PUGET SOUND ENERGY

Fuel Conversion Impact & Process Evaluation

Contents:

- Fuel Conversion Program Impact and Process Evaluation
- Evaluation Report Response

This document contains both the final Home Energy Reports Program Impact Evaluation and the Puget Sound Energy Evaluation Report Response (ERR). PSE program managers prepare 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 AND PROCESS EVALUATION

Residential Fuel Conversion Program

Puget Sound Energy

Date: 8-9-2015

Project name:	Impact and Process Evaluation
Report title:	Residential Fuel Conversion Program
Customer:	Puget Sound Energy,
Contact person:	Ken Agnew
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1 EXECUTIVE SUMMARY

This report documents the results of the impact and process evaluation of the 2011, 2012 and 2013 PSE Fuel Conversion Programs. The program provides financial incentives to PSE customers with electric service to switch electric space and/or water heat to gas space and water heat. The decreased price of gas makes the conversion proposition attractive to PSE customers while PSE claims the reduced electric consumption against state requirements for load reduction and particulate mitigation.

This impact evaluation in this report provides estimates of the electric consumption reduction and the parallel gas consumption increases. These estimates are integrated into an updated cost effectiveness calculation for the program. A final goal of the impact evaluation was to develop ways to use the analysis outcomes to better target the program to increase cost effectiveness. The process evaluation performed interviews with stakeholders and participants to better understand the program process and the participant experience.

1.1 Program Summary

The primary purpose of the PSE Fuel Conversion Program, which has been running since 2008, is to provide cost-effective electric energy savings by providing participants with incentives to convert their electricity-fueled space and/or water heat to natural gas. Additionally, the program is aimed at connecting customers to other rebate programs, provide customers with quality service, grow PSE's gas service, and support the contractor energy efficiency business.

The program offers rebates for heat and water conversion, individually, and together. Table 1-1 below presents the distribution of conversion types during the evaluation period:

Table 1-1: Distribution of Conversions

Population	% of Participants in Evaluation Period
Space and Water Heat	21.1%
Space Heater Only	9.9%
Water Heater Only	69.0%
Total	100.0%

Just over two thirds of conversions were for water heaters only. Space and water heat conversions follow with roughly twenty percent, and space heat only comprise the smallest share at just under ten percent.

1.2 Objectives

1.2.1 Impact Evaluation Objectives

This evaluation had multiple impact evaluation objectives:

- Estimate the change in program participant electric and gas consumption for the three different combinations of space and water heat conversions.

- Using these electric and gas consumption change estimates, produce updated cost-effectiveness estimates for the Fuel Conversion Program.
- Test the potential for using evaluation outputs for targeting cost effective households.

1.2.2 Process Evaluation Objectives

The process evaluation had the following objectives:

- Develop a program logic model to guide the process evaluation and application of evaluation findings to program planning and management.
- Assess participant satisfaction with the program and identify actionable methods to increase the efficiency and effectiveness of program delivery.

1.3 Evaluation Findings

1.3.1 Impact Findings

Table 1-2 summarizes the electric and gas consumption change results. For both electric and gas, the table provides the deemed values used by PSE in the tracking data, the estimated gross change in consumption and the realization rate. The evaluated electric reductions are lower than the deemed values, with realization rates between 81% and 98% of the average tracking data values. The gas consumption increase for space and water heat conversions was lower than deemed, with a realization rate of only 77%. The two individual conversion measures were slightly greater deemed at 108%.

Table 1-2: Gross Electric and Gas Consumption Changes: Evaluated vs Claimed

Measure Group	Electric (kWh)			Gas (therms)		
	Deemed[1]	Evaluated*	Realization Rate	Deemed	Evaluated*	Realization Rate
Space Heat And Water Heat	-13,444	-10,865 (-13,437, -8,293)	81%	799	617 (486, 748)	77%
Space Heat Only	-9,871	-9,720 (-12,385, -7,055)	98%	602	653 (491, 815)	108%
Water Heat Only	-3,500	-3,054 (-4,196, -1,912)	87%	197	212 (61, 362)	108%

*90% confidence interval are provided for each evaluated result

Table 1-3 presents the cost-effectiveness based on updated consumption change results. Individually, the two conversion types that involve space heat have cost effectiveness ratios greater than one. Both deemed and evaluated water heat only conversions have cost effectiveness ratios well below one. Overall, despite the high share of water heat only conversions, the program was cost effective through the evaluation period with a ratio of 1.12. The evaluated cost effectiveness ratios were all lower than cost effectiveness based on

[1] The deemed savings values were taken from the tracking data provided by PSE. These values were averaged across all participants within a measure group for all participants.

tracking data deemed values. On average, across all installation types, the cost effectiveness realization rate was 82%. These cost-effectiveness calculations are consistent with prior PSE practice.

Table 1-3: Benefit Cost Ratios by Measure Group

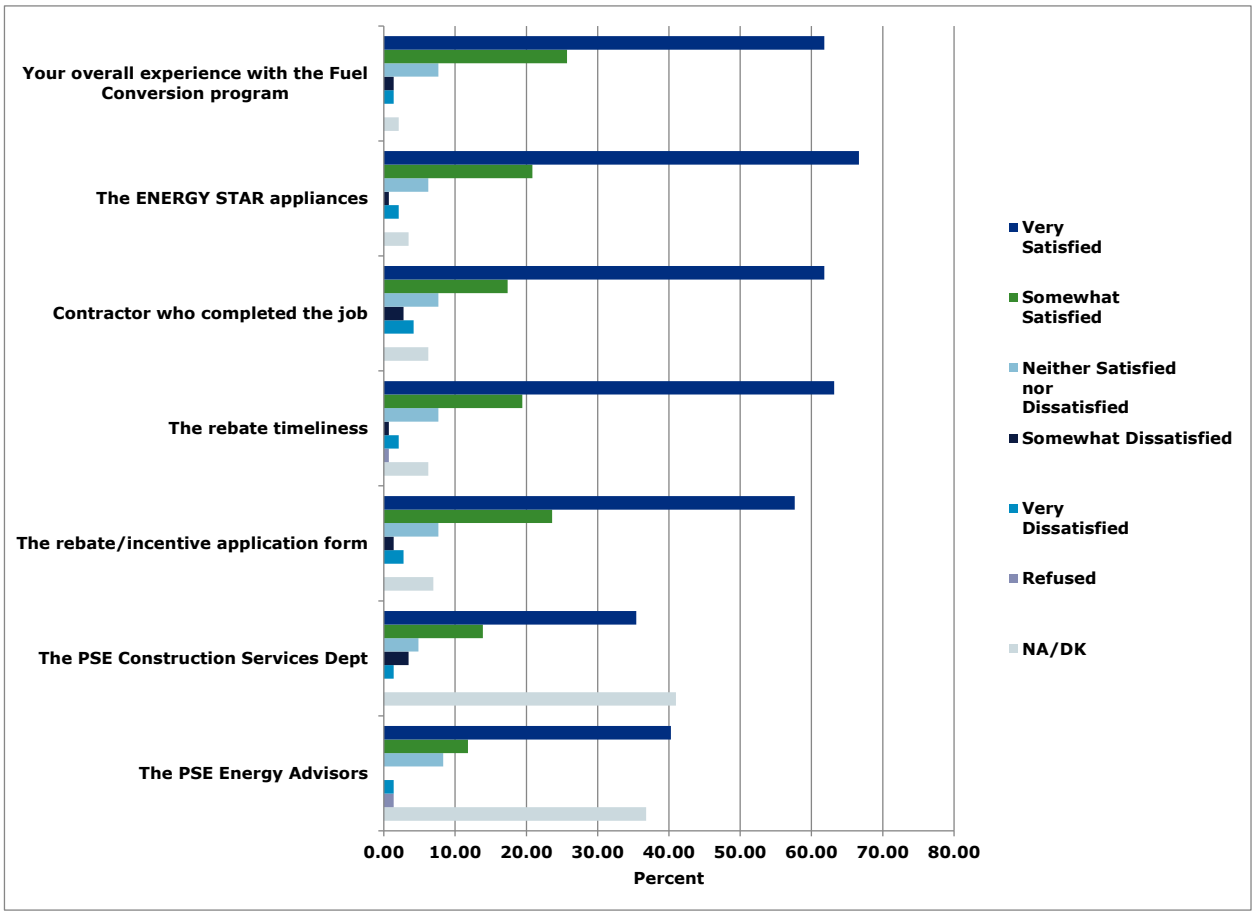
Measure Group	Evaluated Normalized B/C Ratio	Tracking B/C Ratio	Realization Rate
Space Heat and Water Heat (n = 41)	1.74 (1.44, 2.04)	2.09	83%
Space Heat Only (n = 26)	1.33 (1.21, 1.45)	1.44	92%
Water Heat Only (n = 232)	0.34 (0.19, 0.5)	0.48	72%
All Conversions	1.12 (0.76, 1.48)	1.37	82%

1.3.2 Process Evaluation Findings

The interviews and survey provided insight from program managers and program participants through interviews and surveys. The logic model, in section 7.2.1, describes the market actors and program process involved in the PSE Fuel Conversion Program.

Error! Reference source not found. summarizes the satisfaction level of surveyed participants for several attributes of the program. Satisfaction is high across all areas. With "Don't Know/Not Applicable" removed, over 80% of customers rated their satisfaction as either "Very Satisfied" or "Somewhat satisfied" across all program attributes. For the overall program experience, participants were very or somewhat satisfied with the program 90% of the time.

Figure 1-1: Program Satisfaction of Surveyed Participants



1.4 Recommendations

The Impact recommendations are the following:

- DNV GL provides new benchmarks to use to identify cost-effective heat conversion opportunities. These should assist in maintaining the cost-effectiveness of the space heat measures. Water heat is not possible to target given the available data. Water heat is a smaller percentage of overall consumption and it was not possible to find characteristics correlated with higher household-level cost-effectiveness.
- Water consumption and thus water heat is closely related to number of occupants. PSE could consider setting requirements for the number of occupants in a household for water heat only conversion eligibility.

The Process recommendations are the following:

- Continue to streamline the hand off between different groups, including PSE Energy Advisors, Construction Services Department, and contractors.
  - PSE has informed DNV GL that they are continuing to streamline program processes. Based on feedback from the interviews and recommendations for improvement from the CATI surveys, this is an important area for continued improvement.
- Continue to invest in marketing and outreach strategies. Feedback from the interviews and the surveys encouraged PSE to engage in greater marketing of the fuel conversion program, while ensuring the program is targeting to those who have the potential to participate. There also appears to be an ongoing

opportunity to market Energy Advisors as a one-stop-shop for all questions and concerns regarding PSE and PSE programs.

- Consider additional research and screening resources for the both the qualifying measures and the approved contractors. A small number of CATI respondents stated that better screening and oversight of contractors would improve their experience with the program. Another small group stated that increased research into qualifying measures, and some fact sheets to help customers choose appropriate measures would improve the Fuel Conversion Program. Both of these groups were fewer than ten respondents, but still may provide useful guidance for future program improvements.

The details for these recommendations are discussed in the Process Section of this report below.

2 INTRODUCTION

The primary purpose of the PSE Fuel Conversion Program is to provide cost-effective electric energy savings by providing participants with incentives to convert their electricity-fueled space and/or water heat to natural gas. The decreased price of gas makes the conversion proposition attractive to PSE customers while PSE claims the reduced electric consumption against state requirement for load reduction and particulate mitigation. Additionally, the program is aimed at connecting customers to other rebate programs, provide customers with quality service, grow PSE's gas service, and support contractor energy efficiency business.

2.1 Evaluation Objectives

2.1.1 Impact Evaluation Objectives

The primary objective of the impact evaluation is the estimation of the effect of fuel conversion on electric and gas consumption. These estimates feed directly into cost-effectiveness calculations for the program. Specifically, the impact evaluation provides estimates of the electric consumption reduction and the parallel gas consumption increases that resulted from the program. These estimates are integrated into an updated cost effectiveness calculation for the program. A final goal of the evaluation was to develop ways to use the analysis outcomes to better target the program to increase cost effectiveness. The evaluation also provides an estimate of free ridership for the fuel conversion program.

2.1.2 Process Evaluation Objectives

The aims of the process evaluation were twofold:

- To assist PSE program staff in developing a logic model, laid out in a graphic format, to clarify the rationale for the program design and identify program outcomes.
- To conduct customer surveys to assess participant satisfaction with various program components.

2.2 Overview of the Report

The remaining sections of the report are organized as follows:

- Section 3 briefly covers the acquisition and preparation of the analysis data set.
- Section 4 discusses the methodology
- Section 5 presents the impact results
- Section 6 presents the cost effectiveness results
- Section 7 presents the targeting analysis results
- Section 8 contains the process evaluation findings and recommendations
- Sections 9, 10, 11, 12, 13 are report appendices that contain more detailed discussions of the data disposition, modeling methodology, and background information on PSE's approach to cost effectiveness.

3 DATA ACQUISITION AND CLEANING

This section summarizes the data used for the Fuel Conversion project. In particular, it describes the available data, exclusion criteria, and summary statistics of the final dataset used in the consumption change analysis.

3.1 Data Sources

Puget Sound Energy (PSE) provided DNV GL with the following categories of data:

- Program tracking data
- Monthly billing usage
- Daily billing usage
- Hourly temperature data

In addition, DNV GL fielded a survey of program participants. We discuss briefly these five data sources, and how they were prepared in the following paragraphs. A more detailed description of the data preparation is found in Appendix: Detailed Data Disposition, and the survey instrument can be found in Appendix 10 below.

3.1.1 Program Tracking Data

Puget Sound Energy provided DNV GL with Fuel Conversion program tracking data for customers that participated between October 2010 and December 2014. This dataset included specific information such as participant names, addresses, measure type, estimated measure cost, incentive amounts, ex ante savings estimates, and installation date. These data were essential for developing impact estimates and subsequent estimates of cost effectiveness.

There were additional data fields that we expected to find in the tracking data but were not available. We expected that information regarding installed gas water and space heating measures that received additional PSE rebates would be included in the tracking data. This was not the case.

3.1.2 Monthly and Daily Billing Data

DNV GL used both monthly billing and daily consumption data to generate the consumption values used in our savings estimates. Due to the nature of the program, no gas billing data was available for customers who added gas service using a provider other than PSE. This means that relative to the electric consumption a, the gas data was available for fewer participants. Additional data limitations led the evaluation team to combine daily and monthly consumption datasets, aggregating the former to generate monthly consumption values.

