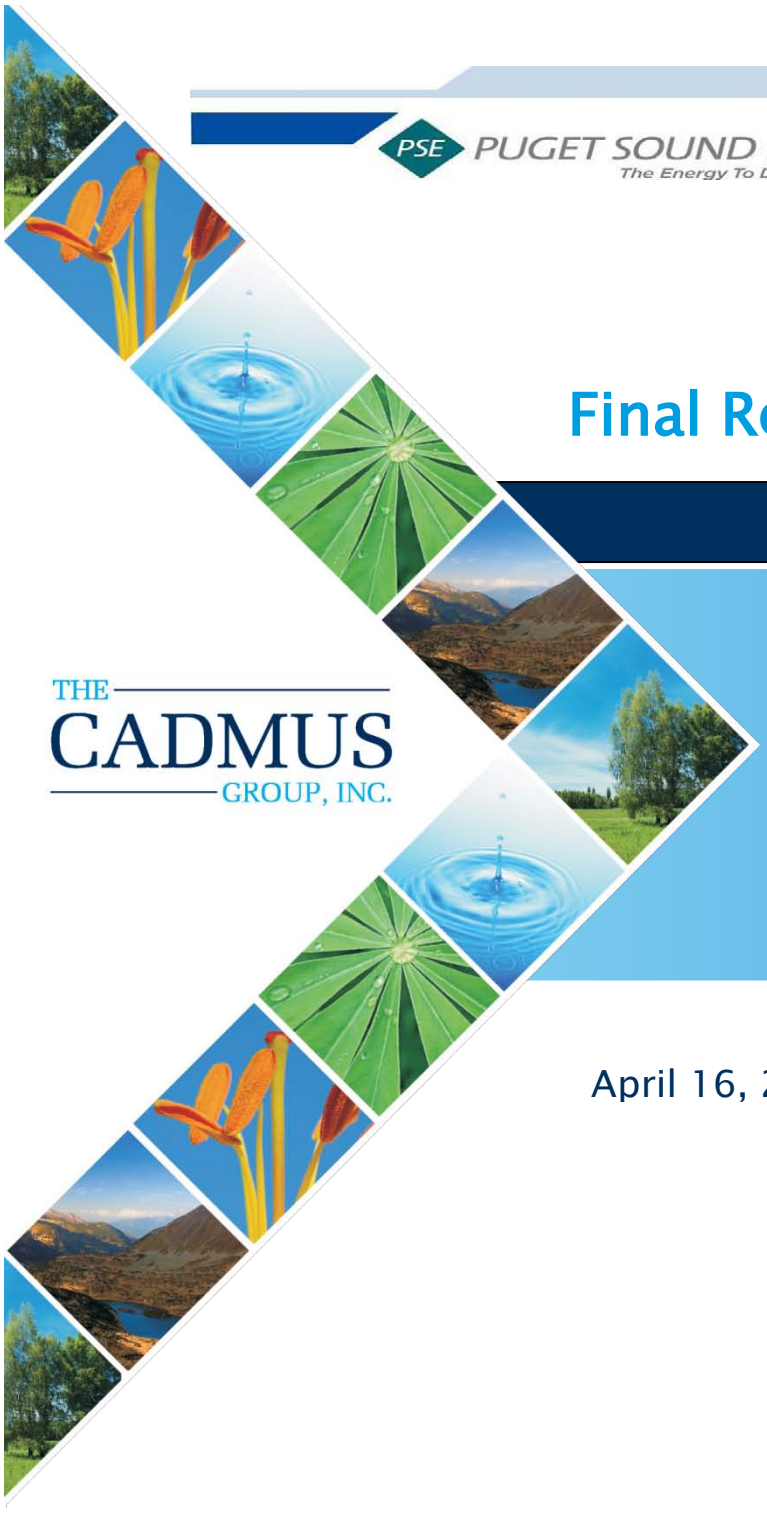
PUGET SOUND ENERGY
The Energy To Do Great Things

Low Income Weatherization Evaluation

Contents:

This document contains both the final **Low Income Weatherization Evaluation Report** 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.



PUGET SOUND ENERGY
The Energy To Do Great Things

Final Report

Low-Income Weatherization Evaluation

THE CADMUS GROUP, INC.

