimate of 18 therms. The billing analysis approach, the most direct measure of savings, indicates a maximum reasonable estimate of annual savings at 10 therms.

6.1 Recommendations

6.1.1 Program Recommendations

The results reported here for the PSE Efficient Water Heater Program provide some evidence that PSE is operating in an increasingly transformed water heater market in PSE territory. Survey data indicates that most contractors discuss energy efficient options with their customers and that a large number of both participant and non-participants start the water heater buying process looking for an energy efficient unit. Combine this with a relative low incremental cost for the ENERGY STAR® units, the already existing strong brand recognition for the ENERGY STAR® products in general, and the modest rebate and you have many of the necessary conditions for a high free ridership for program participants and a high level of naturally-occurring baseline efficiency for non-participants.

As further evidence that the market has adapted to the program parameters, the program tracking indicates that almost all participants installed the minimum qualifying efficiency when they took part in the program. A program that offered higher incentives and required a unit with a higher level of efficiency would generate program attributable savings and push market players to include still higher efficiency units in the selection of water heaters they offer.

6.1.2 Evaluation Improvements

Billing data is a challenging form of data to work with. For a water heater evaluation, the challenge is increased because expect water heater savings are small enough that they can be lost in the natural variation in the data. PSE may have the capability to provide daily bill data for evaluations of this sort. These data will improve the modeling that decomposes consumption into baseload and heating load. They will also give a much better picture of data anomalies

allowing for a cleaner analysis. Making these data available for evaluations as soon as feasible is the single most important step PSE can take to the evaluations of its programs.

Appendix A: Methodology overview

The billing analysis approach used for this evaluation was a site-level modeling approach. This is a two step approach. The first step models each household's pre- and post-installation consumption data individually as a function of weather variables. This modeling produces an optimal decomposition of gas consumptions into baseload and heating load. The difference between the pre- and post-installation baseload represents that change in gas consumption caused by the installation of the new water heater. We run a second set of regressions combining all of the pre-post deltas and controlling for occupancy. The participant and non-participant regressions provide an estimate of the change in consumption between the pre- and post- installation periods for participants. The combined regression provides an estimate of the difference between participant and non-participant change in consumption. This latter result represents the best estimate of savings for efficient gas water heater program.

Site-level Modeling

In the first step of the analysis, we use the model shown in Equation 1 to disaggregate gas consumption for space heating from base load consumption for each site. The heating consumption billing regression uses linear regression to model daily average consumption as a function of heating degree days. The equation is:

$$E_{im} = \mu_i + \beta_H H_{im}(\tau_H) + \varepsilon_{im} \quad \text{Equation 1}$$

where

E_{im}	=	Therms used per day during month *m* for customer *i*;
$H_{im}(\tau_H)$	=	Average heating degree-days at the heating base temperature τ_H during month m, based on daily average temperatures, for customer i's meter reading period;
μ_i	=	baseload consumption estimate for customer i;
β_H	=	Heating coefficient, determined by the regression;
τ_H	=	Heating degree-day base temperature, determined by choice of the optimal regression; and
ε_{im}	=	Regression residual.

In this equation, gas consumption is a function of an intercept which represents baseload (μ_i) and average daily HDD, $H_{mi}(\tau_H)$, which correlates with heating consumption. Monthly bill readings divided by the number of days in the billing period provide the daily therm consumption, represented by E_{im}. Average daily degree days for the billing period are calculated by dividing the sum of daily HDD in the billing period by the number of days in the billing period. Because we obtained monthly consumption data by bill period, and not all customers are on the same bill cycle, heating degree-days for a given month vary among customers.

The intercept μ_i can be understood as base load consumption. This variable captures household-specific, non-degree day correlated gas consumption that occurs across all time periods. Non-heating gas consumption can include water heat, cooking and other gas appliances.

In order to identify the best fit for the weather adjustment components of the model, we tested the specification above using a range of potential degree day bases. This approach effectively estimates the average outdoor temperature at which the heating system turns on for each included household. We selected the degree day base that yielded the highest R^2 value. If the optimal model included a heating parameter estimate that was not statistically significant, we removed the heating term and re-optimized. For the gas model, if the heating trend is not found to be statistically significant, household load is characterized by the average daily load across the available bills.

The site-level degree day regression parameters are usually used to provide an estimate of normalized consumption using normalized annual degree days based on the chosen site-specific, optimal degree day base. Equation 2 shows the calculation for normalized annual consumption.

$$NAC_i = \mu_i * 365 + \hat{\beta}_H \widetilde{H}_i(\tau_H) \qquad \textbf{Equation 2}$$

where

NAC_i = Normalized annual electric consumption for customer *i*;

$\widetilde{H}_i(\tau_H)$ = Normal annual heating degree-days calculated at the heating base temperature τ_H of customer i;

$\hat{\beta}_H$ = Heating parameter estimate from the site level models.

The two individual components of Equation 2 are the decomposed estimates of baseload and normalized in that order. As the data entering the regression is all on a daily average basis, μ_i is multiplied by 365 to put the baseload estimate on an annual basis.

Second Stage Model

The first stage, site-level modeling was done for each household and done separately for pre- and post-installation periods. The delta between the pre- and post-installation estimates of baseload represents the savings for that household.

The second stage regressions are all a variant on Equation 3. The full Equation 3 specification, compares the participant delta (change in consumption) to the non-participant delta. The regression controls for the number of occupants in each household. Despite the fact that the participant and non-participant samples are almost identical with respect to number of occupants in the household, this is a way to control for potential differences in the distribution of occupants relative to savings.

$$\Delta NAB_{it} = \lambda_1 + \lambda_2 OCC_i + \lambda_3 P_i + \lambda_4 OCC_i * P + \varphi_1 T_i + \varphi_2 OCC_i * T_i + \varphi_3 P_i * T + \varphi_4 OCC_i * P * T_i + \varepsilon_{im}$$

Equation 3

where

ΔNAB_i	=	The change in annual baseload consumption for customer *i* from the pre- to post-installation period;
OCC_i	=	Number of Occupants for customer I;
P_i	=	An indicator variable equal to zero for non-participants and one for participants
T_i	=	An indicator variable equal to one for households with some major change in consumption during analysis period (change out furnace, add addition etc), zero otherwise.
$\lambda_1, \lambda_2, \lambda_3, \lambda_4$	=	Non-participant coefficients, determined by the regression;
$\varphi_1, \varphi_2, \varphi_3, \varphi_4$	=	Participant difference coefficients, determined by the regression;
ε_{im}	=	Regression residual.