3.1.3 Hourly Weather Data

DNV GL also received hourly weather data from Jan 1, 20 through December 31, 2014. Weather data were provided for ten weather stations representing PSE service territory. DNV GL has access to PSE's historical weather data used in previous PSE program evaluations. In addition to the actual values used in estimating the site level models, 10 year temperature averages were used to generate the normalized annual consumption values required for the consumption change estimate. These hourly series were used to generate average daily temperatures that were the values used in the evaluation.

3.1.4 Crosswalk from Old to New PSE Database Systems

PSE provided mapping of old premise numbers, customer account numbers and meter number to new system IDs. DNV GL relies on these cross walks to link old system data to new system data. DNV GL also used this information to identify meter numbers of program participants.

3.1.5 Program Participant Survey

The evaluation team contracted with Pacific Market Research to conduct Computer Assisted Telephone Interviews with program participants. These surveys were completed in March 2015. Table 3-1 below presents the disposition of the participant sample contacted for the survey.

Table 3-1: Disposition of Participant Sample Contacted for Survey

Call Disposition	Total	Landline	Wireless
Total Sample	881	547	334
Completes	144	63	81
Call Back To Complete / Unable to Complete	4	3	1
Resolved Numbers	711	473	238
Attempted 8 Or More Times	373	240	133
Disconnected	118	98	20
Hard Refusal	113	71	42
Non-Residential Number	43	29	14
No Such Person	34	15	19
Asked To Be Placed On The DNC List	14	9	5
Fax/Modem Line	6	5	1
Other Language (Not Spanish)	4	3	1
Language/Hearing	2	1	1
Previously Interviewed	2	2	-
Spanish Language	1	-	1
Changed Phone Number	1	-	1
Non-Eligible Respondents	21	9	12
Answering Machine	1	-	1

Given the small number of participants, there was no sample stratification, and the sample population consisted of all program participants with valid phone numbers. The overall response rate was 16.7%. This is a typical response rate for program participants. Table 3-2 below compares the proportion of measure groups found in the program population, versus that of survey responses.

Table 3-2: Comparison of Measure Group Distribution. Population vs. Survey Respondents

Measure Group	Population Percentage	Survey Respondents Percentage
Space Heat And Water Heat	19%	22%
Space Heat Only	10%	8%
Water Heat Only	71%	71%

The evaluation team used a chi-squared test to compare the distribution of measure groups among survey respondents to those among program participants. This test found no statistically significant difference between the two groups.

3.2 Consumption Data Disposition

3.2.1 Preparation of Analysis Dataset

DNV GL used a combination of monthly and daily consumption data to evaluate the impact of the Fuel Conversion program. The evaluation team examined the consumption data for completeness and potential data issues such as duplicates extreme values, missing observations, and other data inconsistencies. The data preparation steps involved the following:

- Removal of duplicate and overlapping reads
- Exclusion of negative reads
- Inspection of missing/zero observations
    - If missing or zero observations were followed by an adjustment, the adjusted consumption value was used, and the value over the periods covering both the missing/zero and non-missing/non-zero periods was used
- Exclusion of households with less than 9 months of pre or post data.

Table 3-3 and Table 3-4 below summarize the data disposition from the original tracking dataset through the process of removing sites with insufficient pre/post data. It should be noted that a substantial number of PSE electric customers do not receive gas service from PSE. This lowers the number of premises with usable gas consumption data considerably. This evaluation uses the PSE gas customers to estimate the conversion-related increase in gas consumption.

Table 3-3: Fuel Conversion Data Disposition-Electric Consumption

Population	Space Heat and Water Heat	Space Heat Only	Water Heat Only	Total
Original Population	**222**	**104**	**724**	**1,050**
Missing Account/Premise Id	42	15	83	140
Not In Customer/Billing Data	17	5	24	46
Other Data Issues (Overlapping Reads, Etc.)	9	8	38	55
Unmatched Zip Codes	4	3	14	21
Insufficient Pre/Post	59	26	151	236
Usable Electric Sites (Treatment Groups)	91	47	414	552

Table 3-4: Fuel Conversion Data Disposition-Gas Consumption

Population	Space Heat and Water Heat	Space Heat Only	Water Heat Only	Total
Original Population	**222**	**104**	**724**	**1,050**
Missing Account/Premise Id	42	15	83	140
Not In Customer/Billing Data	79	33	240	352
Other Data Issues (Overlapping Reads, Etc.)	36	18	73	127
Unmatched Zip Codes	0	0	0	0
Insufficient Post	4	6	98	108
Usable Gas Sites (Treatment Groups)	78	52	155	285

4 METHODS

This section of the report presents the evaluation methodology and preliminary gross consumption change results. The remainder of this section is organized as follows:

1. An overview of the analysis methodology used to generate the gross savings estimates;
2. A high level description of the approach used to construct the comparison group required for the savings estimate and counts of the participant and comparison groups.

A more detailed description of the modelling methodology can be found in Appendix: Modeling Methodology.

4.1 Consumption Change Analysis Methodology

4.1.1 Difference-in-Difference Approach

The gross consumption change analysis focused on a 'simple' difference-in-differences (DD) estimate of the change in consumption between participants and comparison groups.

A DD estimate compares the energy consumption of fuel conversion participants to a 'similar' group of customers. Use of a comparison group helps control for the non-program, exogenous change in energy consumption through the evaluation period. In a true experimental design, the households are randomly selected into either a treatment or comparison group. However, since this is a non-random assignment, the DNV GL evaluation team, following the guidance of the DOE's Uniform Methods Project, chose prior and subsequent participants as the comparison groups for gas and electric fuel, respectively. Table 4-1 below summarizes how the difference-in-differences approach works after constructing comparison groups, reflecting the different approaches taken for electric and gas.

Table 4-1: Pre- and Post- Differences of Participants and Comparison Groups-Electric

Group	Pre	Post	Pre-Post Difference Within Group	Pre-Post Difference Between Groups
Participants (Current Year Conversion)	Non-Program Trend	Non-Program Trend + Program Effect	Program Effect + Non-Program Trend	Program Effect
Comparison (Future Participants for Electric Consumption Change; Past Participants for Gas Consumption Change)	Non-Program Trend	Non-Program Trend	Non-Program Trend	

For households that underwent conversion, the pre-post difference provides an estimate that combines program-related effect and exogenous (non-program-related, natural trend) change. For subsequent participants the pre/post change in electric consumption, covering a period of two years that occurred prior to their fuel conversion, captures only exogenous changes to consumption. Removing the future participants' difference (exogenous, natural trend only) from the current participants' group difference (program + exogenous, natural trend) provides an estimate of change in consumption due to the fuel conversion program.

The comparison group for the change in gas consumption was analogously constructed. However, in this case, the evaluation team used prior participants as the comparison group. This was done to maximize the

amount of gas consumption data available over the two year pre/post evaluation period. Given that this is an electric conversion program, many premises had limited gas usage prior to the conversion. The assumption in a DD analysis is that, for the comparison group, the change in consumption observed during the analysis period is dominated by non-program effects. During the two years following conversion from electric to gas, there is no reason to expect an upward or downward trend to gas consumption. Given the nature of the program structure and the greater data availability, the prior participation group is the best approach with respect to constructing a comparison group. A more detailed description of the DD approach can be found in Appendix: Modeling Methodology.

4.1.2 Construction of Comparison Groups for Program Level Average Savings

To generate program level savings estimates, the evaluation team used a billing analysis and simple difference-in-difference approach. From the analysis dataset described above, the team created treatment and comparison groups for three waves of conversions. Wave 1 includes customers who converted in 2011 and an appropriate comparison group; Waves 2 and 3 include a comparable group of conversions and comparisons for 2012 and 2013, respectively. Sites with an insufficient number of pre- or post- conversion consumption data, defined as fewer than nine months, were removed from the analysis. This process is summarized in greater detail in Appendix: Fuel Conversion Consumption Data Preparation.

4.1.3 Site-level Modelling

The billing analysis consisted of two different sets of billing regressions each applied to both gas and electric. The evaluation team estimated separate site-level regressions for pre- and post-conversion periods for both gas and electric. The site-level regression consisted of the following basic PriSM structure.[2]

$$E_{id} = \alpha_i + \beta_{iH} HDD(\tau_{iH}) + \beta_{iC} CDD(\tau_{iC}) + \varepsilon_{id}$$

Where:

E_{id} = Consumption of site i, on day d, for either gas or electric, pre- or post-conversion

$HDD(\tau_{iH}), CDD(\tau_{iC})$ = Heating or cooling degree days (DD) at optimal DD-bases (τ_{iH}, τ_{iC}) for site i.

$\alpha_i, \beta_{iH}, \beta_{iC}$ = Estimated baseload, heating, and cooling slopes.

ε_{id} = Regression error.

Each regression was estimated across the full range of feasible degree day base combinations.[3] The electric model included the cooling component even though it is not directly relevant to this evaluation because an accurate estimate of baseload depends on properly controlling for cooling consumption. The gas model dropped the cooling component. The best model was chosen based on statistical criteria (R-square). From this model, each site will have estimates of (overall) normalized annual consumption (NAC_i), normalized heating consumption (NAH_i), and baseload consumption (NAB_i), for both pre- and post-conversion periods

[2] The Princeton Scorekeeping Method (PriSM) was a software developed in the 1980s for estimating normalized annual consumption estimates. The structure used for this software is still basis for most billing analysis approaches. Mimi Goldberg, technical advisor on this project, helped develop and test this software.

[3] For instance, does the site-level consumption data best fit a model with HDD base 58 and CDD base 68 or does some other combination best describe the underlying heating and cooling behavior.

for both gas and electric. Site-level differences will also be calculated ($\Delta NAH_i, \Delta NAB_i$). For example, the ΔNAH_i is calculated as follows:

$$\Delta NAH_i = \widehat{\beta_{iH}^{post}}\overline{HDD(\widehat{\tau_{iH}^{post}})} - \widehat{\beta_{iH}^{pre}}\overline{HDD(\widehat{\tau_{iH}^{pre}})}$$

To calculate the difference in difference estimate, we use average annual weather-normalized consumption values for the pre- and post- conversion periods. Weather-normalization puts consumption estimates that may reflect very different weather from the pre- and post-conversion periods onto the same typical weather terms. Table 4-2 and Table 4-3 below present the treatment and comparison group counts for electric and gas difference-in-difference calculations. Because the comparison groups were pooled across different years, a site may be used up to three times in the pooled comparison group. Therefore these counts may (and in the case of the electric comparison group, do) exceed the total number of participants across all years.

Table 4-2: Treatment and Comparison Counts for Difference-in-Difference Estimates-Electric

Conversion Group	Comparison	Treatment
Space Heat and Water Heat	235	91
Space Heater Only	127	47
Water Heater Only	979	414
Total	1,341	552

Table 4-3: Treatment and Comparison Counts for Difference-in-Difference Estimates-Gas

Conversion Group	Comparison	Treatment
Space Heat and Water Heat	116	78
Space Heat Only	85	52
Water Heat Only	577	155
Total	778	285

4.2 Cost Effectiveness Methodology

At the most basic level, cost-effectiveness is determined by calculating the net benefit associated with conversion and comparing that to the net cost associated with the conversion. Several assumptions have to be made in the course of determining these values. This section describes those assumptions, and the resulting values that require calculation.

4.2.1 Calculating Net Benefit Associated with Conversion

The evaluation team, following the approach outlined in the cost-benefit materials provided by PSE, defined the net benefit of the conversion program as the dollar value of the electricity savings resulting from the conversion, minus the dollar value of the commensurate increase in gas consumption. These dollar values were determined using the avoided cost schedule provided by PSE. These schedules can be found in Appendix: Avoided Cost Schedules Used to Determine Net Benefit. The evaluation team assumed a measure life of 30 years, consistent with the avoided cost schedules used, and for each year the value of the change in normalized annual consumption is multiplied by the corresponding cost per unit of energy.

Once avoided cost of electricity and added cost of gas values were determined for each year, the evaluation team summed these to arrive at a present value of each, using a discount rate of 7.77%, also provided by PSE. The ratio of the present value of the benefits, to the sum of the measure cost and present values of additional gas load results in the benefit/cost ratio of each conversion program. The details of this calculation can be found in Appendix: Net Benefit Calculation Methodology.

4.3 Targeting Cost effective Conversions

This section gives an overview of the approach taken to target cost effective conversions. First, we give an overview of the analysis. Second, we discuss how we derived the site-level cost-effectiveness that were required for this process

4.3.1 General Targeting approach

Puget Sound Energy was interested in gaining insight into how the fuel conversion program might be better targeted to increase the program's cost effectiveness. In particular, PSE wanted to find the minimum threshold consumption in the pre period that would make a site cost effective. In order to understand what factors best predicted site level cost effectiveness, the evaluation team ran a series of regressions with the benefit cost ratio as the dependent variable, and combinations of the following as predictors:

- Total Normalized Annual Consumption pre-conversion
- Total Normalized Annual Consumption pre-conversion + Conversion Type with Interactions
- Share of total normalized annual consumption from heating
- Zip Code

The evaluation team chose the benefit/cost ratio as a means of standardizing the metric across the measure groups. Total net benefit for space and space/water conversions are clearly larger than those for water heat only conversions, however, they also incur more substantial upfront costs. The benefit/cost ratio allows us to compare the cost effectiveness of conversions that have different upfront costs.

4.3.2 Site Level Consumption Change Estimates –Difference Only

To develop site-level cost-effectiveness estimates, the evaluation team calculated site level consumption change values. We simply estimated the pre-post different for electric and gas consumption at each site. This value will necessarily include program related and non-program related consumption change. The drawback to this approach is that there is no way to incorporate the comparison group to net out non-program consumption change at the household level. This approach will, however, maintain, with additional error, the relative cost-effectiveness of each household. There is no other way to calculate cost-effectiveness at the household level in a billing analysis context.

4.3.3 Electric and Gas Site-Level NAC

The cost effectiveness calculation requires both pre and post values for both electric and gas consumption to determine the net benefit associated with each individual installation. This means that the sample used to generate these site level cost effectiveness estimates is necessarily smaller than that used to generate program level consumption change results where electric and gas estimates can be done independently.

Because the site-level NACs are limited to a smaller sample, it is expected that the average pre-post changes may also change. For electric consumption decrease, the site-level analysis (difference only) values are larger than those estimated for the overall analysis. For gas consumption increase, the difference only values are smaller. This offset would artificially increase site level cost-effectiveness if it was not adjusted.