April 16, 2012

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EXECUTIVE SUMMARY

In 2011, Puget Sound Energy (PSE) hired The Cadmus Group, Inc. (Cadmus) to perform an assessment of their Low-Income Weatherization program, with the following project components:

- Non-Energy Benefits Assessment;
- Market Evaluation;
- Process Evaluation; and
- Savings Review.

This report provides results separately for each of the project components, providing detail on methodology, data collection, findings, and conclusions specific to each project component.

Each project component involved a range of different data collection and evaluation activities. Cadmus conducted primary data collection through a participant telephone survey and stakeholder interviews, used to inform the process evaluation, as well as the non-energy benefit assessment and savings review. Additionally, this research considered a variety of secondary data, which will be discussed within each project section. Subsequent report sections present detail from analyses specific to each project component.

Conclusions and Recommendations

Non-Energy Benefits Assessment

Upon performing payment and economic impact analyses, in addition to a detailed literature review, Cadmus highlights the following recommended non-energy benefits for inclusion in the low-income cost-effectiveness analysis and program decision discussions, shown in Table 1.

Table 1. Non-Energy Benefits for Cost-Effectiveness Testing

Non-Energy Benefit	Per Participant Impact*		Perspective Adjusted
	Gas	Electric	
Economic Impact**	$5,917	$2,836	TRC
Arrearage Reduction	n/a***	$43.55	UCT, RIM, TRC
Capital Cost Savings	n/a***	$3.53	UCT, RIM, TRC
Environmental	PSE-specific calculation****		TRC
Health, Safety, and Repair	Set equal to costs paid by PSE		PCT, TRC

* Economic impacts reflect the present value over the lifetimes of the installed measures, and payment impacts are annual values.

** Participant savings and utility revenue loss were discounted using 8.1% (PSE's cost of capital). Had a 4% discount rate (the prevailing average 30-year fixed mortgage rate) been used for discounting participant savings, the economic impact for gas and electric programs would have been $6,962 and $5,826, respectively (see Appendix G).

*** Unable to measure due to insufficient sample sizes.

**** PSE indicated they have the internal capability to identify these impacts.

Subsequent report sections present detailed information regarding individual non-energy benefit analyses.