If the Equation 3 regression us run on only participants or only non-participants, then all of the components with participant indicator variable (P_i) will drop out and the results will reflect the change in consumption for just the group that is included in the regression. This is how separate estimates for participant and non-participant average savings were generated.

The final estimate of the difference between participants and non-participants in the change in consumption is calculated with the following Equation 4.

$$\Delta\Delta NAB_{it} = \hat{\lambda}_1 + \hat{\lambda}_2 \overline{O}CC_i + \hat{\lambda}_3 P_i + \hat{\lambda}_4 \overline{O}CC_i * P$$

Equation 4

where

$\Delta\Delta NAB_i$	=	The difference in participant ΔNAB_i *compared to non-participant* ΔNAB_i
$\overline{O}CC_i$	=	Average number of Occupants for participants;
P_i	=	The indicator variable equal to one to identify the participant difference.
$\hat{\lambda}_1, \hat{\lambda}_2, \hat{\lambda}_3, \hat{\lambda}_4$	=	Parameter estimates from Equation 3
P_i	=	The indicator variable equal to one to identify the participant difference.

Appendix B: Puget Sound Energy Participant Survey Instrument

Puget Sound Energy

Residential Participant Survey – High Efficiency Water Heaters

Survey Code (From Letter In Bold):	
Name:	
Address:	
City, State Zip:	

Q1. According to our records, a tank-type high efficient gas water heater was installed at this address, on or shortly before <Install Date>. Regarding this installation, which of the following is true?

- ○ A high efficiency water heater was installed and someone at this address received the rebate.
- ○ A high efficiency water heater was installed but someone else received the rebate.
- ○ A high efficiency water heater was installed but no one received a rebate.
- ○ A new water heater was installed and that is all I know for sure.
- ○ No water heater of any kind was installed at this address.
- ○ I received a rebate for a high efficiency water heater just not for this address.

Please stop here and return survey to us

- ○ A rebated tankless water heater was installed at this address.

Q2. Was the water heater installed on or shortly before < Install date>?

○ Yes ○ No, when was it installed _____ ○ Don't know

Q3. Is the new water heater still installed and working?

○ Yes
○ Don't know

Go to Q5

○ No, what happened to it? _____
_____

Q4. When was it removed/did it stop working? _____ ○ Don't know

Q5. The rebated water heater…

○ replaced another gas water heater
○ replaced an electric water heater

Go to Q6

○ was installed in addition to an existing gas water heater.
○ was installed in a new house
○ Other _____

Go to Q11

○ Don't Know

Q6. Approximately how old was the water heater that was replaced?

- ○ 0 to 5 years
- ○ 6 to 15 years
- ○ 16 to 25 years
- ○ More than 25 years
- ○ Don't Know

Q7. Why did you replace your old water heater?

- ○ It was leaking
- ○ It was no longer working properly
- ○ It was undersized
- ○ I wanted something more efficient
- ○ It stopped working
- ○ It became unsafe to operate
- ○ Other _____
- ○ Don't Know

Q8. Before the installation, did you go without hot water?

○ No
○ Only a few days ○ Up to a week
○ More than a week ○ Don't know

Q9. Is the new water heater the same size as the water heater it replaced?

○ Yes } **Go to Q11**
○ Don't know
○ No

Q10. Is it bigger or smaller? ○ Bigger ○ Don't Know ○ Smaller

Q11. Have you changed the temperature setting since it was installed?

○ Made it hotter ○ Made it cooler
○ Still where the contractor set it ○ Don't know

Q12. How does the hottest water you can get from the tap compare with the previous water heater?

○ About the same ○ Hotter
○ Not as hot ○ Don't know

Q13. Do you have a second water heater?

○ Yes, a gas one } **Go to Q14**
○ Yes, something other than gas
○ No
○ Don't know } **Go to Q17**

Q14. Have you made any changes to your other water heater in the last five years?

○ Yes, replaced it
○ Yes, changed the temperature setting } **Go to Q15**
○ Yes, turned it off
○ No,
○ Don't Know } **Go to Q17**

Q15. Do you think your hot water use increased, decreased, or stayed the same as a result of these changes?

○ Increased ○ Decreased ○ Stayed the same ○ Don't know

Q16. What month and year did these changes occur? _____ ○ Don't know

Q17. What is the square footage your home (no garage or unfinished basement)? _____ sf

Q18. What type of home do you live in?

○ Single-family detached ○ 5 or more unit building
○ Mobile home ○ Don't know
○ 2, 3, or 4-unit building

Q19. Including yourself, how many people live in your home at least 6 months of the year? _____

Q20. Have you replaced a gas furnace in the last 5 years?

○ Yes
○ No } **Go to Q22**
○ Don't Know

Q21. What month and year did this replacement occur? _____ ○ Don't know

Q22. Have you made any other major changes in the last 5 years that would've affected your gas use? Check the change you think would have had the **greatest** effect on gas usage.

○ Insulation or Windows ○ Other _____
○ Gas Clothes Dryer ○ No major changes to gas use. → **Go to Q25**
○ Gas Cooking Equipment ○ Don't know → **Go to Q25**
○ Number of occupants

Q23. As a result of this change, has your gas use increased, decreased, or stayed the same?

○ Increased ○ Decreased ○ Stayed the same ○ Don't know → **Go to Q25**

Q24. What month and year did this change occur? _____ ○ Don't know

Q25. Before you started considering replacing your water heater (see Q7, above) were you aware that some models were significantly more energy efficient than others?

○ Yes, through information from PSE
○ Yes, from sources other than PSE
○ No
○ Don't Know → **Go to End**

Q26. When working with your contractor, plumber or supplier to obtain your new water heater which statement was most true?

○ My contractor, plumber or supplier **never** discussed energy efficient water heaters.
○ My contractor, plumber or supplier discussed standard and energy efficient water heaters.
○ My contractor, plumber or supplier **only** discussed energy efficient water heaters.
○ I started out looking for an energy efficient water heater.
○ Don't Know → **Go to End**

Q27. On a 0 to 10 scale, with 0 being not at all likely and 10 being very likely, how likely is it that you would have purchased the same or an equally efficient water heater if you had not received a <rebate amount> rebate from Puget Sound Energy?

○ 0 ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10
○ Don't know

Q28. Consider how important any awareness and education provided by PSE or by your contractor, plumber or supplier was to your decision compared to the <rebate amount> rebate from PSE: Choose the number between 0 and 10 that best describes the importance of each of these factors.