In addition, whereas the electricity values are comparable, the values for gas consumption changes differ considerably.

The evaluation team adjusted for the fact that the difference-only approach required for the cost effectiveness calculations is not aligned with the overall evaluation results. The team applied an adjustment factor to each site based on the ratio of the average difference-in-difference estimate and the average difference only estimate within each conversion group. These values, are presented in Table 4-4 and Table 4-5 below, for electric and gas respectively:

Table 4-4: Difference-Only Adjustment Factor-Electric

Measure Group	Difference-in-Difference Consumption Change	Difference Only Consumption Change	Adjustment to Difference Only Consumption Change
Space and Water Heat	10,865	11,618	94%
Space Heat Only	9,720	10,519	92%
Water Heat Only	3,054	3,318	92%

Table 4-5: Difference-Only Adjustment Factor-Gas

Measure Group	Difference-in-Difference Consumption Change	Difference Only Consumption Change	Adjustment to Difference Only Consumption Change
Space and Water Heat	617	612	101%
Space Heat Only	653	656	99%
Water Heat Only	212	218	97%

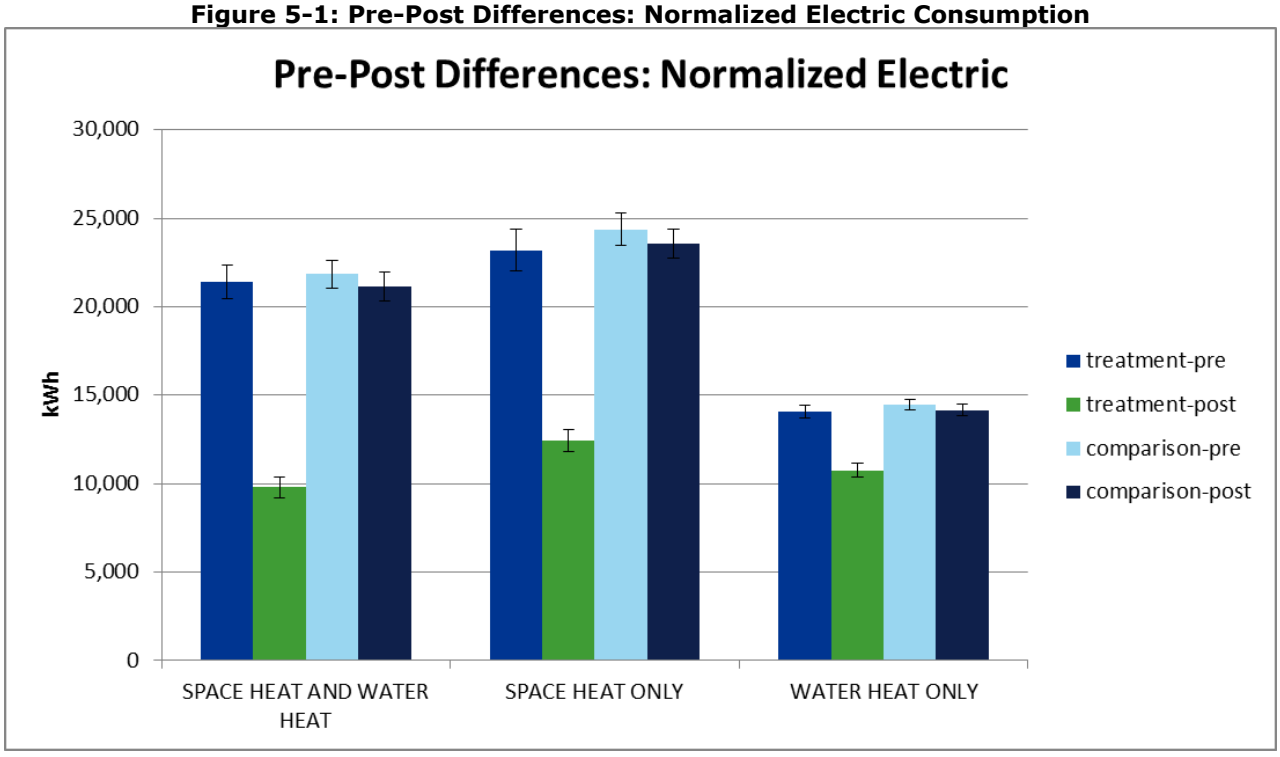
The conversion group-specific adjustment factors were applied to each site. This correction makes use of group level averages but it does align the average difference-only cost-effectiveness values with the overall evaluation results.

5 IMPACT RESULTS

5.1 Consumption Change Estimates

This section summarizes the normalized annual consumption difference-in-difference estimates. Figure 5-1 below compares the average change in normalized annual consumption for the three major measure groups between participant and comparison groups. The first two bars in each group capture the participant pre-to-post reductions in consumption. The last two bars in each group capture the comparison group pre-to-post reductions in consumption. The latter difference is an estimate of the non-program change occurring during the evaluation period.

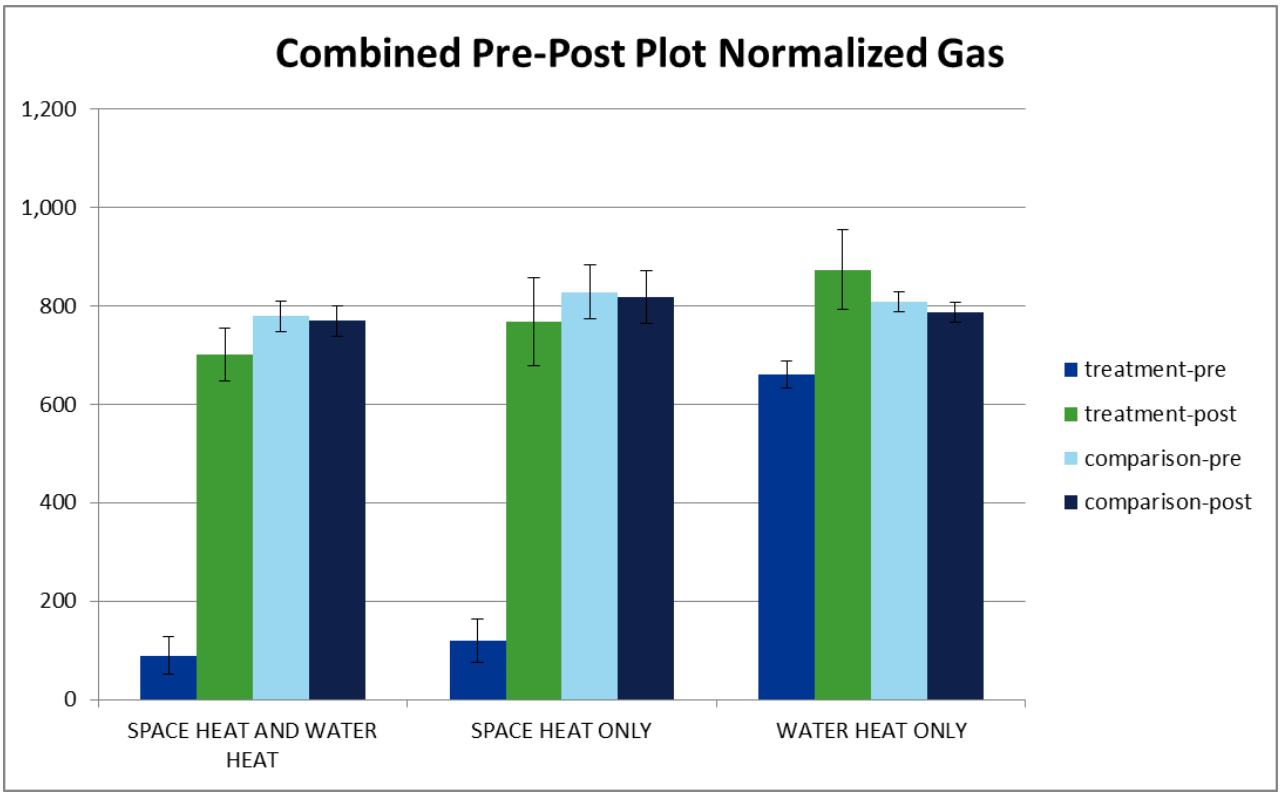
Figure 5-1: Pre-Post Differences: Normalized Electric Consumption



Across all three measure groups the treatment sites showed substantial reductions in consumption that are statistically significant at the 90% level; the comparison groups showed no statistically significant change. The relatively low pre-period consumption level for water heat only conversions reflects the fact that many of these sites already had non-electric space heat.

Figure 5-2 below shows a statistically significant increase in gas consumption across all three measure groups. Again, in the case of water heat only conversions, the large pre-period gas consumption reflects the fact that many of these sites had gas space heat, rather than electric space heat.

Figure 5-2 Pre-Post Differences: Normalized Gas Consumption



5.1.1 Difference-in-Difference Results

This section presents the difference-in-difference total consumption savings estimates for each of the major measure groups (Space and Water Heat, Space Heat Only, Water Heat Only). Appendix: Modeling Methodology below contains a mathematical description of this estimation procedure.

Error! Reference source not found. presents normalized annual usage difference between pre- and post-conversion for participants for each of the following measure groups: space heating only, space and water heating conversion, and water heat conversion only.

Table 5-1: Change in Annual Consumption between Pre/Post-period

Consumption Change	Space Heat and Water Heat (90% CI)	Space Heat Only (90% CI)	Water Heat Only (90% CI)
Electric (kWh)	**-10,865** (-13,437, -8,293)	**-9,720** (-12,385, -7,055)	**-3,054** (-4,196, -1,912)
Gas (Therms)	**617** (486, 748)	**653** (491, 815)	**212** (61, 362)

Table 5-2 ssummarizes the electric and gas consumption change results in the context the deemed values used by PSE in the tracking data. We provide a realization rate to reflect the relationship between estimated and tracking values. The evaluated electric reductions are lower than the deemed values, with realization rates between 81% and 98% of the average tracking data values. The gas consumption increase for space

and water heat conversions was lower than deemed, with a realization rate of only 77%. The two individual conversion measures were slightly greater deemed at 108%.

Table 5-2: Gross Electric and Gas Consumption Changes: Evaluated vs Claimed

Measure Group	Electric (kWh)			Gas (therms)		
	Deemed	Evaluated*	Realization Rate	Deemed	Evaluated*	Realization Rate
Space Heat And Water Heat	-13,444	-10,865 (-13,437, -8,293)	81%	799	617 (486, 748)	77%
Space Heat Only	-9,871	-9,720 (-12,385, -7,055)	98%	602	653 (491, 815)	108%
Water Heat Only	-3,500	-3,054 (-4,196, -1,912)	87%	197	212 (61, 362)	108%

*90% confidence interval are provided for each evaluated result

6 COST EFFECTIVENESS ASSESSMENT

6.1 Cost Effectiveness Results

The overall results of the "normalized" annual consumption cost-effectiveness analysis are summarized in Table 6-1 below. The benefit cost ratio for the space and water heat and space heat only conversions are not statistically different from each other, but they both have cost effectiveness ratios that are at least roughly four times that of water heat only conversions.

Table 6-1: Benefit Cost Ratios by Measure Group

Measure Group	Evaluated Normalized B/C Ratio	Tracking B/C Ratio	Realization Rate
Space Heat and Water Heat (n = 41)	1.74 (1.44, 2.04)	2.09	83%
Space Heat Only (n = 26)	1.33 (1.21, 1.45)	1.44	92%
Water Heat Only (n = 232)	0.34 (0.19, 0.5)	0.48	72%
All Conversions	1.12 (0.76, 1.48)	1.37	82%

As is to be expected, the variation in benefit/cost ratios was larger for conversions that involved space heating. Differences in square footage, insulation, number of occupants, among other characteristics likely lead to much larger variation in the conversions that include space heat.

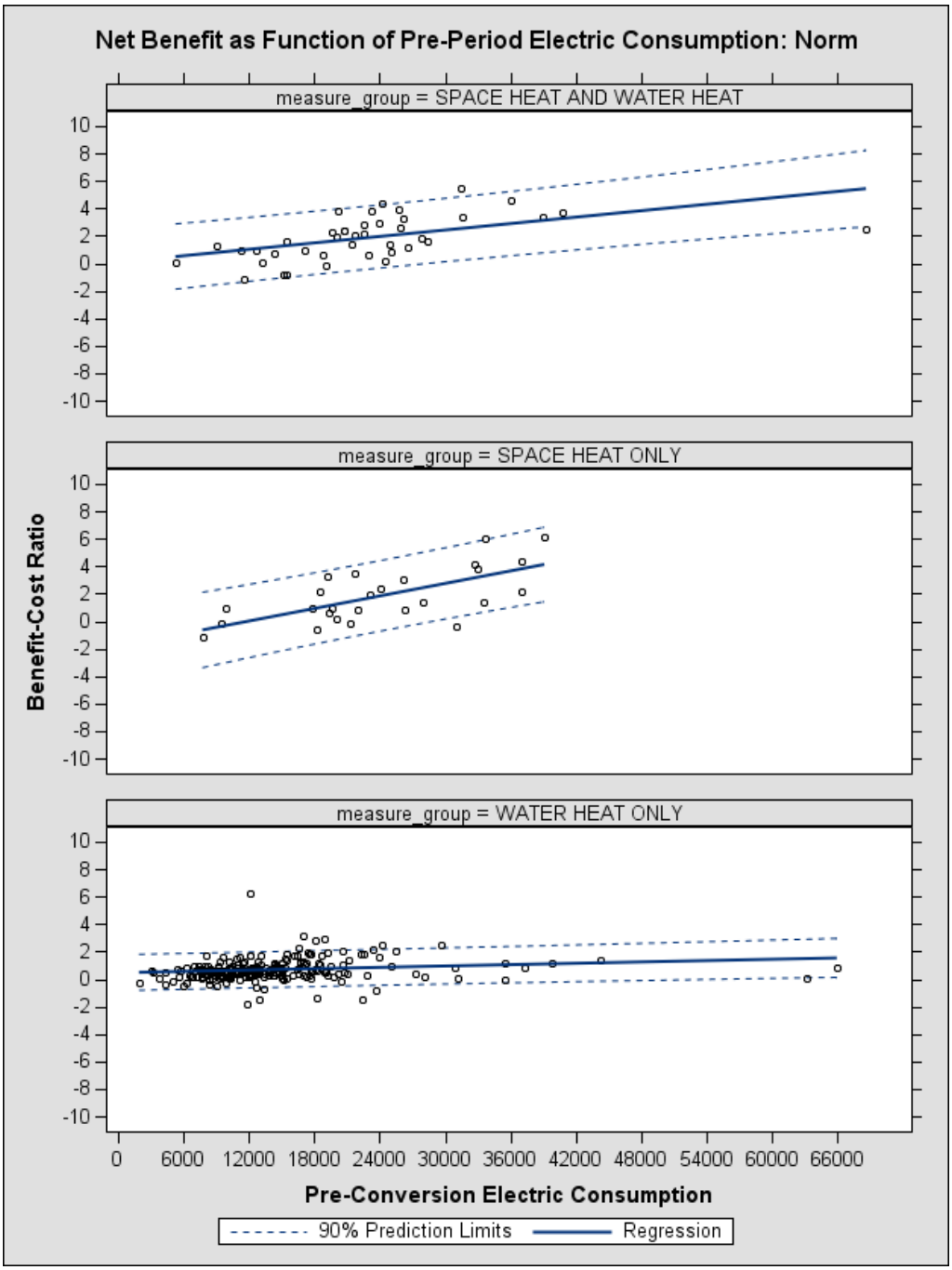
Material provided to DNV GL by PSE included an overall cost effectiveness estimate weighted by the estimated annual kWh saved by each measure group[4].