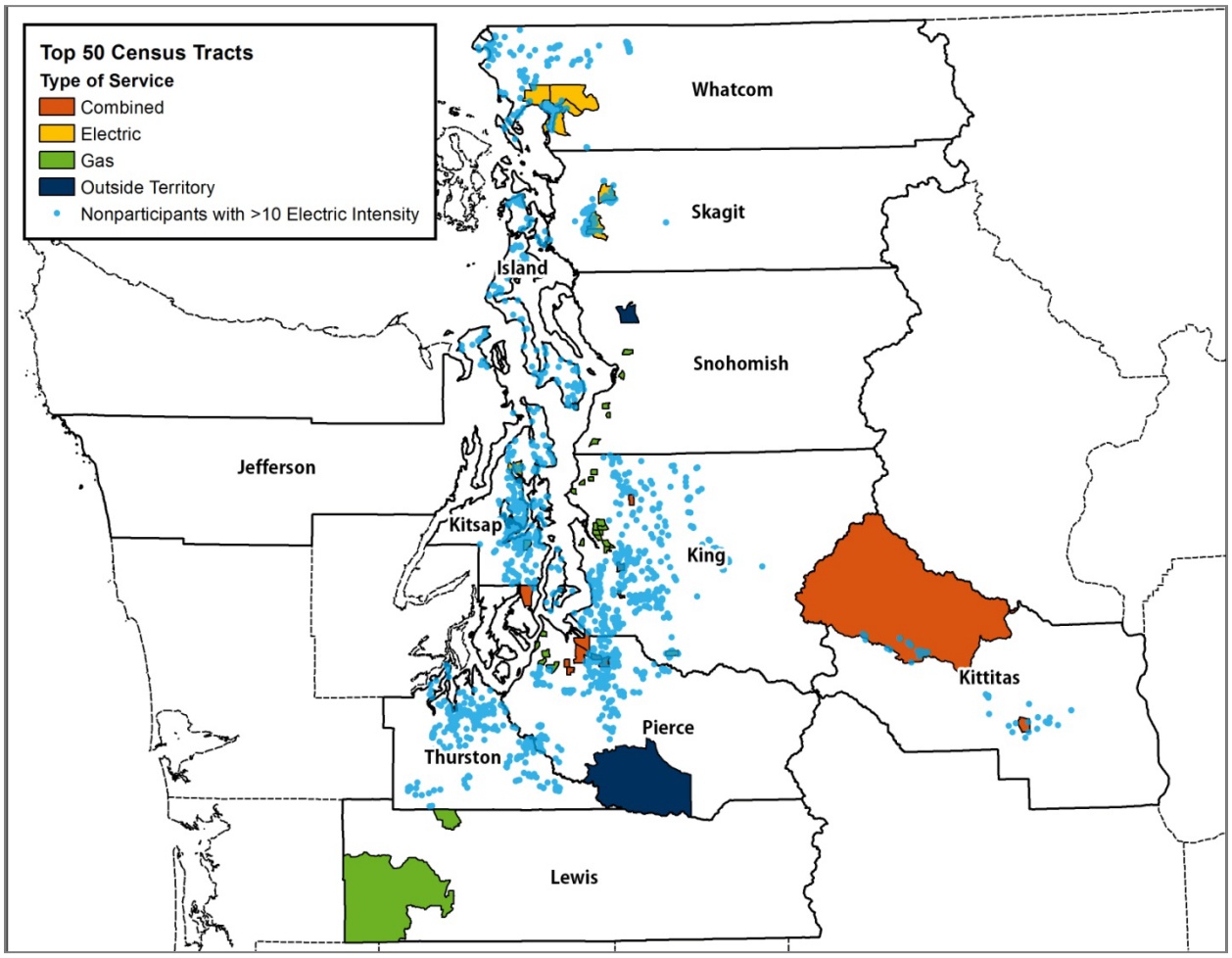
Market Assessment

Through spatial analysis, incorporating a range of data (including historical PSE program low-income weatherization participation, U.S. Census data, and a PSE nonparticipant sample, Cadmus developed a series of map outputs, highlighting a variety of metrics considered for this analysis. The objectives of this analysis were twofold:

- To develop maps of historical and eligible participants for PSE's low-income weatherization program; and
- To develop maps targeting eligible participants and regions (e.g., census tracts) based on different prioritization criteria, including underserved and higher-need areas, and customers with high energy consumption.

Figure 1 provides a final map, developed for exploring efficient targeting, and integrating a variety of criteria defining the top 50 census tracts (based on weighted targeting analysis) and high-energy users within the PSE region (Appendix C presents additional maps).

Figure 1. The Top 50 Census Tracts with High-Energy Use Eligible Participants*



*The final map product shows the top 50 census tracts, classified by service type, overlain by all eligible participants who, according to the billing analysis, have an electric intensity more than 10 kWh/sqft. Houses intersecting the top 50 census tracts are probable low-income weatherization program candidates.

Using the map in Figure 1 primarily for demonstration purposes, Cadmus discussed results with PSE staff, and presented strategies for efficiently targeting future program participants. Methods employed for identifying underserved or high-need areas approximated a gap analysis, allowing PSE to target specific areas (e.g., census tracts, ZIP codes) for expanding program offerings. At the same time, incorporating high consumption as a means of targeting or prioritizing participation focused on identifying individuals meeting specific criteria. Cadmus offered the following recommendations for methods to integrate efficient targeting into the low-income weatherization program's delivery:

- Develop a targeted high-consumption weatherization pilot program;
- Work with agencies to integrate high consumption into their prioritization calculations;
- Work with agencies to highlight high-need or underserved areas within their service territories;

- Increase agency budget allocations to help target high-need or underserved areas; and
- Increase marketing and program awareness in high-need or underserved areas.

A list of the top 50 census tracts, including the associated ZIP+4 information for nonparticipants, is provided in Appendix H.

Process Evaluation

Conclusions and recommendations, developed through the process evaluation, are presented below by topic area.

Program Goals and Objectives

Conclusions

- PSE's program objectives appear to more closely align with agencies than those of typical low-income weatherization programs managed by utilities, as became evident through discussions with utility and agency staff, and through program policy changes (i.e., increased percentage allocations for repair and health and safety budgets).