○ 0 The awareness and education was everything
○ 1
○ 2
○ 3
○ 4
○ 5 The awareness/education and the rebate were equally important
○ 6
○ 7
○ 8
○ 9
○ 10 The rebate was everything

○ Don't know

ALT. On a 0 to 10 scale, with 0 being not at all likely and 10 being very likely, how likely is it that you would have purchased a less efficient water heater if you had not received a <rebate amount> rebate from Puget Sound Energy?

Appendix C: Puget Sound Energy Residential Water Heater Survey Instrument

Puget Sound Energy

Residential Water Heater Survey

Survey Code (From Letter In Bold):	
Name:	
Address:	
City, State Zip:	

Q29. Have you purchased a gas water heater for installation at this address, between January 2007 and the present?

○ Yes ○ No. ○ Don't know. } **Go to End**

Q30. When did you install the new water heater?

○ installation month _____ year _____ ○ Don't know → **Go to End**

Q2A The date of installation is critical to a study we are doing. Would you say that you are pretty confident that the installation took place during that month or within one month on either side of it?

○ Yes ○ No. ○ Don't know. } **Go to End**

Q31. Is the new water heater still installed and working?

○ Yes ○ Don't know } **Go to Q5** ○ No, what happened to it? _____ _____

Q32. When was it removed/did it stop working? _____ ○ Don't know

Q33. The water heater…

○ replaced another gas water heater ○ replaced an electric water heater } **Go to Q6**

○ was installed in addition to an existing gas water heater. ○ was installed in a new house } **Go to**

○ Other _____ **Q11**
○ Don't Know

Q34. Approximately how old was the water heater that was replaced?

○ 0 to 5 years
○ 6 to 15 years
○ 16 to 25 years
○ More than 25 years
○ Don't Know

Q35. Why did you replace your old water heater?

○ It was leaking
○ It was no longer working properly
○ It was undersized
○ I wanted something more efficient
○ It stopped working
○ It became unsafe to operate
○ Other _____
○ Don't Know

Q36. Before the installation, did you go without hot water?

○ No
○ Only a few days
○ More than a week
○ Up to a week
○ Don't know

Q37. Is the new water heater the same size as the water heater it replaced?

○ Yes } **Go to Q11**
○ Don't know } **Go to Q11**
○ No

Q38. Is it bigger or smaller? ○ Bigger ○ Don't Know ○ Smaller

Q39. Have you changed the temperature setting since it was installed?

○ Made it hotter
○ Still where the contractor set it
○ Made it cooler
○ Don't know

Q40. How does the hottest water you can get from the tap compare with the previous water heater?

○ About the same
○ Not as hot
○ Hotter
○ Don't know

Q41. Do you have a second water heater?

○ Yes, a gas one } **Go to Q14**
○ Yes, something other than gas } **Go to Q14**
○ No } **Go to Q17**
○ Don't know } **Go to Q17**

Q42. Have you made any changes to your other water heater in the last five years?

○ Yes, replaced it } **Go to Q15**
○ Yes, changed the temperature setting } **Go to Q15**
○ Yes, turned it off } **Go to Q15**
○ No, } **Go to Q17**
○ Don't Know } **Go to Q17**

Q43. Do you think your hot water use increased, decreased, or stayed the same as a result of these changes?

○ Increased ○ Decreased ○ Stayed the same ○ Don't know

Q44. What month and year did these changes occur? _____ ○ Don't know

Q45. What is the square footage your home (no garage or unfinished basement)? _____ sf

Q46. What type of home do you live in?
○ Single-family detached
○ Mobile home
○ 2, 3, or 4-unit building
○ 5 or more unit building
○ Don't know

Q47. Including yourself, how many people live in your home at least 6 months of the year? _____

Q48. Have you replaced a gas furnace in the last 5 years?

○ Yes ○ No } **Go to Q22**
○ Don't Know }

Q49. What month and year did this replacement occur? _____ ○ Don't know

Q50. Have you made any other major changes in the last 5 years that would've affected your gas use? Check the change you think would have had the **greatest** effect on gas usage.

○ Insulation or Windows
○ Gas Clothes Dryer
○ Gas Cooking Equipment
○ Number of occupants
○ Other _____
○ No major changes to gas use. → **Go to Q25**
○ Don't know → **Go to Q25**

Q51. As a result of this change, has your gas use increased, decreased, or stayed the same?

○ Increased ○ Decreased ○ Stayed the same ○ Don't know → **Go to Q25**

Q52. What month and year did this change occur? _____ ○ Don't know

Q53. Before you started considering replacing your water heater (see Q7, above), were you aware that some models were significantly more energy efficient than others?

○ Yes, through information from PSE ○ No
○ Yes, from sources other than PSE ○ Don't Know → **Go to End**

Q54. When working with your contractor, plumber or supplier to obtain your new water heater which statement was most true?

○ My contractor, plumber or supplier **never** discussed energy efficient water heaters.
○ My contractor, plumber or supplier discussed standard and energy efficient water heaters.
○ My contractor, plumber or supplier **only** discussed energy efficient water heaters.
○ I started out looking for an energy efficient water heater.
○ Don't Know → **Go to End**

Q55. When you purchased the water heater, did you buy . . .

○ an ENERGY STAR© tank-type water heater?
○ a tankless water heater
○ some other kind of gas water heater ○ other or Don't know

Q56. Were you aware that there was a rebate available from PSE if you purchased an ENERGY STAR© tank-type water heater?

○ Yes → **Go to End** ○ No

Q57. If you purchased a non- ENERGY STAR© tank-type water heater, on a scale of 0 to 10 where 0 is not very likely and 10 is very likely, how likely is it that a $40 rebate would have convinced you to purchase an ENERGY STAR© tank-type water heater?