[4] Contained in the document

7 TARGETING CONVERSIONS TO INCREASE COST EFFECTIVENESS

The evaluation team compared plots of benefit cost ratios as a function of total consumption in the pre period by conversion type:

Figure 7-1: Benefit Cost Ratio as Function of Pre-Conversion Normalized Consumption



The plot above strongly suggest the following:

- The threshold pre period consumption for a cost effective conversion varies across the conversion groups.
- There are clear differences in both the level and in the rate of increase in cost effectiveness as a function of pre period total consumption across measure groups.

The evaluation team used these regression equations to find the average pre-conversion total consumption and heating consumption that yielded a given benefit/cost ratio.

Table 7-1, Table 7-2, and Table 7-3 below elaborate on the first point by presenting the minimum pre period consumption value required for selected benefit cost ratios. The values below represent the average pre-conversion consumption level (total and heating only) that correspond to a given benefit cost ratio. These results are based on the normalized consumption estimates. In general, these will provide the right approximate cut-off for each cost-effectiveness level.

Table 7-1: Minimum Normalized Pre-Conversion Consumption (kWh) Required for selected benefit-cost ratios

Target B/C Ratio	Space and Water Heat	
	Pre-Conversion Total Consumption	Pre-Conversion Heat Consumption
0.5	5,484	700
1	11,894	3,968
1.5	18,305	7,236
2	24,715	10,504
2.5	31,125	13,772
3	37,535	17,040
3.5	43,946	20,308
4	50,356	23,576
4.5	56,766	26,844
5	63,176	30,112

Table 7-2: Minimum Normalized Pre-Conversion Consumption (kWh) Required for select benefit-cost ratios

Target B/C Ratio	Space Heat Only	
	Pre-Conversion Total Consumption	Pre-Conversion Heat Consumption
0.5	15,291	3,734
1	18,580	6,312
1.5	21,870	8,889
2	25,159	11,466
2.5	28,449	14,043
3	31,738	16,621
3.5	35,027	19,198
4	38,317	21,775
4.5	41,606	24,353
5	44,896	26,930

Table 7-3: Minimum Normalized Pre-Conversion Consumption (kWh) Required for select benefit-cost ratios

Target B/C Ratio	Water Heat Only	
	Pre-Conversion Total Consumption	Pre-Conversion Heat Consumption
0.5	2,996	0
1	34,246	6,278
1.5	65,496	13,421
2	>75,000	>20,000
2.5	>75,000	>20,000
3	>75,000	>20,000
3.5	>75,000	>20,000
4	>75,000	>20,000
4.5	>75,000	>20,000
5	>75,000	>20,000

As the tables above shows, the break-even points differ across conversion groups, with the combined conversion breaking even at the lowest pre-consumption level. Moreover, the Space Heat Only conversions have the steepest slope.

The effect of implementing alternative selection criteria on the average benefit cost ratio are summarized in Table 7-4 below. For each cut-off cost-effectiveness level we indicate what percent of the program would have still qualified and what the overall benefit-cost ratio would have been with that cut off.

Table 7-4: Average Benefit/Cost Ratios Using Different Pre-Conversion Total Consumption Selection Criteria:

Measure Group	% of Sample	Minimum B/C Ratio	Average Benefit/Cost Ratio
SPACE HEAT AND WATER HEAT	90%	1	2.0 (1.6, 2.3)
	73%	1.5	2.3 (2, 2.7)
	32%	2	2.8 (2.2, 3.4)
	15%	2.5	3.6 (2.8, 4.4)
SPACE HEAT ONLY	77%	1	1.8 (1, 2.6)
	54%	1.5	2.6 (1.8, 3.3)
	38%	2	2.9 (1.8, 3.9)
	31%	2.5	3.2 (2, 4.3)
WATER HEAT ONLY	99%	0.5	0.3 (0.2, 0.5)
	3%	1	0.4 (0, 1.3)

There is evidence that targeting households with a certain heating load can lead to improved benefit/cost ratio for space heat and water heat conversions, and space heat only conversions. There are no cut-offs that help target the water heater conversion.

7.1.1 Recommendations from Targeting

The cut-offs provided above will facilitate increase cost-effectiveness of the space heat conversion measures if that is a goal of the program. As expected, the tighter eligibility requirements will decrease the number of participants in the program compared to with cut-offs.

The water heater conversion measure does not generate enough savings or show sufficient differentiation with any available characteristics to allow for the identification of useful cut-offs. Water consumption and heated water consumption are known to be correlated with the number of occupants in a household. These data are not available for analysis, but if the number of occupants were screened, it is possible that households with greater than two occupants would provide greater cost-effectiveness than those with fewer occupants.

8 PROCESS EVALUATION

The purpose of the Fuel Conversion process evaluation is to provide findings and recommendations to aid in program planning and management. DNV GL conducted a process evaluation using in-depth interviews and surveys to:

- Investigate current program operations from multiple perspectives,
- Determine program process successes, barriers, and weaknesses, and
- Synthesize feedback from program stakeholders.

The process evaluation included in-depth interviews with program staff, the development of a program logic model, and administration of the participant survey that included impact as well as process components. The outcomes for these tasks are to:

- Develop a program logic model to guide the process evaluation and application of evaluation findings to program planning and management.
- Assess participant satisfaction with the program and identify actionable methods to increase the efficiency and effectiveness of program delivery.

The first task of the Fuel Conversion Program process evaluation included in-depth interviews with PSE staff who work closely with the program: the Market Manager-Dealer Channel, the Market Manager- Energy Advisors, and the Program Manager. These interviews were important in defining the components of the program marketing, delivery, and creating a logic model.

8.1 Program Description

The Single Family Fuel Conversion Program provided by Puget Sound Energy offers rebates up to $3,550 for switching from electric fuel to natural gas. The rebate is limited to current PSE electricity customers in single family homes located in a natural gas service area for PSE or for Cascade Gas.

8.1.1 Marketing

PSE supports a number of different avenues for program outreach and marketing. In the staff interviews, the interviewees spoke about their roles in marketing and outreach of the program. If a customer calls PSE with questions about their bill or interest in saving money, the Energy Advisor (EA) describes different energy saving opportunities, including the Fuel Conversion Program. The customer will then need to confirm their eligibility with the Construction Department and then speak with a contractor or the EA to discuss water and/or space heat conversion. At the time of the DNV GL interviews, PSE was working on streamlining the qualification steps and this process may have changed.

Though EAs are an important gateway to the program, contractors are still the primary marketing and outreach partners according to the Market Manager-Dealer Channel and the Program Manager. PSE supports contractor awareness campaigns to ensure that contractors know about the program and have the resources to market the program to potential customers. According to interviewees, PSE created the Contractor Alliance Network to facilitate connections and give contractors the ability to act as agents for PSE. The Contractor Alliance Network provides information on PSE programs, including Fuel Conversion. There is an initial products training and continuing education requirement to keep contractors up to date on program details. PSE provides supplemental marketing materials targeted to customers in the form of emails, newsletters, and information on the website.

Interviewees discussed the benefit of collaborative engagement with contractors as well as other organizations whenever possible. One interesting example of collaborative marketing mentioned by the Market Manager of the Dealer Channel was with a water heating company. The company received financing from the distributor so they could add to the program rebate to offer a combined rebate.

8.1.2 Program Delivery

As mentioned in the previous section, the Energy Advisors are an important gateway to participation in the program. This is the case whether customers hear about the program from PSE website or from contractors, or other organization or media source. The EAs ask a range of questions to best understand how to assist the customer and if, depending on information provided, the Fuel Conversion seems like the best fit, they will direct the caller to the PSE Construction Department (this has been the process as of 2014, processes may have changed since this data collection).

Once the Construction department confirms customer eligibility, the Energy Advisor typically recommends a Tier 1[5] contractor to perform the work. The customer may choose to use that contractor or find their own, as long as the business is a member of the Contractor Alliance Network. The contractor generally also confirms eligibility, completes the projects, and submits paperwork for the rebate. The program delivery steps are outlined in greater detail in the Logic Model section of this report.

8.2 Staff Interview Findings

DNV GL summarized the results from the in-depth interviews and reviewed relevant program documents. The in-depth interviews provided insight to a number of important points about the Fuel Conversion Program. Important points of note are also listed below:

Constraints:

- Costs associated with moving the gas meters and, in some areas, street repair, impeded project participation. These costs tend to be beyond PSE's control yet they do affect the program's rate of success.
- The PSE Construction Services Office is undergoing a major restructuring at this time that may influence program delivery in potentially unforeseen ways.
- Customers without 12 consecutive months of billing data are ineligible. According to interviewees, this can cause frustration for customers interested in Fuel Conversion Program.

Collaborative efforts:

- Partnerships are an important strength of the program, including strong working relationships with contractors and successful marketing and outreach with Cascade Gas.
- Energy Advisors are important gatekeepers and salespeople for the program. They also serve as the feedback loop for customer complaints and compliments. Improvements under development now will seek to provide improved information and create a seamless transition for the customer from the advisor to the program.

Program staff questions regarding customer experience:

- Interviewees were interested to know whether there was a change in participant's energy bill after the Fuel Conversion. This is something the DNV GL addressed in the survey task of the process evaluation.

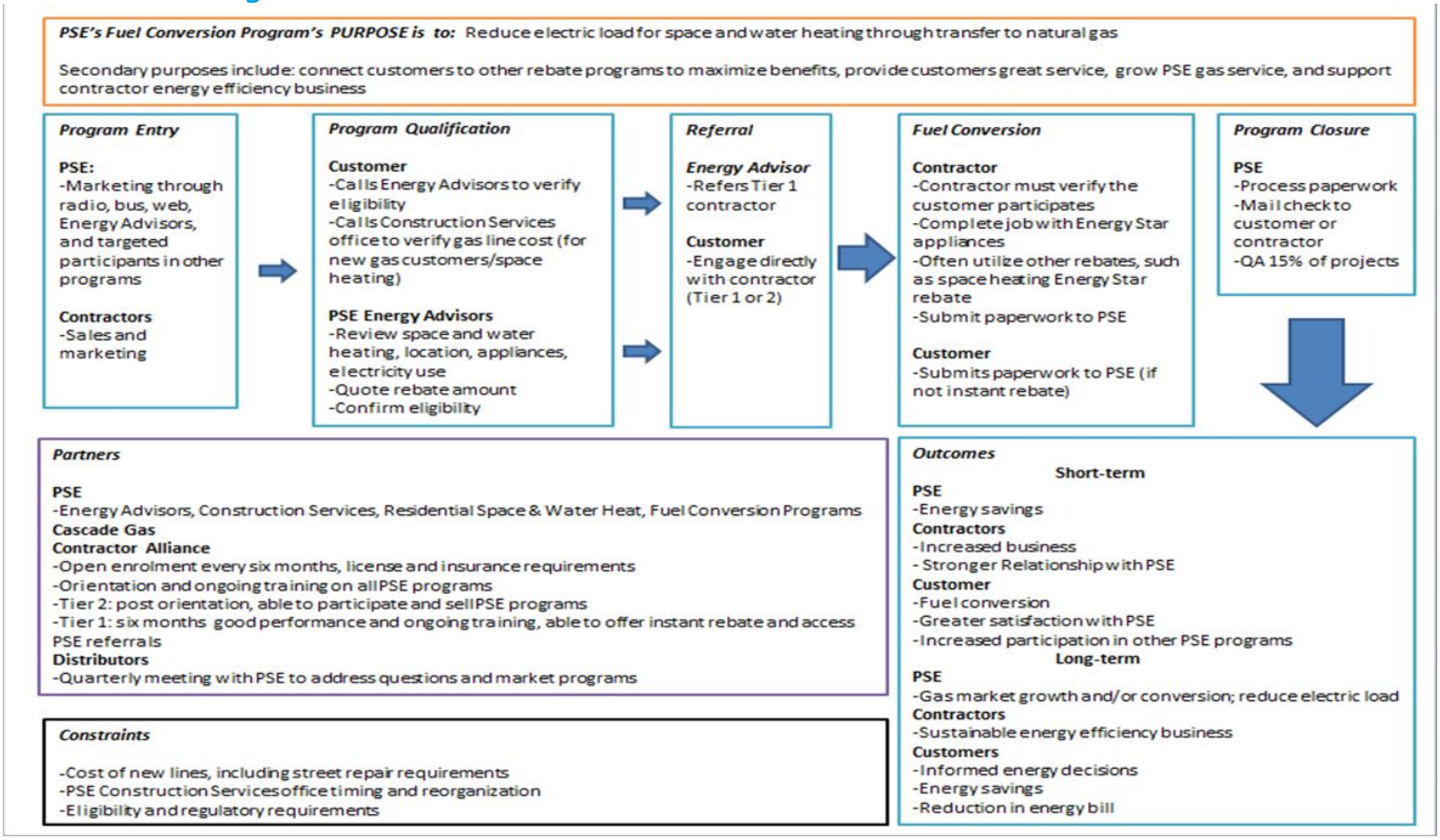
[5] Eligible contractors fall into one of two tiers. Tier 2 is the entry tier made up of pre-screened contractors within the Contractor Alliance Network. If a contractor meets specific performance requirements in the first six months of participation in the Contractor Alliance Network, then they can be approved for Tier 1. PSE reviews contractor performance every six months. The Fuel Conversion program also treats Tier 1 contractors slightly differently. Tier 1 contractors get instant rebates from the program. They can also get referred by PSE to customers. There is a small fee for any referrals that eventually include any installations. Contractors can opt in/out of referrals (according to Malcolm).