Program Delivery

Conclusions

- Increasing PSE's health and safety and repairs budget provided a positive change for the program, from both utility and agency staff perspectives.
- Regular, open communication with agencies emerged as a program strongpoint among all parties.
- Despite state implementation protocols, variations appeared between agencies—and potentially agency staff—regarding installation procedures (e.g., CFLs, energy-efficient showerheads). Variations also appeared in types of measures offered through the agencies (e.g., refrigerator replacement).
- While some agencies chose not to offer (or rarely offer) low-cost water heating measures (e.g., aerators, energy-efficient showerheads), with one agency indicating associated low customer satisfaction, participant survey results appear to contradict this assumption: 88% of customers receiving energy-efficient showerheads provided positive satisfaction ratings.
- Agency variations in providing potential weatherization participants with a bundle of low-cost measures during pre-assessment reveals another potential missed opportunity, both in terms of providing benefits to customers not qualifying for full weatherization, for PSE achieving easy, cost-effective energy savings.
- Reduced agency capacity, in conjunction with lower-than-average federal funding levels, may seriously constrain agencies' abilities to maintain production or delivery on par with pre-Recovery Act levels.
- All agencies interviewed cited Washington's state prevailing wage laws as a concern, posing a barrier to delivering a wider range of measure installations (e.g., energy-efficient

showerheads) and to delivering the same holistic program approach in a cost-effective manner.

- While Department of Energy and Washington state protocols list high energy consumption as a factor allowed in participant prioritization, agencies have not been able to integrate this criterion in their work.
- Existing conditions of homes, with repairs to be addressed prior to weatherization approval, present a barrier to program delivery and participation of income-eligible customers.
- While PSE has offered some past programs within tribal lands, revisiting program delivery to these customers and overcoming previous delivery barriers will be important, as these areas represent significant opportunities to address both high-need customers and to achieve energy savings.

Recommendations

- Continue direct communication with agencies regarding mid-year funding reallocations.
- Continue working with agencies to identify potential, unspent funding, which can be reallocated to agencies with greater potential for spending within a program year.
- Work with agencies to integrate high-energy consumption as prioritization criteria.
- Work with the agencies to help integrate high-consumption targeting criteria into their prioritization calculations.
- Work with stakeholders to standardize delivery.
- Work with stakeholders to standardize low-cost measure bundles for initial home inspections.
- Provide education to customers about benefits of energy-efficient domestic hot water equipment.
- Work with stakeholders to make program adjustments that address changes in funding levels and state wage requirements.
- Explore options for delivering weatherization to tribal areas within PSE's territory.

Communication

Conclusions

- Communications between PSE and agencies appears very effective

Program Tracking

Conclusions

- Agency satisfaction with PSE's LIW Online System reporting tool indicates the system works well for both small and large agencies and is not overly burdensome.

Recommendations

- Consider collecting additional input assumptions for calculating more robust savings estimates.

Quality Assurance and Control

Conclusions

- Neither the Washington State Department of Commerce (Commerce) nor PSE identified significant or systematic issues affecting the program delivery process or finished projects, based on monitoring efforts conducted in recent years.
- Problems or issues did not arise regarding PSE's independent monitoring efforts alongside those performed by Commerce.
- Between PSE's monitoring 15% of its completed weatherization projects, and Commerce monitoring 20% (as of 2009), sufficient quality assurance activities appear in place.

Participant Findings

Conclusions

- When benchmarking awareness of utility contributions to other low-income weatherization programs, PSE's participants ranked among higher levels of their awareness of utility sponsorship (45%).
- Increased education surrounding home heating temperature settings may be required, given a large percentage of participants receiving programmable thermostats reporting to have reversed the set-points to pre-project levels (80%).
- A significant portion of PSE's participants (43%) reported using secondary heating sources, including 18% indicating use of electric room heaters.

Recommendations

- Increase PSE sponsorship awareness through leave-behind materials.
- Increase education surrounding thermostat setbacks to affect behavior change and increase measure persistence (which translates into energy savings).
- Work with agencies to increase education surrounding use of secondary heat sources.