○ 0 ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10
○ Don't know

Appendix D:

p1	part 1		All
	N	ColPctN	N
A high efficiency water heater was installed and someone at this address received the rebate.	595	68 %	595
A high efficiency water heater was installed but someone else received the rebate.	6	0 %	6
A high efficiency water heater was installed but no one received a rebate.	111	12 %	111
A new water heater was installed and that is all I know for sure.	158	18 %	158
All	870	100 %	870

Q3	part				
	0		1		All
	N	ColPctN	N	ColPctN	N
A ceramic filter in the burner plugged up and the burner could not get adequate oxygen. We had it replaced, under warranty, with another high energy efficiency unit. It cost $423 to replace it.	.	.	1	0 %	1
Don't know	.	.	7	0 %	7
Yes	170	100 %	861	99 %	1031
All	170	100 %	869	100 %	1039

Q5 The water heater	part				All
	0		1		
	N	ColPctN	N	ColPctN	N
Don't know	1	0 %	26	2 %	27
not sure if gas or electric, but was replacing a 10 year	1	0 %	.	.	1
replaced an electric water heater	16	9 %	40	4 %	56
replaced another gas water heater	150	88 %	799	91 %	949
was installed in a new house	1	0 %	.	.	1
was installed in addition to an existing gas water heater	1	0 %	4	0 %	5
All	170	100 %	869	100 %	1039

Q6 Approximately how old was the water heater that was replaced?	part				All
	0		1		
	N	ColPctN	N	ColPctN	N
0 to 5 years	13	7 %	20	2 %	33
16 to 25 years	39	23 %	238	28 %	277
6 to 15 years	95	57 %	478	56 %	573
Don't know	8	4 %	81	9 %	89
More than 25 years	11	6 %	22	2 %	33
All	166	100 %	839	100 %	1005

Q7 Why did you replace your old water heater?	part				All
	0		1		
	N	ColPctN	N	ColPctN	N
10 years old-time to replace	.	.	1	0 %	1
A plumbing leak required the removal & reinstallation of the water heater so we decide to buy a new one.	.	.	1	0 %	1
A water heater at condominium unit failed indicating others installed at same time were close to failing.	.	.	1	0 %	1
Age	1	0 %	1	0 %	2
Age - approximately 10 years old	.	.	1	0 %	1
Age - worried it would fail; condo association offered a group deal to replace	.	.	1	0 %	1
Aging	.	.	1	0 %	1
As a safety precaution	.	.	1	0 %	1
Because furnace was also being replaced and water heater installation required furnace removal	.	.	1	0 %	1
Changed from electric to natural gas	1	0 %	.	.	1
Changed to hydronic heat	1	0 %	.	.	1
Concerned it may fail and better efficiency	.	.	1	0 %	1
Concerned it might leak due to age	1	0 %	.	.	1
Condo Association recommended	.	.	1	0 %	1
Converted to direct vent to outdoors	.	.	1	0 %	1
Converted to gas	1	0 %	.	.	1
Corroded	.	.	1	0 %	1
Did not want to rent anymore	.	.	1	0 %	1

Q7 Why did you replace your old water heater?	part				All
	0		1		
	N	ColPctN	N	ColPctN	N
Don't know	1	0 %	11	1 %	12
Exceeded expected lifespan	.	.	1	0 %	1
Had entire house repaired, so a good time to replace an old waterheater with something more efficient	.	.	1	0 %	1
Heard that it should be replaced when it is 12-15 years old or it may leak	.	.	1	0 %	1
Homeowners Board of Directors highly recommended replacement of water heaters for all units to prevent possible water damage.	.	.	1	0 %	1
I thought it was leaking - turned out it was just at the inlet fitting at top	1	0 %	.	.	1
I wanted something more efficient	20	12 %	114	13 %	134
I wanted something more efficient and getting old	.	.	1	0 %	1
I wanted something more efficient and starting to have problems with pilot light going out	.	.	1	0 %	1
I wanted something more efficient; getting old	1	0 %	.	.	1
I wanted something more efficient; it was very old	1	0 %	.	.	1
I wanted something more efficient; stuff was coming out of the heater	1	0 %	.	.	1
I wanted to replace before I had a problem (12 year old heater) and get something more energy efficient.	.	.	1	0 %	1
I was installing a furnace and since the waterheater was so old, it made sense to do both at once. Otherwise, I would have waited.	.	.	1	0 %	1
I was replacing my gas furnace at that time and the water heater was nearing the end of its shelf-life, so I deceided to replace bo	.	.	1	0 %	1
Internal corrosion	.	.	1	0 %	1
It became unsafe to operate	4	2 %	7	0 %	11
It looked ready to go	1	0 %	.	.	1

Q7 Why did you replace your old water heater?	part				All
	0		1		
	N	ColPctN	N	ColPctN	N
It stopped working	8	4 %	58	6 %	66
It stopped working; broke open & flooded basement	.	.	1	0 %	1
It was 13 years old	.	.	1	0 %	1
It was 14 years old	.	.	1	0 %	1
It was 20 years old	.	.	1	0 %	1
It was a rental	.	.	1	0 %	1
It was corroded	.	.	1	0 %	1
It was getting old	1	0 %	4	0 %	5
It was getting old and we were replacing all flooring and didn't want to risk future flooding - aslo for increased efficiency.	.	.	1	0 %	1
It was leaking	69	41 %	389	46 %	458
It was leaking and I wanted something more efficient	.	.	1	0 %	1
It was leaking, it was no longer working properly, I wanted something more efficient	.	.	1	0 %	1
It was leaking, it was not longer working properly	.	.	1	0 %	1
It was leaking; I wanted something more efficient	.	.	3	0 %	3
It was leaking; It became unsafe to operate	.	.	1	0 %	1
It was leaking; It was no longer working properly	.	.	2	0 %	2
It was leaking; It was undersized; I wanted something more efficient	.	.	1	0 %	1
It was leaking; it stopped working	.	.	1	0 %	1

Q7 Why did you replace your old water heater?	part				All
	0		1		
	N	ColPctN	N	ColPctN	N
It was leaking; it was no longer work properly	.	.	1	0 %	1
It was leaking; it was no longer working properly	.	.	3	0 %	3
It was leaking; replaced pressure relief valve a couple of times - felt it was unsfafe and time for new one before failure.	.	.	1	0 %	1
It was leaking; rust	.	.	1	0 %	1
It was leased	.	.	1	0 %	1
It was no longer working properly	37	22 %	145	17 %	182
It was no longer working properly; I wanted something more efficient	.	.	1	0 %	1
It was no longer working properly; it was undersized; I wanted something more efficient	.	.	1	0 %	1
It was old	.	.	1	0 %	1
It was old.	.	.	2	0 %	2
It was over 10 years old	.	.	1	0 %	1
It was undersized	2	1 %	11	1 %	13
It was undersized; tankless	1	0 %	.	.	1
It wask leaking; it was no longer working properly; it stopped working	.	.	1	0 %	1
Leased from gas company and lease cost kept increasing	.	.	1	0 %	1
Moved water heater to different location in house and needed side venting instead of ceiling vent	.	.	1	0 %	1
Needed electric circuit for air conditioner	.	.	1	0 %	1
Old	.	.	1	0 %	1