- Other questions related to transferring customers to Cascade Gas, and accessing usage data after the fuel conversion for those customers.

DNV GL used the interview feedback to develop the Fuel Conversion Logic Model. A logic model is a framework or picture that lays out the program theory graphically. A logic model identifies partners (stakeholders), necessary resources, activities, and how these activities (and inputs) can lead towards reaching the program goals; it also identifies potential, constraints that should be monitored/addressed to ensure success in reaching outcomes. A logic model allows program staff to thoroughly think through how various activities/resources and interactions can lead to a desired short, near and long-term goal. It allows them and other stakeholders to plan for program needs, build consensus around goals, and match program outcomes to evaluation and measurement.

DNV GL also used in-depth interview responses to inform the development of the participant survey and the creation of the final report.

8.2.1 Logic Model



8.3 Participant Satisfaction

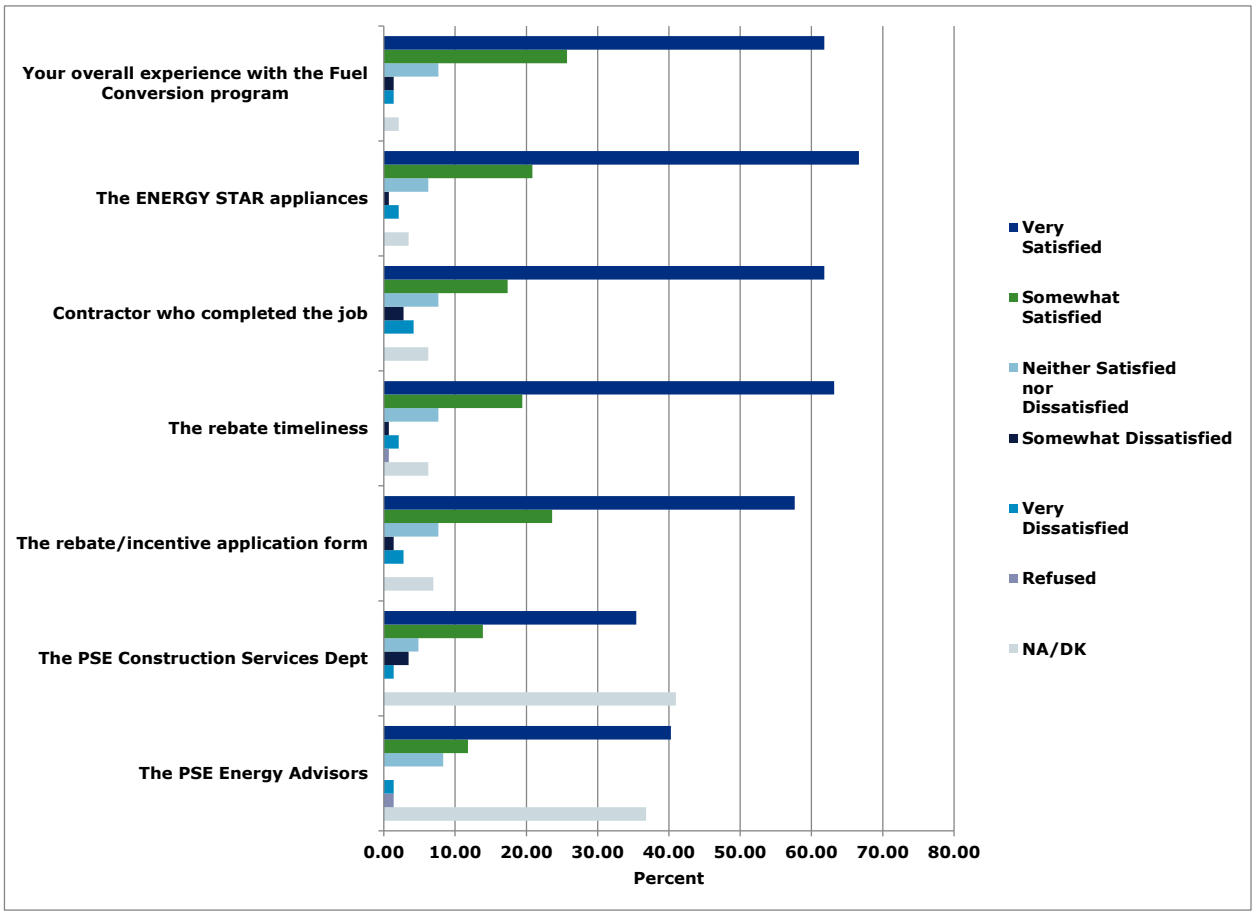
The primary purpose of the participant survey was to assess participant satisfaction with different aspects of the Fuel Conversion Program. Participants provided satisfaction ratings on seven specific program attributes:

- The PSE Energy Advisors
- The PSE Construction Services Dept.
- The rebate or incentive application form
- The rebate timeliness
- The contractor who completed the job
- The ENERGY STAR appliances
- Their overall experience with the Fuel Conversion program

For each of these attributes, we asked respondents to use a five-point scale, where one is very dissatisfied and five is very satisfied. Table 8-1 shows participant satisfaction rating by program attribute.

Figure 8-1 illustrates that all attributes showed a high degree of satisfaction where a response was supplied. The "Very Satisfied" results dominate all lower satisfaction responses. Customers giving a rating of 5 ("Very Satisfied") or 4 ("Somewhat satisfied") represent at least 80% of customers when the "Don't Know/Not Applicable" responses are removed. 90% of customers were very or somewhat satisfied with the overall experience with the program.

Figure 8-1 Program Satisfaction of Surveyed Participants by Program Attribute



Removing the "Don't Know/Not Applicable" responses for the questions targeting energy advisors and the PSE construction services department, customers rate their satisfaction with these two groups as very or somewhat satisfied at a solid 85% and 84%, respectively. This is consistent with the 84% rating for contractors. According to the Staff interview, the Energy Advisors and Construction Services Department were both important gateways to program participation and program approval. Where participants interacted (or remembered interacting) with these groups, their experiences were overwhelmingly positive.

The high levels of "Don't Know/Not Applicable" for the questions relating to energy advisors and the PSE construction services department do raise a question. They may reflect the structure of the program, where customers converting only water heat may not interact with either group. The results inFigure 8-3, below, appear to support this conclusion with water heat conversion showing higher levels of don't know/not applicable. It may also reflect the pass-through nature of the relationship compared to the contractor. Because the responses that are provided are so positive, these responses are not a red flag but may highlight an opportunity. PSE may be able to improve the marketing of the Energy Advisors as an ideal connection point with PSE. They clearly do a good job with customers and expanding or enhancing their exposure to the customer will enhance customer knowledge of PSE, other energy efficiency programs etc.

Conversion program processes also rated highly. Customers rated their satisfaction with both the application process and the timeliness of the rebate payment as very or somewhat satisfied at 87% and 88%, respectively. Finally, customers rated themselves as very or somewhat satisfied with EnergyStar appliances 91% of the time. This result may reflect the customers' total experience with EnergyStar beyond the program, but it is also an indication of satisfaction with the integration of EnergyStar gas installations with the conversion program.

Table 8-1 provides the tabular results presented in Figure 8-1.

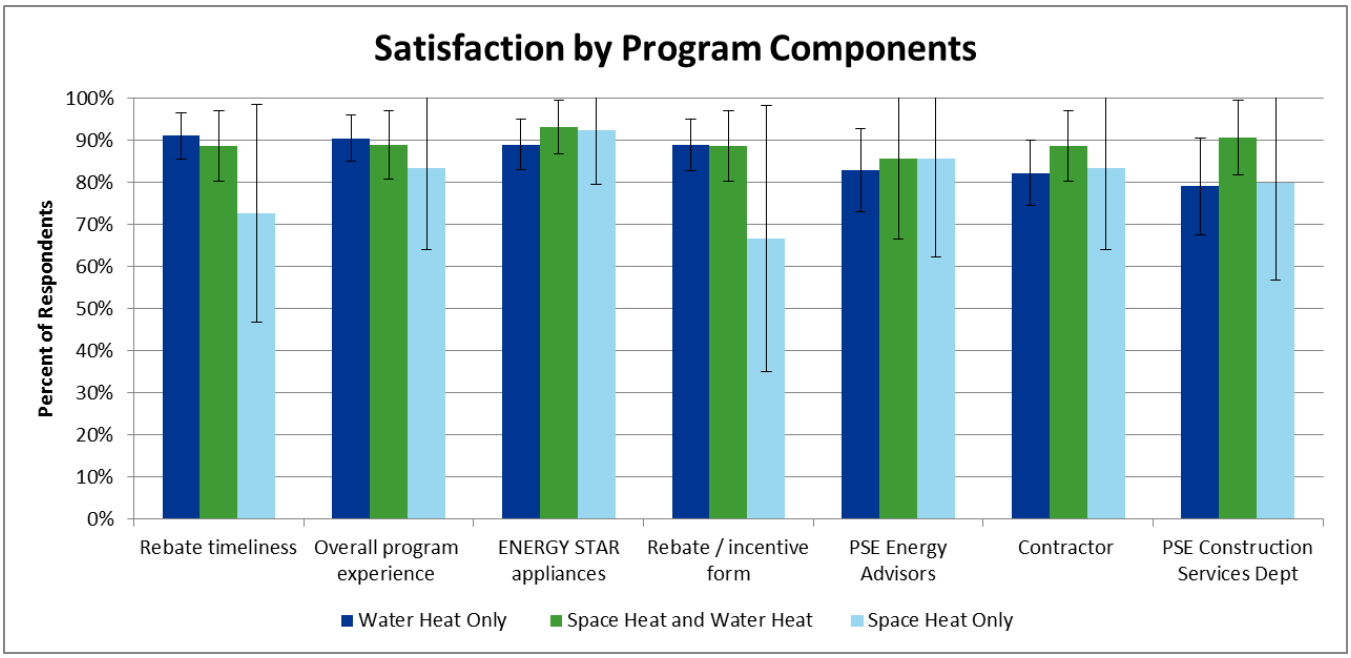
Table 8-1: Total Respondent Satisfaction by Program Attribute

All Conversion Groups (n=144)	Very Satisfied	Somewhat Satisfied	Neither Satisfied nor Dissatisfied	Somewhat Dissatisfied	Very Dissatisfied	NA/DK
The PSE Energy Advisors	40% (36%, 44%)	12% (9%, 15%)	8% (6%, 11%)	0% 0%	1% (0, 2%)	37% (32%, 41%)
The PSE Construction Services Dept.	35% (31%, 39%)	14% (11%, 17%)	5% (3%, 7%)	3% (2%, 5%)	1% (0, 2%)	41% (37%, 45%)
The rebate or incentive application form	58% (54%, 62%)	24% (20%, 27%)	8% (5%, 10%)	1% (0%, 2%)	3% (1%, 4%)	7% (5%, 9%)
The rebate timeliness	63% (59%, 67%)	19% (16%, 22%)	8% (5%, 10%)	1% (0%, 1%)	2% (1%, 3%)	6% (4%, 8%)
The contractor who completed the job	62% (57%, 65%)	17% (14%, 20%)	8% (5%, 10%)	3% (1%, 4%)	4% (3%, 6%)	6% (4%, 8%)
The ENERGY STAR appliances	67% (63%, 71%)	21% (17%, 24%)	6% (4%, 8%)	1% (0%, 1%)	2% (1%, 3%)	3% (2%, 5%)
Your overall experience with the Fuel Conversion program	62% (58%, 66%)	26% (22%, 29%)	8% (5%, 10%)	1% (1%, 2%)	1% (1%, 2%)	2% (1%, 3%)

Survey Question: SATIS1 For each of the following program components, please tell me how satisfied or dissatisfied you were, using a scale from one to five, where one is very dissatisfied and five is very satisfied: a) The PSE Energy Advisors, b)The PSE Construction Services Dept., c)The rebate or incentive application form, d)The rebate timeliness, e)The contractor who completed the job, f)The ENERGY STAR appliances g)Your overall experience with the Fuel Conversion program

As mentioned throughout this report, there are three different types of fuel conversion available to participants. The survey targeted all three participation segments. Water heat only conversions were the most common among respondents (N = 85), followed by space and water heat conversions (N = 45), and space heat only conversions were the least common (N = 14). Figure 8-2 shows the percentage of respondents who rated their satisfaction with each program component as "very satisfied" or "somewhat satisfied (a 4 or 5 on the 5 point scale). The ratings are segmented by program participation.