Participant Non-Energy Benefits

Conclusions

- PSE participants reported a perceived value associated with each non-energy benefit asked about through the survey.
- Though non-energy benefits PSE participants cited (e.g., comfort, health) have been valued in various studies (some of which have been listed in the non-energy benefit literature review performed for this project), many of these exhibit a wide range of estimates, making it difficult to isolate a single, defensible value to use for claiming additional program benefits.

Recommendations

- Consider exploring more detailed research in valuing some participant non-energy benefits.

Energy-Saving Education

Conclusions

- High response rates regarding energy education recollection, reviewing materials provided by the agencies and PSE, and adopting energy-savings behaviors all indicate the energy education curriculum and delivery have effectively encouraged behavioral changes.
- Despite high rates of recollection, review, and adoption related to energy education materials and curriculum, opportunities exist to focus energy education on areas requiring improvements. Specifically, increased education should target certain behavioral changes with lower adoption percentages, which typically result in higher energy savings (e.g., thermostat setbacks, reduced shower and hot water use).

Recommendations

- Focus energy education on actions resulting in high-energy savings.
- For areas of need, target energy education to increase awareness and affect behavior change. Working directly with agencies, as well as developing PSE-specific energy education materials for participants, may help increase awareness surrounding water-heating measures (e.g., energy-saving showerheads), use of secondary heating systems, thermostat programming, and energy savings actions resulting in high electric savings.

Participant Satisfaction

Conclusions

- Overall, participants reported high satisfaction levels with PSE's low-income weatherization program.
- Participants also expressed satisfaction with measure installations, with the majority indicating "excellent" or "good" ratings for each measure type.

Savings Review

Recommended Adjustments Types

Cadmus updated measure assumptions, based on participant and stakeholder interview data, regional data, the Low-Income Weatherization Manual, and previous Cadmus studies. Adjustments fell into three categories: updating methodology; updating assumptions with low-income specific values; and updating general assumptions (not low-income specific). Low-income specific adjustments included updating variables from general residential values to low-income specific values (e.g., baseline efficiency of water heaters). This category also included adjustments to match PSE's program design or the Low-Income Weatherization Manual's guidelines. General assumption adjustments are those made to algorithms or assumptions that are not specific to any particular residential segment. Table 2 summarizes types of adjustments recommended for each measure.

Table 2. Summary of Recommended Updates for Each Measure

Measure	No Change	Update Methodology	Update with LI Assumptions	Update General Assumptions
Floor Insulation			X	
Attic Insulation			X	
Wall Insulation			X	
Roof Insulation			X	
Duct Insulation and Duct Sealing			X	
Structure Sealing			X	
Windows			X	
Refrigerator Replacement*			X	
Showerheads			X	
Water Heater Replacement			X	
Whole House Fans				X
Ductless Heat Pump		X		
Programmable Thermostat				X
Pipe Insulation	X			
Smart Strips	X			
CFLs, Light Socket Conversion, Fixtures*	X			
LEDs	X			

* Savings calculations for these measures included some low-income assumptions. Appendix E provides greater detail.

As shown above, nine measures should be adjusted for low-income specific values. Though energy savings for refrigerator replacements were already low-income specific, Cadmus recommends updating to a low-income specific value more specific to PSE territory. For two additional measures, Cadmus suggests updates to general assumptions.

Overall Recommendations and Considerations

The following suggestions refine future program energy savings values:

- **Additional data collection.** Collecting additional, site-specific or measure-specific information will improve the accuracy of energy savings. Suggested data can be easily collected while visiting homes or through a participant survey. Appendix E provides recommendations on variables to collect for each measure.
- **Monitor RTF calculator updates.** Energy savings for two measures—smart strips and ductless heat pumps—have been based on provisionally deemed RTF values. The Bonneville Power Administration, Northwest Energy Efficiency Alliance, and other electric utilities in the Northwest are currently conducting metering studies, on both smart strips and ductless heat pumps, to determine more accurate savings values. Once those studies are complete, the RTF will update deemed values. PSE should consider updating

these measures once the RTF provides updates. Additionally, the Energy Independence and Security Act (EISA), which takes effect in October 2012, will affect energy savings for CFLs and LEDs. Though the RTF currently accounts for EISA using a weighted average within each year (2011, 2012, and 2013), RTF deemed savings likely will be updated annually. As most PSE calculations are aligned with the RTF, updates to the low-income weatherization program savings should coincide with RTF updates.