Q7 Why did you replace your old water heater?	part				All
	0		1		
	N	ColPctN	N	ColPctN	N
Old - replace before problems	.	.	1	0 %	1
Old and a risk of leaking	.	.	1	0 %	1
Old and discontinued lease from WNG	.	.	1	0 %	1
Old and replaced furnace so had btoh done @ the same time.	.	.	1	0 %	1
Others had failed in subdivision	.	.	1	0 %	1
Over 10 years old	1	0 %	2	0 %	3
Overdue for replacement	.	.	1	0 %	1
PAST WARRANTE DATE BY 2 YEARS	1	0 %	.	.	1
Part of total repiping	.	.	1	0 %	1
Preventative	.	.	1	0 %	1
Preventative maintenance	1	0 %	2	0 %	3
Preventative maintenance - to prevent a potential leak.	.	.	1	0 %	1
Preventive Maintenance	.	.	1	0 %	1
Pro-active	1	0 %	.	.	1
Radiant heat in new addition	1	0 %	.	.	1
Ready to replace	1	0 %	.	.	1
Recommended by plumber as my electric heater was old	1	0 %	.	.	1
Remodeled - needed side vent	.	.	1	0 %	1

Q7 Why did you replace your old water heater?	part				All
	0		1		
	N	ColPctN	N	ColPctN	N
Replace rented one	.	.	1	0 %	1
Replaced before trouble cause I didn't want the mess	.	.	1	0 %	1
Replaced electric	.	.	1	0 %	1
Replaced it before it burst	.	.	1	0 %	1
Replaced water heater with furnace	.	.	1	0 %	1
Replaced with furnace	.	.	1	0 %	1
Replacing rental heater	.	.	1	0 %	1
Roof leaked onto it and the sides were corroded but it was still working	.	.	1	0 %	1
Rust at seam	.	.	1	0 %	1
Rust showing	1	0 %	.	.	1
Rusting outside	.	.	1	0 %	1
Suggested by HOA	.	.	1	0 %	1
Technician working on furnace and knowledgable about water heaters shoed me its install date indicating it could go out shortly.	1	0 %	.	.	1
The water was rusty	1	0 %	.	.	1
Thought it was time	1	0 %	.	.	1
To cut down on monthly rental fees	.	.	1	0 %	1
Tubes inside disinegrated	.	.	1	0 %	1
Two stopped working due to flood damage	1	0 %	.	.	1

Q7 Why did you replace your old water heater?	part				All
	0		1		
	N	ColPctN	N	ColPctN	N
Was getting old	.	.	1	0 %	1
Was leased and wanted to buy one	1	0 %	.	.	1
Was making a noice and about 15 years old.	.	.	1	0 %	1
Was on rental program - wanted to own tank.	.	.	1	0 %	1
Was rental	.	.	1	0 %	1
Water and rust on top	.	.	1	0 %	1
Water smelled bad	.	.	1	0 %	1
Water was becoming rusted	.	.	1	0 %	1
it was reaching the age that it may fail	.	.	1	0 %	1
it was rented	.	.	1	0 %	1
wanted a new one before the old one started to leak as several in the development did.	.	.	1	0 %	1
was 15 years old; wnated to replace before it failed.	.	.	1	0 %	1
All	166	100 %	838	100 %	1004

Q8 Before the installation, did you go without hot water?	part				All
	0		1		
	N	ColPctN	N	ColPctN	N
Don't know	1	0 %	19	2 %	20
More than a week	4	2 %	5	0 %	9
No	120	72 %	578	68 %	698
Only a few days	38	22 %	230	27 %	268
Up to a week	3	1 %	7	0 %	10
All	166	100 %	839	100 %	1005

Q9 Is the new water heater the same size as the water heater it replaced?	part				All
	0		1		
	N	ColPctN	N	ColPctN	N
Don't know	13	7 %	91	10 %	104
No	55	33 %	170	20 %	225
Yes	98	59 %	578	68 %	676
All	166	100 %	839	100 %	1005

Q10 Is it bigger or smaller?	part				All
	0		1		
	N	ColPctN	N	ColPctN	N
Bigger	28	48 %	138	68 %	166
Don't know	10	17 %	30	14 %	40
Smaller	20	34 %	33	16 %	53
All	58	100 %	201	100 %	259

Q11 Have you changed the temperature setting since it was installed?	part				All
	0		1		
	N	ColPctN	N	ColPctN	N
Don't know	6	3 %	54	6 %	60
Made it cooler	28	16 %	164	18 %	192
Made it hotter	28	16 %	100	11 %	128
Still where the contractor set it	108	63 %	550	63 %	658
All	170	100 %	868	100 %	1038

Q12 How does the hottest water you can get from the tap compare with the previous water heater?	part				All
	0		1		
	N	ColPctN	N	ColPctN	N
About the same	96	56 %	612	70 %	708
Don't know	15	8 %	66	7 %	81
Hotter	34	20 %	127	14 %	161
Not as hot	25	14 %	63	7 %	88
All	170	100 %	868	100 %	1038

Q13 Do you have a second water heater?	part				All
	0		1		
	N	ColPctN	N	ColPctN	N
Don't know	1	0 %	4	0 %	5
No	161	94 %	826	95 %	987
Yes, a gas one	5	2 %	21	2 %	26
Yes, something other than gas	3	1 %	17	1 %	20
All	170	100 %	868	100 %	1038

Q14 Have you made any changes to your other water heater in the last five years?	part				All
	0		1		
	N	ColPctN	N	ColPctN	N
Don't know	1	12 %	1	2 %	2
No	3	37 %	21	55 %	24
Yes, changed the temperature setting	.	.	2	5 %	2
Yes, replaced it	3	37 %	13	34 %	16
Yes, turned it off	1	12 %	1	2 %	2
All	8	100 %	38	100 %	46

Q15 Do you think your hot water use increased, decreased, or stayed the same as a result of these changes?	part				All
	0		1		
	N	ColPctN	N	ColPctN	N
Decreased	.	.	1	6 %	1
Don't know	1	20 %	1	6 %	2
Increased	.	.	1	6 %	1
Stayed the same	4	80 %	13	81 %	17
All	5	100 %	16	100 %	21

Q18 What type of home do you live in?	part				All
	0		1		
	N	ColPctN	N	ColPctN	N
2, 3, or 4-unit building	4	2 %	39	4 %	43
5 or more unit building	3	1 %	16	1 %	19
Don't know	4	2 %	8	0 %	12
Mobile home	.	.	1	0 %	1
Single-family detached	159	93 %	804	92 %	963
All	170	100 %	868	100 %	1038