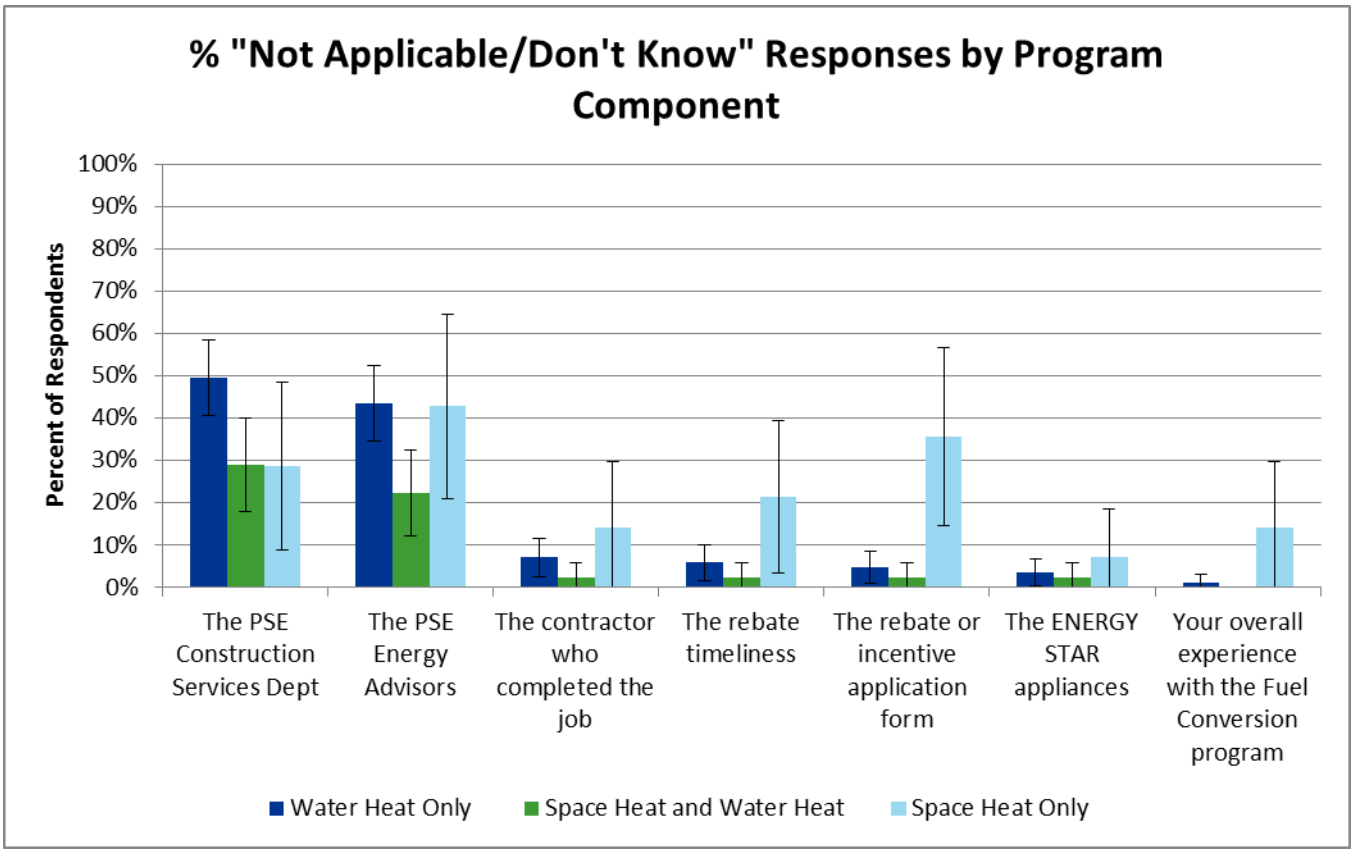
Figure 8-2: Percentage of Very or Somewhat Satisfied by Program Participation



Respondents who converted space heating fuel only (n=14) frequently rated their satisfaction lower across all program components. The sample was small and therefore has a wider confidence interval than the other two groups so in some instances these results may not be statistically significant. However, it is worth considering what might drive this lower trend given its frequency across the attributes. Nothing in the other results developed offers insight into the reasons for this finding.

Figure 8-3 provides the percentage of respondents who answered with a "Don't Know/Not Applicable" response. Two trends are apparent in these data. First, the relative high rate of "Don't Know/Not Applicable" for the Energy Advisors and Construction Services Department are somewhat unexpected, especially the former. Many water heat conversion participants may not interact with Energy Advisors, but most of the others participants would have in the application process. Space and water heater conversion participants have much higher levels on these questions than any of the others. While it is not important for participants to specifically remember the Construction Services group, Energy Advisors are intended to be a primary point of contact for customers, and it would be better if they were better remembered.

Figure 8-3: Percentage "Don't Know/Not Applicable" by Program Participation



Second, the space heat only group had a higher level of non-response for all questions. This, combined with the frequent lower levels of satisfaction raises the question as to whether the experience of this small subgroup is sub-optimal in some way. As stated before, the number of respondents was small, so these results are primarily suggestive, but given the consistency across the answers, it might be an area worth pursuing.

The survey asked participants whether they noticed any change in their energy bill. Table 8-2 shows the responses and confidence interval range for participants across the three different conversion groups, as well as the total response for all groups.

Table 8-2: Change in Energy Bill Post Conversion by Program Participation[6]

Conversion Group	Increase	Decrease	No change	NA/DK
Space and Water Heat (N = 45)	2% (0%*, 6%)	89% (81%, 97%)	4% (0%*, 10%)	4% (0%*, 10%)
Space Heat Only (N = 14)	0% (0%, 0%)	86% (70%, 100%*)	7% (0%*, 19%)	7% (0%*, 19%)
Water Heat Only (N = 85)	12% (6%, 18%)	62% (54%, 71%)	9% (4%, 15%)	16% (10%, 23%)
All Conversion Groups (N = 144)	8% (5%, 10%)	73% (69%, 77%)	8% (5%, 10%)	12% (9%, 15%)

(Satis3) What change, if any, have you noticed in your total gas and electric energy bill; after the fuel conversion?

As Table 8-2 indicates, the majority of respondents across all groups reported a decrease in their energy bill after completing a fuel conversion project. Respondents who switched both space and water heat were the most likely to report that the fuel conversion reduced their energy bill (89% compared to 86% for Space Heat Only, and 62% for Water Heat Only). The water heat result is statistically significantly different from the two space heat options.

The survey also asked respondents about any changes in the comfort of their homes after the fuel conversion. Table 8-3 shows the results by project and across all conversion groups. Those who completed Space Heat Only conversions were the most likely to report that they noticed an increase in comfort (86%). Seventy-six percent of respondents who had Space and Water Heat conversions reported that they noticed an increase in comfort, while only 49% of Water Heat Only reported an increase in comfort.

Table 8-3 Change in Home Comfort by Program Participation[7]

Conversion Group	Increase	Decrease	No change	NA/DK
Space and Water Heat (N = 45)	76% (65%, 86%)	0% (0%, 0%)	20% (10%, 30%)	2% (0%*, 6%)
Space Heat Only (N = 14)	86% (70%, 100%*)	7% (0%*, 19%)	0% (0%, 0%)	7% (0%*, 19%)
Water Heat Only (N = 85)	49% (40%, 58%)	4% (0%, 7%)	44% (35%, 52%)	4% (0%, 7%)
All Conversion Groups (N = 144)	61% (57%, 65%)	3% (1%, 4%)	32% (28%, 36%)	3% (2%, 5%)

8.3.1 Recommendations for Improvement

When asked, "What suggestions, if any, do you have for improving the program?" 6 out of 10 (63%) stated that they could not think of any ways to improve. Most of those respondents did not elaborate, but some stated that "the program is good the way it is."

Eleven percent of respondents (16 out of 144) stated that the program would improve with better customer service. Those respondents reported confusion working with different program partners, and requested more

[6] We provide confidence intervals as an estimation of the potential variability compared with the entire population of program participations. Since the CATI survey respondent group for some segments, particularly the Space Heat Only group, there is a wide range for variability. Because of this variability, some of the confidence intervals reported lower bounds below 0% and in one incidence an upper bound above 100%. DNV GL has applied a rational ceiling to those values and only reported results within possible bounds, i.e.: it would not be possible to have a negative response rate or a response rate over 100% for a survey question. The values are marked by asterisks in Table 8-2: Change in Energy Bill Post Conversion by Program Participation.

[7] See previous footnote

and clearer program information, for example: "the people that we had to deal with should be a lot more knowledgeable about what is going on [with the program]"

The remaining 26% percent provided comments that span across six different topics. Although the numbers are small, the information could prove useful feedback for program managers:

- Ten respondents noted PSE should "let more people know about the program" suggesting a need to increase the level of marketing in order to increase participation. Most of these respondents were very happy with the program, and suggested making more people aware of the opportunity.
- Nine respondents recommended expanding and increasing rebates, "give more rebates and higher rebates, and people would do more."
- Eight respondents mentioned challenges working with the program qualified contractors. Some of those respondents stated that contractors did not have necessary program information, "Make sure to mail out the details before the contractors start the job. The [approved] equipment needs to clearly written and understood." Others stated that they had worked with contractors who were not educated on the program or energy efficiency requirements, "[PSE needs] to qualify the contractors more. [One company] installed a unit that was not ENERGY STAR. Either They were fraudulent or do not have knowledgeable staff."
- Six respondents recommended program improvements related to the energy efficiency measures. Recommendations included increasing the number of qualifying measures, greater research into each measure's functionality, and providing more product information to help the consumer choose appropriate measures for installation. All of these respondents had converted to Water Heat, and some mentioned specific problems with energy efficient washing machines and tankless water heaters: "do not give rebates for the tankless water heaters because they do not work."
- Three respondents recommended conducting evaluations closer to the time of program participation, "this call should be made closer to the fuel conversion, instead of calling us three years later."
- Two respondents requested that the program focus on solar energy, "I feel like natural gas is a bridge fuel source that will help us for a short time. I would like to see PSE have more programs encourage solar."

9 APPENDIX: DETAILED DATA DISPOSITION

9.1 Appendix: Fuel Conversion Tracking Data Preparation

The DNV GL evaluation team received two files from PSE containing program tracking data. The first contained program participants from 2011-2013. The second included 2014 participants. Slight differences in the two files required separate processing before the two files were combined into a single tracking dataset containing all 2011-2014 participants.

Once the two files were sufficiently prepped for combination, the next task was using the crosswalk datasets provided by PSE to link the account/premise IDs from the pre-April 2013 billing system to those from the post-April 2013 billing data, hereafter referred to as the 'old' and 'new' billing systems, respectively.

9.1.1 Preparation of 2011-2013 Tracking Data

Prior to combining the two tracking datasets, each dataset was separately prepared. This involved dropping irrelevant variables, changing relevant variables to the appropriate type, and identifying unique participant sites. For the last task, the team identified duplicates of the following combination:

(old system account id)- (new system account id)-(old system premise id)-(new system premise id)

The team chose this combination because of the need to link the account/premise id combinations from the old and new billing systems. Most of the duplicate entries were the result of error corrections, and were removed from the final tracking dataset. Following these preparation steps, the 2011-2013 tracking dataset had 788 unique participant site combinations.

9.1.2 Preparation of 2014 Tracking Data

Preparation for the 2014 tracking data followed a similar path, with slight adjustments stemming from differences between the two files provided by PSE. In particular, one of the corrections in the tracking data involved combining space and water heat conversions that had been coded as both combined conversions and as separate water and heat conversions. These duplicates were consolidated. The 2014 tracking dataset had 262 unique participant site combinations.

9.1.3 Combining 2011-2013 and 2014 Tracking Data

At a high level, this step in the data preparation involved combining the 2011-2013 and 2014 tracking datasets, determining which billing system ids were missing for each participant premise, using the crosswalk datasets to obtain system ids missing from the original tracking datasets, and describing the final distribution of system ids. The evaluation team removed from the analysis sites that did not have both the 'new' and 'old' system account and premise ids.

9.2 Appendix: Fuel Conversion Consumption Data Preparation

The preparation of consumption data consisted of two main tasks: integrating 'old' and 'new' consumption data systems, and integrating daily and monthly consumption data. The former was necessary because PSE

switched to a new billing system in March of 2013. The latter was necessary, because new system data for 2014 was not provided with the original data request.

9.2.1 Pull Daily Consumption Data/Aggregate Daily Data to Monthly

For 2013 and 2014 consumption data, the evaluation team used daily data provided to DNV GL. For the purposes of this evaluation, the daily consumption was aggregated to the monthly level.

9.2.2 Preparation January 2010-March 2013 Data

The inputs for this step consisted of the following:

- Monthly consumption data from January 2010-March 2013 for participants who converted in 2011-2013
- Monthly consumption data from January 2011-December 2013 for participants who converted in 2014
- Old system/new system id crosswalk datasets provided by PSE

The data were reshaped from wide to long, key variables were recoded from character to numeric, and new system ids were added to the datasets using the crosswalk datasets provided by PSE.

9.2.3 Preparation April 2013-December 2013 Data

The inputs for this step consisted of the following:

- Monthly consumption data from 'old' monthly system data (January 2013-March 2013)
- Monthly consumption data from 'new' monthly system data (April 2013-December 2013)
- Old system/new system id crosswalk datasets provided by PSE

The monthly consumption data from the 'old' system were reshaped from wide to long, key variables were recoded from character to numeric, and new system ids were added to the datasets using the crosswalk datasets provided by PSE. These datasets were then appended

9.2.4 Preparation January 2014-December 2014 Data

The inputs for this step consisted of the following:

- Daily consumption data aggregated to the monthly level

The daily datasets were aggregated to the monthly level

9.2.5 Combining of January 2010-December 2014 Data

The inputs for this step consisted of the following:

- Monthly consumption data from the 2010-2012 system and 2013-2014 system
- Program tracking data containing measure/site characteristics that were relevant to the consumption change analysis

In this program, the consumption datasets from each system were prepped and then separately merged to the tracking dataset on all four account/premise ids (from both the old and new systems). A unique fuel id corresponding to each account/premise id combination was created.
The two system datasets were stacked, and the outputs (along with a list of account/premises that were not matched to the consumption data, were outputted).

9.2.6 Consumption Data Checks

The input for this step consisted of the following:

- Monthly consumption data from 2010-2014

In this program, various checks are run on the consumption datasets. In particular, for each unique fuel id, the number of bill periods are counted, duplicate bill months are either combined (if the consumption values correspond to an estimate and adjustment), or flagged. Bill dates that are invalid (overlapping bill start and end dates, e.g.) are flagged. Finally, average daily values for each bill period are calculated, and sites with missing, zero, negative, and extreme reads (sites with at least one average daily consumption value in 99th percentile of consumption across all sites) are flagged. The final dataset (with site level flags included) is outputted, and the average daily use over the entire evaluation period is plotted.

9.2.7 Merge Consumption Data with Temperature Data

The inputs for this step consisted of the following:

- Monthly consumption data from 2010-2014
- Daily actual and 10-year average temperature data for 2006-2013 and 2014 (two datasets)

In this program, the following tasks are performed: the two temperature datasets are combined and subsetted to include only the evaluation period. Degree days are generated for all degree day base temperatures that will be used in the analysis, and in the case of TMY, the degree days are summed over an entire year. This value is required for the calculation of normalized annual consumption.

Next the program calculates average degree days per billing period for each site. This is done by merging the billing data set to the weather data set using zip codes. Approximately 25% of zip codes found in the billing data were not found in the temperature data. In these cases, the program substituted the closest available zip code that was found in the temperature data to find the appropriate weather station.

Finally, the program outputs a list of sites that did not match to any weather stations, and plots the average daily consumption and average actual/TMY temperature data by bill month for each site. The dataset that is output from this program contains site/measure characteristics, average daily consumption for each bill month, as well as temperature and average degree days by bill period for each site.

9.2.8 Prepare Consumption and Temperature Dataset for PRISM

The input for this step consisted of the following:

- Combined monthly consumption/temperature/Degree Day data from 2010-2014

The full input dataset is divided into subsets for analysis. The first way generates constructed comparison groups for each of the three years of participant data (2011-2013). Each of these "waves" is outputted as a separate dataset on which the PRISM code is run. These datasets are then combined to construct program-level savings estimates. The data are subsetted by year for the site level pre/post consumption change analysis that is used in the cost-effectiveness estimate.