Q19 Including yourself, how many people live in your home at least 6 months of the year?	part				All
	0		1		
	N	ColPctN	N	ColPctN	N
0	4	2 %	22	2 %	26
1	28	16 %	137	15 %	165
2	73	42 %	430	49 %	503
3	31	18 %	132	15 %	163
4	22	12 %	107	12 %	129
5	9	5 %	34	3 %	43
6	2	1 %	4	0 %	6
7	1	0 %	2	0 %	3
All	170	100 %	868	100 %	1038

Q20 Have you replaced a gas furnace in the last 5 years?	part				All
	0		1		
	N	ColPctN	N	ColPctN	N
Don't know	1	0 %	14	1 %	15
No	118	69 %	543	62 %	661
Yes	51	30 %	311	35 %	362
All	170	100 %	868	100 %	1038

Q22 Have you made any other major changes in the last 5 years that wouldâ€™ve affected your gas use?	part				All
	0		1		
	N	ColPctN	N	ColPctN	N
Greened entire home	.	.	1	0 %	1
2 gas fireplaces	.	.	1	0 %	1
2006/2007 - Finished family room with sheet rock, carpet and gas firepla	.	.	1	0 %	1
600 sf addition	.	.	1	0 %	1
Added 500 sq to house	.	.	1	0 %	1
Added 600sf room	.	.	1	0 %	1
Added attic insulation	.	.	2	0 %	2
Added gas heater to workshop	.	.	1	0 %	1
Added gas log in fireplace	1	0 %	.	.	1
Added second furnace	.	.	1	0 %	1
Added two gas fireplaces	.	.	1	0 %	1
All of the above	1	0 %	3	0 %	4
All of the above & a gas fireplace	1	0 %	.	.	1
All of the above except gas clothes dryer	.	.	1	0 %	1
All of the above except gas cooking equipment	1	0 %	.	.	1
All of the above except number of occupants	1	0 %	.	.	1
Attic insulation	.	.	1	0 %	1
Changing electric to gas water heater	.	.	1	0 %	1
Chronically ill occupant requires warmer indoor setting	.	.	1	0 %	1
Converted to a gas fireplace	1	0 %	.	.	1
DADU now on this gas line	.	.	1	0 %	1
Did not have gas in home prior to 2007	1	0 %	.	.	1
Don't know	4	2 %	29	3 %	33
Doors, windows	.	.	1	0 %	1
Dual Fuel Range	.	.	1	0 %	1
Electric dryer	.	.	1	0 %	1

Q22 Have you made any other major changes in the last 5 years that wouldâ€™ve affected your gas use?	part				All
	0		1		
	N	ColPctN	N	ColPctN	N
Energy Star Dishwasher & front-load washer	1	0 %	.	.	1
Energy doors, new has fireplace	.	.	1	0 %	1
Failed solar system	.	.	1	0 %	1
Fireplace gas insert	.	.	1	0 %	1
Fireplace insert	.	.	2	0 %	2
Fixed the furnace	.	.	1	0 %	1
Furnace	1	0 %	.	.	1
GAS RANGE AND GAS WALL HEATER	1	0 %	.	.	1
Gas Closthes Dryer; Gas logs	.	.	1	0 %	1
Gas Clothes Dryer	2	1 %	13	1 %	15
Gas Clothes Dryer; Gas Cooking Equipment	1	0 %	.	.	1
Gas Clothes Dryer; Gas Cooking Equipment; Gas Fire Places (2)	.	.	1	0 %	1
Gas Clothes Dryer; Number of Occupants	.	.	1	0 %	1
Gas Cooking Equipment	4	2 %	32	3 %	36
Gas Cooking Equipment, added heat pump and additional gas fireplace	.	.	1	0 %	1
Gas Cooking Equipment; (2) Fireplace	1	0 %	.	.	1
Gas Cooking Equipment; Number of occupants	.	.	1	0 %	1
Gas Fireplace	.	.	2	0 %	2
Gas Fireplace Insert	.	.	1	0 %	1
Gas clothes dryer and number of occupants	1	0 %	.	.	1
Gas cooking equipment and number of occupants	1	0 %	.	.	1
Gas fireplace	.	.	3	0 %	3
Gas fireplace for heating	.	.	1	0 %	1
Gas fireplace insert	.	.	1	0 %	1
Gas insert	.	.	1	0 %	1
Heat Pump- Air - New Gass furnace all installed in August 2007	.	.	1	0 %	1

Q22 Have you made any other major changes in the last 5 years that wouldâ€™ve affected your gas use?	part				All
	0		1		
	N	ColPctN	N	ColPctN	N
Heat pump	.	.	1	0 %	1
Hydronic heat	1	0 %	.	.	1
Increase size of house (heating area)	.	.	1	0 %	1
Increased use of wood heat	.	.	1	0 %	1
Installaton of North-West-Climate Control	.	.	1	0 %	1
Installed Gas Fireplace	.	.	1	0 %	1
Installed a gas fireplace	1	0 %	2	0 %	3
Installed a large jetted tub	.	.	1	0 %	1
Installed air conditioner	.	.	1	0 %	1
Installed front storm door	.	.	1	0 %	1
Installed wood burning fireplace	.	.	1	0 %	1
Insulated Door	.	.	1	0 %	1
Insulatin or Windows; Gas Cooking Equipment	.	.	1	0 %	1
Insulatin or windows, gas clothes dryer	.	.	1	0 %	1
Insulation of crawl space; also installed heat pump in August, 2009	1	0 %	.	.	1
Insulation or Windows	30	17 %	149	17 %	179
Insulation or Windows and new door	.	.	1	0 %	1
Insulation or Windows; Added @ 600 sq. feet	.	.	1	0 %	1
Insulation or Windows; All doors	.	.	1	0 %	1
Insulation or Windows; Gas Clothes Dryer; Number of Occupants (Seasonal	.	.	1	0 %	1
Insulation or Windows; Gas Cooking Equipment	.	.	1	0 %	1
Insulation or Windows; Gas Cooking Equipment; Fireplace	.	.	1	0 %	1
Insulation or Windows; Gas generator	1	0 %	.	.	1
Insulation or Windows; High Efficiency Washer/Dryer	.	.	1	0 %	1
Insulation or Windows; Number of Occupants	.	.	1	0 %	1
Insulation or Windows; Number of occupants	.	.	4	0 %	4

Q22 Have you made any other major changes in the last 5 years that wouldâ€™ve affected your gas use?	part				All
	0		1		
	N	ColPctN	N	ColPctN	N
Insulation or Windows; changed from electric dryer to gas dryer	.	.	1	0 %	1
Insulation or Windows; fireplace, insulation	.	.	1	0 %	1
Insulation or windows and gas clothes dryer	.	.	1	0 %	1
Insulation or windows and gas cooking equipment	.	.	1	0 %	1
Insulation or windows and gas fireplace	1	0 %	.	.	1
Insulation or windows and number of occupants	.	.	3	0 %	3
Insulation or windows, fireplace	.	.	1	0 %	1
Insulation or windows, gas clothes dryer, and gas cooking equipment	1	0 %	1	0 %	2
Insulation or windows, gas clothes dryer, gas cooking equipment	.	.	1	0 %	1
Insulation or windows, gas cooking equipment	1	0 %	.	.	1
Insulation or windows, gas cooking equipment, number of occupants	.	.	1	0 %	1
Insulation or windows; siding	.	.	1	0 %	1
Insurlation or Windows; Number of occupants	1	0 %	.	.	1
Just insulated attic and changed sliding door	.	.	1	0 %	1
Kitchen remodel and expansion	.	.	1	0 %	1
Less time at home.	.	.	1	0 %	1
Living in home part time	.	.	1	0 %	1
Lower heat temp in winter	.	.	1	0 %	1
Lowered the thermostate on gas furnace to 65 degrees	.	.	1	0 %	1
Lowered thermostat	.	.	1	0 %	1
Major remodel	.	.	1	0 %	1
Medical problems requiring more heat	.	.	1	0 %	1
New ducting in crawl space	1	0 %	.	.	1
New furnace has heat pump	.	.	1	0 %	1
New roof	.	.	1	0 %	1
New roof & heat pump	.	.	1	0 %	1

Q22 Have you made any other major changes in the last 5 years that wouldâ€™ve affected your gas use?	part				All
	0		1		
	N	ColPctN	N	ColPctN	N
New siding	1	0 %	.	.	1
New space heater	1	0 %	.	.	1
No major changes to gas use	88	51 %	449	51 %	537
No.	.	.	1	0 %	1
Number of occupants	15	8 %	71	8 %	86
Number of occupants and also installed a gas BBQ but increased occupants	.	.	1	0 %	1
Number of occupants and new master suite	.	.	1	0 %	1
Number of occupants; getting new windows	.	.	1	0 %	1
Number of occupants; lowered home temp a lot	.	.	1	0 %	1
Number of occupants; lowered thermostate to 68 degrees.	.	.	1	0 %	1
Occupants	.	.	1	0 %	1
Pellet Stove	.	.	1	0 %	1
Rat infestation - gas use is ongoing until we fix it	.	.	1	0 %	1
Re-sided home with insulation over old siding	.	.	1	0 %	1
Reduced thermostat setting	.	.	1	0 %	1
Removed gas fireplace	.	.	1	0 %	1
Replaced defective programmable thermostat	.	.	1	0 %	1
Replaced gas furnace with hybrid system - electric heat pump/gas furnace	.	.	1	0 %	1
Replaced the traditional gas water heater with a Tankless Water heater	1	0 %	.	.	1
Stay-at-home mom	.	.	1	0 %	1
Steel door between garage and house	.	.	1	0 %	1
Storm door	.	.	1	0 %	1
The new water heater is not a fast reheat one as the previous one was	.	.	1	0 %	1
Turn temp on furnace	.	.	1	0 %	1
Turned off gas fireplace	.	.	1	0 %	1
Use cold water for almost all laundry	.	.	1	0 %	1

Q22 Have you made any other major changes in the last 5 years that wouldâ€™ve affected your gas use?	part				All
	0		1		
	N	ColPctN	N	ColPctN	N
Use the pool more at times	.	.	1	0 %	1
Used electric space heaters	.	.	1	0 %	1
We were gone for 5 months in 2009	.	.	1	0 %	1
Windows & gas cooking equipment	.	.	1	0 %	1
Windows and number of occupants	.	.	1	0 %	1
Windows, gas clothes dryer, gas cooking euipment, & new heat exchanger o	.	.	1	0 %	1
Windows; electric washer and dryer	.	.	1	0 %	1
added gas fireplace	1	0 %	.	.	1
here less	.	.	1	0 %	1
high efficiency washing machine, front load	.	.	1	0 %	1
hung curtains in stairwell leading to front door as well as along stairw	.	.	1	0 %	1
new major efficiency furnace	.	.	1	0 %	1
All	170	100 %	868	100 %	1038

Q23 As a result of this change, has your gas use increased, decreased, or stayed the same?	part				All
	0		1		
	N	ColPctN	N	ColPctN	N
Decreased	25	32 %	132	33 %	157
Don't know	20	25 %	105	26 %	125
Increased	15	19 %	67	17 %	82
Stayed the same	18	23 %	87	22 %	105
All	78	100 %	391	100 %	469

Q25 Before you started considering replacing your water heater (see Q7, above), were you aware that some models were significantly more energy efficient than others?	part				All
	0		1		
	N	ColPctN	N	ColPctN	N
Don't know	13	7 %	72	8 %	85
No	22	12 %	116	13 %	138
Yes, from sources OTHER than PSE	72	42 %	340	39 %	412
Yes, through information from PSE	63	37 %	340	39 %	403
All	170	100 %	868	100 %	1038

Q26 When working with your contractor, plumber or supplier to obtain your new water heater which statement was most true?	part				All
	0		1		
	N	ColPctN	N	ColPctN	N
Don't know	14	8 %	96	12 %	110
I started out looking for an energy efficient water heater	55	35 %	268	33 %	323
My contractor, plumber or supplier discussed standard and energy efficient water heaters	42	26 %	263	32 %	305
My contractor, plumber or supplier never discussed energy efficient water heaters	27	17 %	66	8 %	93
My contractor, plumber or supplier only discussed energy efficient water heaters	19	12 %	104	13 %	123
All	157	100 %	797	100 %	954

Q27	part		All
	1		
	N	ColPctN	N
0 - Not at all likely	129	18 %	129
10 - Very likely	169	24 %	169
Don't know	78	11 %	78
1	34	4 %	34
2	28	3 %	28
3	32	4 %	32
4	14	1 %	14
5	44	6 %	44
6	15	2 %	15
7	42	5 %	42
8	69	9 %	69
9	47	6 %	47
All	701	100 %	701