9.2.9 Plot Prepped Electric and Gas Consumption Data

The input for this step consisted of the following:

- The prepped gas and electric consumption data for constructed comparison/treatment group analysis dataset (3 datasets corresponding to 3 waves for each fuel type)
- The prepped gas and electric consumption data for each program evaluation year (3 datasets corresponding to 3 waves for each fuel type)

This program plots the data that has been subsetted in advance of PRISM analysis. In particular, for each fuel/wave combination, it plots the following:

- Average daily consumption against average actual monthly temperature and the 10 year average monthly temperature.
- Average daily consumption for pre/post gas and electric consumption

10 PARTICIPANT SURVEY INSTRUMENT

The Fuel Conversion Program evaluation includes a survey of past participants (2011-2014) in the Fuel Conversion Program. The surveys will provide valuable information to estimate free ridership, characterize alternative conversion baselines, and assess customer satisfaction with various elements of the program. The evaluation work plan outlined CATI goals:

- Free Ridership and Alternative Baselines
    1. Confirm that the respondent was active in the decision-making process
    2. Establish pre-program gas service level – No gas, gas space heat only, gas water heat only
    3. Understand the full extent of work that was done - Was the conversion part of a bigger project, etc.
    4. Lay the groundwork with framing questions that help return the respondent to their frame of mind at the time the decisions were made
    5. Investigate different dimensions of what the respondent might otherwise have done including the following alternatives: change existing electric space of water heating; convert space or water heat to gas, and install standard or efficient equipment

- Customer Satisfaction
    6. The customer's interactions with the program and program contractors
    7. Satisfaction with the installation process for new measures
    8. Satisfaction with the outcome based on comfort, reduced bills, etc.

10.1.1 Database Variables

Variable	Description
<ADDRESS>	Program participant address
<MONTHYEAR>	Season (fall, winter, etc.) and year Fuel Conversion completed
<SPACE/WATER/SPACE AND WATER>	Heating Converted

10.1.2 Introduction/Screener

I0 Hello, my name is _____, and I'm calling on behalf of Puget Sound Energy. May I speak with <CONTACT NAME>?

[IF CONTACT NAME IS AVAILABLE, READ I1]
[IF CONTACT NAME IS NOT AVAILABLE, ASK]

I am calling to talk to you about your participation in the Fuel Conversion program. This is a voluntary survey we are conducting on behalf of Puget Sound Energy to help them improve their energy-efficiency programs, and should take less than 10 minutes to complete.

I1. Are you familiar with this household's decisions about electric and gas service in the past year? IF "YES" GO TO CELL1 **[IF NEITHER AVAILABLE, ARRANGE FOR CALLBACK]**

[IF NECESSARY:
PSE is conducting a survey about households' energy decisions in their service area.

This is NOT a sales call and the information that you provide will be kept strictly confidential

Puget Sound Energy will use your input to improve the programs they offer to residential customers.

You may validate the legitimacy of this study by contacting Jim Perich-Anderson via phone at 425-424-6435]

CELL1 Great, I just need to ask a few questions before we can get started on the survey, have you received this call on a wireless phone or on a landline phone?

1	WIRELESS	GOTO CELL2
2	LANDLINE	GOTO I2
98	DON'T KNOW	CALLBACK
99	REFUSED	CALLBACK

CELL2 Are you driving a vehicle or using any equipment or machinery that requires your attention?

[INTERVIEWER: IF RESPONDENT SAYS YES, READ] Due to safety reasons we will need to call you back at a more convenient time. Thank you very much.

1	YES	CALLBACK
2	NO	I2
98	DON'T KNOW	CALLBACK
99	REFUSED	CALLBACK

I2 Do you or anyone else in your household work for a gas or electric utility, including Puget Sound Energy?

1	Yes	SPECIFY:_____ ➔THANK & TERMINATE
2	No	I3
98	DON'T KNOW	THANK & TERMINATE
99	REFUSED	I3

I3. According to our records, your household <**ADDRESS**> participated in PSE's Fuel Conversion program in <**MONTHYEAR**>. Is that correct?
[IF NECESSARY:

- Are you familiar with the program that encourages customers to convert to natural gas as the primary source for their space heat and/or water heat uses?
- The PSE Fuel Conversion program provides rebates for single-family retrofit measures and services to convert to natural gas as the primary source for their space heat and/or water heat uses.]

1	Yes	I4
2	No, different address	TT
2	No, different program date	[CORRECT PROGRAM DATE, PROCEED TO I3a]
98	DON'T KNOW	Find other contact/ Reschedule/TT
99	REFUSED	Find other contact/ Reschedule/TT

I4. According to our records, your home switched **your <SPACE/WATER/SPACE AND WATER>** heating from Electric to Natural Gas. Is that correct? By space heating I mean your heater or furnace. [MARK THE ONE CORRECT OPTION]
[IF NECESSARY: We are calling today to ask only about switching to natural gas through the PSE Fuel Conversion program.]

1	Gas **Space** Heating ONLY	PE0
2	Gas **Water** Heating ONLY	PE0
3	Gas Space and Water Heating **BOTH**	PE0
98	DON'T KNOW	Find other contact/ Reschedule/TT
99	REFUSED	Find other contact/ Reschedule/TT

10.1.3 Previous Equipment

PE0. I have a few questions about your home's **previous** fuel source and heating equipment.
[IF I4 = 3, SKIP TO PE2]

PE1. **Before** the fuel switch to <I4>, did your home have any gas service?

1	No gas	PE2
2	Gas space heat only	PE2
3	Gas water heat only	PE2
98	DON'T KNOW	PE2
99	REFUSED	PE2

PE2 Who is your natural gas service provider **now**? IF NEEDED: Sometimes this changes after the fuel conversion.

1	PSE	IF I4 = 1, 3; THEN PE3 IF I4 = 2; THEN PE5
2	Cascade	
77	OTHER, SPECIFY	
98	DON'T KNOW	
99	REFUSED	

PE3. Do you recall what type of space heating system your home had previously…?

1	Electric Baseboard – Long electric heaters on the wall by the floor	PE4
2	Forced air – Furnace with ducts	
3	Hot Water – Radiators or in-floor radiant heat	
77	[Other] Specify	
98	DON'T KNOW	
99	REFUSED	

PE4. Do you know how old your previous space heating system was when you replaced it?

1	Yes, SPECIFY:____	IF I4 = 3; THEN PE5 IF I4 = 1; THEN M0
2	No	
98	DON'T KNOW	
99	REFUSED	

PE5. Do you recall if your previous WATER heater was a…? [READ ALL, CHOOSE ONE]

1	Tank-type (storage)	PE6
2	Tankless water heater	
3	Did not replace an existing WH.	
77	[Other] Specify	
98	DON'T KNOW	
99	REFUSED	

PE6. Do you know how old your previous water heater was when you replaced it?

1	[RECORD AGE]	M0
98	DON'T KNOW	
99	REFUSED	

10.1.4 Installed Measures

M0 Now I have a few questions about what you installed as part of the Fuel Conversion program.
[IF I4 = 1,3; THEN M1. IF I4 = 2; THEN M2]

M1. What type of space heating equipment did you install through the switch to gas space heating?

1	Energy Star Furnace	IF I4 = 3; THEN M2 IF I4 = 1; THEN M3
2	Energy Star Boiler	
77	Other, SPECIFY____	
98	DON'T KNOW	
99	REFUSED	

M2. What water heating equipment did you install through the switch to gas water heating?

1	Energy Star Gas water heater	M3
2	Energy Star Tankless Gas water heater	
3	Energy Star Integrated Boiler/Water Heater	
77	Other, SPECIFY____	
98	DON'T KNOW	
99	REFUSED	

M3. Was the fuel switch part of a larger home project?

1	Yes	M3a
2	No	B0
98	DON'T KNOW	B0
99	REFUSED	B0

M3a What else was included in the project? [DO NOT READ, MARK ALL THAT APPLY]

1	Insulation (roof, wall and/or pipe)	B0
2	High efficiency faucet and/or shower heads	
3	Energy efficient dishwashers,	
4	Energy efficiency washing machines	
5	Energy Efficiency gas ovens	
6	Room addition	
7	Bathroom addition	
8	General remodelling	
77	Other	
98	DON'T KNOW	
99	REFUSED	

10.1.5 Influence on Behavior

B0 Now I'd like to discuss your decision to complete a switch to gas fuel.

B1. What were your main reasons for completing the fuel switch? [DO NOT READ. MARK ALL THAT APPLY]

1	Bill savings	B2
2	Energy efficiency	IF NOT B1=1, THEN B1a
3	Upgrade appliances	
4	Lower emissions/environmental	
77	OTHER, SPECIFY____	
98	DON'T KNOW	
99	REFUSED	

B1a. Were you aware, prior to the program, that gas fuel was less costly than electric?

1	Yes	B2
2	No	
98	DON'T KNOW	
99	REFUSED	

B2. Without the PSE Fuel Conversion program, what would have been the likelihood of your home switching from electric to gas fuel sources? READ 4-1 IF NEEDED

4	Very likely	B3
3	Somewhat likely	B3
2	Not very likely	B3
1	Very unlikely	B3
98	DON'T KNOW	B3
99	REFUSED	B3

B3. In particular, how important was the program **rebate** in your decision to complete the fuel conversion project? ? READ 4-1 IF NEEDED

4	Very important	B4
3	Somewhat important	
2	Not very important	
1	Very unimportant	
98	DON'T KNOW	
99	REFUSED	

B4. ***[Only ask if B2 ≠ "Very Likely" and I4 = 1,3]*** Without the PSE Fuel Conversion program, what type of space heating would you have used?

1	Current system	B5
2	Another standard efficiency heating system	
3	High efficiency heat pump	
77	OTHER, SPECIFY____	
98	DON'T KNOW	
99	REFUSED	

B5. Without PSE's Fuel Conversion program, would you have completed the fuel conversion at the same time as you did, earlier than you did, later than you did, or never?

1	At the same time	B6
2	Earlier	B6
3	Later	B5a
4	Never	B6
98	DON'T KNOW	B6
99	REFUSED	B6

B5a ***[Only ask if B5 = "Later"]*** Approximately how many months later would you have completed the project?
[PROMPT: IF NECESSARY, TRY FRAMING THE TIME AS BEGINNING WITH MORE OR LESS THAN TWO YEARS LATER.]

1. Less than 6 months
2. 6 months to a year
3. 1-2 years
4. 3-4 years
5. 5 or more years

98. Don't know
99. Refused

B6. During the time a year before and a year after **<MONTHYEAR>**, did you make ***any other*** major changes to your home? [DO NOT READ]
[NOTE: IF THE RESPONDENT ASKS WHY WE ARE ASKING THIS QUESTION, EXPLAIN THAT MAJOR CHANGES IN A HOME CAN IMPACT ENERGY CONSUMPTION PATTERNS.]

1	Yes	B6a
2	No	B7
98	DON'T KNOW	
99	REFUSED	

B6a. Please briefly describe these changes to your home?

1	[RECORD RESPONSE VERBATIM] PROBE AND CLARIFY FULLY	B7
98	DON'T KNOW	
99	REFUSED	

B7. Did the number of people living in your home change during that time?
[CLARIFY AS NEEDED. IF NECESSARY: A year before and a year after <**MONTHYEAR**>,]

1	Yes, Increased, SPECIFY_____	IF I4 = 1,3; THEN B8 IF I4 = 2; THEN B10
2	Yes, Decreased, SPECIFY_____	
3	No change	
98	DON'T KNOW	
99	REFUSED	

B8. Since you installed the new space heater, have you changed your thermostat settings?

1	Yes, Increase heat	B9
2	Yes, Decrease heat	
3	No change	
98	DON'T KNOW	
99	REFUSED	

B9. Since you installed the new space heater, have you either stopped using or added any other additional space heating?

1	Stopped using	IF I4 = 1; THEN SATIS0 IF I4 = 3; THEN B10
2	Added	
3	Neither	
98	DON'T KNOW	
99	REFUSED	

B10. Since you installed the new Water Heater, have you changed the amount of HOT water used? DO NOT READ

1	Yes	B10a
2	No	B11
98	DON'T KNOW	
99	REFUSED	

B10a. Would you say the amount of hot water used is more, less, or about the same as you used before installing the new water heater? CLARIFY AS NEEDED

1	More	B11
2	Less	
3	About the same	
98	DON'T KNOW	
99	REFUSED	

B11. If you turned on the hot water only, is the temperature warmer, cooler, or about the same as hot water from your previous water heater? CLARIFY AS NEEDED

1	Warmer	SATIS0
2	Cooler	
3	About the same	
98	DON'T KNOW	
99	REFUSED	

10.1.6 Satisfaction

SATIS0. Next I have a few questions about how satisfied you were with different aspects of this program.

SATIS1 For each of the following program components, please tell me how satisfied or dissatisfied you were, using a scale from one to five, where one is very dissatisfied and five is very satisfied.
[IF NECESSARY: Depending on the type of rebate, some components may not apply] ROTATE A-F, G LAST

		Very satisfied				Very dissatisfied	NA/ DK	Refused
a	The PSE Energy Advisors	5	4	3	2	1	98	99
b	The PSE Construction Services Dept.	5	4	3	2	1	98	99
c	The rebate or incentive application form	5	4	3	2	1	98	99
d	The rebate timeliness	5	4	3	2	1	98	99
e	The contractor who completed the job	5	4	3	2	1	98	99
f	The ENERGY STAR appliances	5	4	3	2	1	98	99
g	Your overall experience with the Fuel Conversion program	5	4	3	2	1	98	99

SATIS2a - [Only ASK IF SATIS1a – f < 3; ASK FOR EACH. ONLY ASK SATIS1g < 3, IF NO OTHERS < 3] Why were you not satisfied with <PROGRAM COMPONENT>?

1	[RECORD]	SATIS3
98	DON'T KNOW	SATIS3
99	REFUSED	SATIS3

SATIS3 What change, if any, have you noticed in your ***total*** gas and electric energy bill; after the fuel conversion?

1	Increase	SATI3a
2	Decrease	SATI3a
3	No change	SATIS4
98	DON'T KNOW	SATIS4
99	REFUSED	SATIS4

SATI3a Roughly how much in dollars has the bill **<increased/decreased>** a month

1	[RECORD]	SATIS4
77	VERBATIME RESPONSE NOT NUMERIC	SATIS4
98	DON'T KNOW	SATIS4
99	REFUSED	SATIS4

SATIS4 What change, if any, have you noticed in the comfort of your home after the fuel conversion? [IF NEEDED: Any change in the comfort or convenience of your water heating?]