Q28	part 1		All
	N	ColPctN	N
0 - The awareness and education was everything	101	14 %	101
10 - The rebate was everything	15	2 %	15
5 - The awareness/education and the rebate were equally important	230	32 %	230
Don't know	55	7 %	55
1	33	4 %	33
2	46	6 %	46
3	66	9 %	66
4	53	7 %	53
6	33	4 %	33
7	24	3 %	24
8	32	4 %	32
9	13	1 %	13
All	701	100 %	701

Q27. When you purchased the water heater, did you buy . . .	part		
	0		All
	N	ColPctN	N
A tankless water heater	26	18 %	26
An ENERGY STARÂ© tank-type water heater	55	38 %	55
Other or Don't know	28	19 %	28
Some other kind of gas water heater	33	23 %	33
All	142	100 %	142

Q28. Were you aware that there was a rebate available from PSE if you purchased an ENERGY STAR© tank-type water heater?	part		
	0		All
	N	ColPctN	N
No	90	63 %	90
Yes	52	36 %	52
All	142	100 %	142

Q29 If you purchased a non- ENERGY STARÂ© tank-type water heater, on a scale of 0 to 10 where 0 is not very likely and 10 is very likely, how likely is it that a $40 rebate would have convinced you to purchase an ENERGY STAR© tank-type water heater?	part 0		All
	N	ColPct N	N
0 - Not very likely	11	12 %	11
10 - Very likely	13	14 %	13
Don't know	31	34 %	31
1	1	1 %	1
3	2	2 %	2
4	1	1 %	1
5	9	10 %	9
6	7	7 %	7
7	5	5 %	5
8	7	7 %	7
9	3	3 %	3
All	90	100 %	90

Measure Metrics

Evaluation Report Response

Program: High Efficient Gas Storage Water Heater Program

Program Manager: Dennis Rominger

Study Report Name: Impact Evaluation of PSE Efficient Water Heater Program

Report Date: June 16, 2010

Evaluation Analyst: Bobette Wilhelm

Date of ERR: December 7, 2010

Key Impact Evaluation Report Recommendations:

The Impact Evaluation suggests that the market baseline for energy efficiency water heaters has increased and that PSE's Program should consider raising the minimum efficiency requirement.

The Impact Evaluation also suggests that the average base load energy use for water heaters is lower for PSE's service territory.

This Impact Evaluation, per section 3.1.2, estimates base load water heating therm usage of 200 therms. As calculated by the report, engineered savings are determined at 15.1 therms from standard efficiency (code) to high efficiency (.62 EF or better) water heaters during the program years of 2005-2007.

Discussion of Key Findings/Analysis:

There is broad agreement that looking at market research within PSE's service territory could provide more perspective into the energy savings (and free ridership) associated with PSE's Program. Page 1-3, section 1.4.1, suggests that PSE's program hasn't pushed the market to include "still higher efficiency units", and refers to a high degree of free ridership due to our program design. July 2010 inquiries to key distributors and retailers of both code and high efficiency water heaters indicate a low market penetration of high efficiency water heaters. The sales percentage between code and high efficiency is likely far less for the study evaluation years of 2005-2007. Recent inquires found the following:

- Gensco has sold 44% of Energy Star water heaters from 12/1/2009 – 6/21/2010. There wasn't a breakout for new construction vs. retrofit market.
- Pacific Plumbing on a 6-month rolling average has sold 38% of Energy Star water heaters for the retrofit market ending June 2010. Again, there were no distinctions between new construction vs. retrofit market.
- Ferguson has sold only 3% of qualifying Energy Star Product in the last year, 2009.
- AO Smith which also manufacturers under State and American brand indicate that only 25% of their product shipped to Washington State is Energy Star as of June 2010.

- Rheem has shared that 33% of their product shipped to Washington State are .62 EF or better.
- Lowe's has sold only 23% of product that is Energy Star within Washington State. Because Lowe's sells mostly to customers and contractors involved in retrofit application, this might represent the current percentage of existing homes installing High Efficient .62 EF water heaters. According to KEMA's 2005 residential water heater market, retailers are 41-51% of the market. More recently AO Smith indicated that they value the retail market at 50-55%.

This information suggests for the period of 2005-2007, Free Ridership did not account for all of the reduction in energy savings. In fact, we believe the value of PSE's program during these years have pushed distributors and retailers to stock and sell the products that are now available and our program continues to push market share for high efficiency water heaters. The Program cannot solely take savings for this market transformation effect.

The other potential effect is energy take-back. Take-back is something that is difficult and expensive to evaluate. The only real way to know the level of take-back associated with this evaluation would include finding out the energy factor of the unit that non-participants installed.

Based upon engineering calculations, PSE knows that high efficiency water heaters should save energy over code water heaters. So, if take back was a factor, because this program claims a relatively small 18 therms in savings, a larger non-participant sample size might be necessary to fully understand the impacts from a billing analysis. Another approach would be to also conduct a metering study.

Subsequent Program Adjustments:

1. A market research study should be performed to better understand baseline.
2. The Program's minimum efficiency will increase from .62 EF to .67 EF on January 1, 2011 that will align with changes made by Energy Star in September 2010.
3. Subsequent Program energy savings will utilize the 200 therm base load energy use for water heaters within PSE's service territory as suggested in the KEMA Impact Evaluation.

New Energy Star criteria is currently being evaluated for determining future water heating program design. Energy Star has increased their EF from .62 to .67 effective September 1, 2010. Future program design will be calculated upon base load information received from this Impact Evaluation and new Energy Star criteria. It should also be noted that PSE announced this summer that any .62 EF water heater installed after July 31, 2010 would no longer be eligible for a PSE rebate.

Evaluation also recommends an RFP in 2011 or 2012 to solicit bids for a metering study of code, 0.62 and 0.67 EF water heaters. The study would acquire valuable information on actual annual water heater usage and savings for single family homes in PSE service area; the operating efficiency of water heaters (do they operate at rated efficiency?); and the load shape of water heaters. A sophisticated metering study would address these interests, and the market research study would address baseline questions. Both studies could be included in a single RFP/contract to assure optimal cost efficiency and synergies across the range of desired information on impact, process and market effects. Such a study is estimated to cost about $200,000, however water heating reflects a major portion of PSE Residential gas savings market potential, and the usage data alone will have continuing value for the foreseeable future as code and energy factors ratchet upward.