1	Increase	SATI4a
2	Decrease	SATI4a
3	No change	
98	DON'T KNOW	
99	REFUSED	

SATI4a In what ways?

1	[RECORD]	SATIS5
98	DON'T KNOW	SATIS5
99	REFUSED	SATIS5

SATIS5 What suggestions, if any, do you have for improving the program?

1	[RECORD]	W0
98	DON'T KNOW	W0
99	REFUSED	W0

10.1.7 Wrap-Up

W0 Those are all the questions I have for you. Is there anything that you want me to pass on to PSE?

1 [RECORD RESPONSE]
2 [No response]
96 REFUSED
97 DON'T KNOW

W1 Thank you very much for your time and opinions.

RECORD GENDER

1 Male
2 Female
3 Can't determine

11 APPENDIX: MODELING METHODOLOGY

11.1 Difference-in-Difference Estimates

There are several ways to calculate the DD estimate that are each mathematically equivalent. The DD approach DNV GL took in this evaluation consisted of calculating the following values:

1. $\Delta C_{Treatment}$: the change in average annual consumption observed after the conversion for the treatment group. This gives us the total change in consumption, and includes any non-conversion changes that may have occurred between these two periods as well. In this evaluation, $\Delta C_{Treatment} = \Delta C_{Treatment}^{Post} - \Delta C_{Treatment}^{Pre}$.

2. $\Delta C_{Comparison}$: the change in average annual consumption observed over the same period for the comparison group. This gives us only the change in consumption due to non-program effects (since this group did not undertake a conversion). In this evaluation, $\Delta C_{Comparison} = \Delta C_{Comparison}^{Post} - \Delta C_{Comparison}^{Pre}$.

3. $(\Delta C_{Treatment} - \Delta C_{Comparison})$: the DD estimate. This will remove non-program related changes in consumption, leaving an estimate of the change due to the program.

12 APPENDIX: AVOIDED COST SCHEDULES USED TO DETERMINE NET BENEFIT

The avoided cost per kWh used in the analysis were taken from the "Residential Space Heat" and "Residential Water Heat" columns of the schedule below, provided by PSE. For conversions that included both space and water heat, these columns were summed, to obtain a total avoided cost associated with the conversion.

Electric Conservation Cost Effectiveness Standard, 2014-2015

Includes Energy and Capacity and does NOT apply the conservation Credit to energy or capacity

	End-use Type						
	Single Family Space Heat	Single Family Heat Pump	Multifamily Space Heat	Residential Water Heat	Residential Refrigerator	Residential Plug Load	Residential Lighting
Measure Life	SF Space Heat	SF Heat Pump	MF Space Heat	Res Water Heat	Res Refrigerator	Plug Load	Res Lighting
1	$ 0.128	$ 0.1192	$ 0.1089	$ 0.0672	$ 0.0573	$ 0.0696	$ 0.0701
2	$ 0.249	$ 0.2319	$ 0.2119	$ 0.1311	$ 0.1115	$ 0.1355	$ 0.1366
3	$ 0.363	$ 0.3385	$ 0.3094	$ 0.1916	$ 0.1632	$ 0.1981	$ 0.1997
4	$ 0.473	$ 0.4411	$ 0.4036	$ 0.2513	$ 0.2147	$ 0.2597	$ 0.2618
5	$ 0.579	$ 0.5403	$ 0.4948	$ 0.3102	$ 0.2659	$ 0.3204	$ 0.3231
6	$ 0.680	$ 0.6361	$ 0.5829	$ 0.3683	$ 0.3167	$ 0.3801	$ 0.3833
7	$ 0.776	$ 0.7259	$ 0.6655	$ 0.4228	$ 0.3641	$ 0.4360	$ 0.4399
8	$ 0.867	$ 0.8120	$ 0.7444	$ 0.4755	$ 0.4100	$ 0.4899	$ 0.4946
9	$ 0.953	$ 0.8926	$ 0.8186	$ 0.5247	$ 0.4529	$ 0.5403	$ 0.5455
10	$ 1.033	$ 0.9687	$ 0.8887	$ 0.5715	$ 0.4939	$ 0.5883	$ 0.5940
11	$ 1.109	$ 1.0402	$ 0.9547	$ 0.6156	$ 0.5327	$ 0.6335	$ 0.6398
12	$ 1.181	$ 1.1077	$ 1.0170	$ 0.6575	$ 0.5696	$ 0.6765	$ 0.6832
13	$ 1.249	$ 1.1720	$ 1.0762	$ 0.6977	$ 0.6048	$ 0.7175	$ 0.7247
14	$ 1.313	$ 1.2327	$ 1.1321	$ 0.7357	$ 0.6381	$ 0.7564	$ 0.7641
15	$ 1.374	$ 1.2899	$ 1.1850	$ 0.7716	$ 0.6699	$ 0.7932	$ 0.8013
16	$ 1.430	$ 1.3437	$ 1.2347	$ 0.8056	$ 0.6999	$ 0.8279	$ 0.8364
17	$ 1.484	$ 1.3942	$ 1.2815	$ 0.8376	$ 0.7283	$ 0.8607	$ 0.8695
18	$ 1.534	$ 1.4420	$ 1.3257	$ 0.8682	$ 0.7554	$ 0.8919	$ 0.9011
19	$ 1.582	$ 1.4872	$ 1.3674	$ 0.8970	$ 0.7810	$ 0.9214	$ 0.9309
20	$ 1.627	$ 1.5297	$ 1.4068	$ 0.9244	$ 0.8052	$ 0.9493	$ 0.9591
21	$ 1.671	$ 1.5520	$ 1.4439	$ 0.9502	$ 0.8282	$ 0.9757	$ 0.9858
22	$ 1.713	$ 1.5729	$ 1.4789	$ 0.9745	$ 0.8499	$ 1.0006	$ 1.0110
23	$ 1.755	$ 1.5924	$ 1.5119	$ 0.9976	$ 0.8705	$ 1.0242	$ 1.0348
24	$ 1.796	$ 1.6107	$ 1.5429	$ 1.0193	$ 0.8899	$ 1.0464	$ 1.0573
25	$ 1.837	$ 1.6277	$ 1.5722	$ 1.0399	$ 0.9082	$ 1.0674	$ 1.0785
26	$ 1.876	$ 1.6437	$ 1.5998	$ 1.0593	$ 0.9256	$ 1.0873	$ 1.0986
27	$ 1.916	$ 1.6587	$ 1.6258	$ 1.0777	$ 0.9421	$ 1.1061	$ 1.1176
28	$ 1.954	$ 1.6727	$ 1.6504	$ 1.0951	$ 0.9576	$ 1.1238	$ 1.1355
29	$ 1.993	$ 1.6858	$ 1.6736	$ 1.1115	$ 0.9723	$ 1.1406	$ 1.1525
30	$ 2.031	$ 1.6980	$ 1.6954	$ 1.1271	$ 0.9863	$ 1.1564	$ 1.1685

The added costs per therm used in the cost effectiveness calculation were taken from the table below:

Additional Cost Of Gas						
Measure	Water Therm	Space Therm	Total Therm	PV One Therm Gas WH (over 30 years)	PV One Therm Gas SH (over 30 years)	PV Gas Costs Per House
Natural Gas Water and Space Heating - BB	197	602	799	8.67	12.51	9,239
Natural Gas Water and Space Heating - FAF	197	602	799	8.67	12.51	9,239
Natural Gas Space Heating Only -BB		602	602	8.67	12.51	7,531
Natural Gas Space Heating Only -FAF		602	602	8.67	12.51	7,531
E2G Fuel Conv - WH Only - Storage	197		197	8.67	12.51	1,708
E2G Fuel Conv - WH Only - Tankless	197		197	8.67	12.51	1,708

13 APPENDIX: NET BENEFIT CALCULATION METHODOLOGY

13.1 PSE's Approach to Cost Effectiveness Calculations

In evaluating program cost effectiveness, PSE uses Total Resource Cost (TRC). The TRC is determined by comparing the electricity savings due to conversion of space and water heat of a typical single family house to the cost of natural gas used to replace the electricity. This section includes a high level description of PSE's approach to determining the FC program's cost effectiveness[8]. The inputs to this calculation framework of cost-effectiveness calculations include the following:

1. Avoided cost of energy
2. Avoided cost of capacity
3. Program overhead costs
4. Customer costs
5. Program incentives
6. Non-energy benefits
7. Measure life
8. Load shape used in calculation of avoided cost
9. discount rate used for calculation of the present value of costs and benefits

In the context of the FC program, the picture is slightly complicated by the fact that avoided cost of electric space and water heat is offset by the added cost of replacing this with gas space/water heat.

The remainder of this section covers how each of the inputs above is determined.

13.1.1 Avoided cost of energy

The tables provided by PSE included the total avoided cost of energy and capacity, as well as the energy conservation credit.

[8] This approach was determined by reviewing the following documents: "Calculating the Cost-Effectiveness of Puget Sound Energy's Efficiency Programs" (2011); "Puget Sound Energy 2012-2013 Biennial Electric Conservation Achievement Review (BECAR) Final Report" (2014)

13.1.1.1 Total Avoided Cost of Energy

The total cost of energy (TCE) avoided is defined as the present value of the stream of avoided costs over the measure life. PSE determines the using the following equation[9]:

$$TCE_{jy} = WAAMPE_{jy} + LL_{jy} + PA_y + RPSC_y + CC_{jy}$$

Where:

TCE_{jy} ≡ Total avoided cost of energy for end-use category j in year y.

$WAAMPE_{jy}$ ≡ Weighted average annual market price of energy for end-use category j in year y.

LL_{jy} ≡ Line losses for end-use category j in year y.

PA_y ≡ Value of planning adjustment in year y.

$RPSC_y$ ≡ Value of the avoided cost associated with renewable portfolio standard in year y.

CC_{jy} ≡ Value of the conservation credit for end-use category j in year y.

13.1.1.2 Present Value of Avoided Cost of Energy

The for each year is then converted to a present value as follows:

$$PV_{jy} = \frac{TCE_{jy}}{(1+I)^y}$$

Where:

PV_{jy} ≡ Present value of year y's avoided cost of energy for end-use category j in year y

TCE_{jy} ≡ Total avoided cost of energy for end-use category j in year y.

I ≡ Interest rate used for discounting PSE uses authorized rate of return on rate base (ROR).

[9] "Avoided Cost Calculations for Electric Energy Efficiency Programs" (2012)

13.1.1.3 Present Value of Stream of Avoided Costs of Energy

The present value of the avoided costs for end-use category j are then summed over the measure life.

$$PVSACE_j = \sum_{y=1}^{N} \frac{TCE_{jy}}{(1+I)^y}$$

Where:

$PVSACE_j$ ≡ Present value of the stream of avoided cost of energy for end-use category j

TCE_{jy} ≡ Total avoided cost of energy for end-use category j in year y.

I ≡ Interest rate used for discounting PSE uses authorized rate of return on rate base (ROR).

N ≡ Measure life.

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Driven by our purpose of safeguarding life, property and the environment, DNV GL enables organizations to advance the safety and sustainability of their business. We provide classification and technical assurance along with software and independent expert advisory services to the maritime, oil and gas, and energy industries. We also provide certification services to customers across a wide range of industries. Operating in more than 100 countries, our 16,000 professionals are dedicated to helping our customers make the world safer, smarter and greener.

Evaluation Report Response

Program:	Fuel Conversion
Program Manager:	Kevin Peterson
Study Report Name:	Impact and Process Evaluation: Residential Fuel Conversion Program
Report Date:	August 9th, 2015
Date ERR to Program Manager:	August 10th, 2015
Evaluation Analyst:	Jim Perich-Anderson
Date of ERR:	August 18th, 2015

Evaluation Overview, Methodology and Key Findings:

Overview:

This report documents the results of the impact and process evaluation of the 2011, 2012 and 2013 PSE Fuel Conversion Programs. The program provides financial incentives to PSE customers with electric service to switch electric space and/or water heat to gas space and water heat. The decreased price of gas makes the conversion proposition attractive to PSE customers while PSE claims the reduced electric consumption against state requirements for load reduction and particulate mitigation.

This impact evaluation in this report provides estimates of the electric consumption reduction and the parallel gas consumption increases. These estimates are integrated into an updated cost effectiveness calculation for the program. A final goal of the impact evaluation was to develop ways to use the analysis outcomes to better target the program to increase cost effectiveness. The process evaluation performed interviews with stakeholders and participants to better understand the program process and the participant experience.

Key Findings/Analysis:

The table below summarizes the electric and gas consumption change results. For both electric and gas, the table provides the deemed values used by PSE in the tracking data, the estimated gross change in consumption and the realization rate. The evaluated electric reductions are lower than the deemed values, with realization rates between 81% and 98% of the average tracking data values. The gas consumption increase for space and water heat conversions was lower than deemed, with a realization rate of only 77%. The two individual conversion measures were slightly greater deemed at 108%. The 2011-2013 deemed savings values for 'space heat only' and 'water heat only' fall within the error band at the 90% confidence interval.

More detailed information surrounding overall findings and analysis can be found in the final evaluation report which is provided in a link below.

Measure Group	Electric (kWh)			Gas (therms)		
	Deemed[1]	Evaluated*	Realization Rate	Deemed	Evaluated*	Realization Rate
Space Heat And Water Heat	-13,444	**-10,865** (-13,437, -8,293)	81%	799	617 (486, 748)	77%
Space Heat Only	-9,871	**-9,720** (-12,385, -7,055)	98%	602	653 (491, 815)	108%
Water Heat Only	-3,500	**-3,054** (-4,196, -1,912)	87%	197	212 (61, 362)	108%

*90% confidence interval are provided for each evaluated result

PSE Program Response to Evaluation Findings:

Action Plan:

Beginning January 1st, 2017, PSE will continue established program delivery but will adjust our savings accordingly to match the result actuals from the evaluation findings. The program will continue with our current deemed savings values for 2016 as the results of this evaluation were completed after our program budget & savings had been finalized.

In order to tackle some of the barriers outlined in the evaluation, the program will also be removing the current kWh requirement (19,000 kWh) for Space and Space & Water Heat incentives.

The program will continue to employ the same work specifications currently in place, however there will be efforts made to better align ourselves with CCS (Customer Construction Services) and Products & Services (Gas Growth) goals.

[1] The deemed savings values were taken from the tracking data provided by PSE. These values were averaged across all participants within a measure group for all participants.