- **Billing analysis.** Energy savings for weatherization measures could be more accurately determined using billing analysis. Modeling or calculating energy savings for specific weatherization measures can be difficult due to variations in home characteristics and customer behaviors, and due to measure interaction effects. A billing analysis, comparing pre- and post-install energy consumption, may provide a solid estimate of household level energy savings.

NON-ENERGY BENEFIT ASSESSMENT

In this section, Cadmus presents findings from an assessment of non-energy benefit associated with PSE's low-income weatherization program. First, methodology and results are presented for two sets of detailed analyses surrounding the program's economic and payment impacts. Second, a brief summary describes Cadmus' non-energy benefit literature review, followed by guidance on incorporating non-energy benefits for cost-effectiveness testing.

Payment Analysis

Cadmus' analysis of payment behaviors focused on determining the low-income weatherization program's effects on participants' payment frequency and levels, based on utility customer transaction records. Cadmus compared changes in participants' payment behaviors with those of a comparison group, establishing the program's net effects.

Methodology

Comparison Group Identification

As PSE provided data on historical program participants from 2005 to the mid-2011, the analysis focused on weatherization's impacts from the 2008 program year, while using 2010 and 2011 participants as the comparison group. Table 3 demonstrates pre- and post-period distinctions for this analysis, and treatment periods of each group.

Table 3. Payment Analysis Participant and Comparison Groups

Group	2007 Pre	2008 Participation	2009 Post	2010-2011 Participation	Final Sample*
Treatment		X			51
Comparison				X	91

* Final sample based on electric accounts, discussed in more detail below.

Data Sources and Cleaning

PSE provided Cadmus with 2005 to 2010 monthly payment data for the low-income customer sample. Combined, these datasets included the following:

- Payment transaction dates;
- Actual billed amounts by billing period;
- Source and amount (if any) of external payment assistance by billing period;
- Arrearage amount (customer's monthly unpaid ending account balance); and
- Reconnections by billing period.

Cadmus aggregated all data sources to the annual level for pre- and post-periods, and subset to unique premises/accounts from the treatment and comparison groups. Cadmus only conducted final analyses on premises if a full 12 months of active usage was present.

Cadmus restricted this analysis only to electric usage, as the number of gas accounts proved too small to allow meaningful inferences. Pre- and post-period consumption was examined to determine whether significant outliers existed.

In order to be included in the analysis, premise and account numbers had to be successfully matched to payment data for both the pre and post periods. Once merged, data were screened to ensure that the same account number stayed with the premise in question for the full 12 billing periods in both the pre and post periods and that in each of these billing periods active usage was being incurred. As shown in Table 4, this final screen led to a dramatic reduction in the number of participants included, most likely due to high mobility rates in the low income segment, particularly in mobile homes (which made up the majority of participants).

Table 4. Payment Data Validation

Group	Group	
	Comparison	Treatment
Unique premises	622	194
Successfully matched to payment data	409	140
No changes in account number, full 12 months pre/post	91	51

Analysis

To test for program impacts, Cadmus used a difference-of-differences technique, which involves first taking the difference between the pre-treatment and post-treatment periods (2007 and 2009, respectively) within each group, and then taking the difference of those differences. That is, for each metric examined (referred to as "program impact" in the equation below):

Cadmus used two sample t-tests of the null hypothesis that this impact equaled zero. Where this test returned a p-value < 0.1, it could be said, with 90 % confidence that a program impact occurred. Appendix A provides test details.

Customer Payment Metrics

Low-income households are widely understood to have significantly greater energy cost burdens than other households. Effective weatherization programs can ease financial burdens, thereby increasing these households' capability to make utility payments.

Cadmus contrasted the following customer payment metrics between treatment and comparison groups for 12 months prior to and 12 months after participation:

- **Arrangement metrics:**
  - Total annual payment arrangements (in dollars);
  - Proportion of annual billed amounts covered by payment arrangements; and
  - Proportion of households receiving payment arrangements.
- **Payment and billing metrics:**
  - Average annual billed amount;
  - Average number of late payments per year;

- Proportion of households with at least one late payment per year;
- Proportion of annual billed amount paid on time by customer; and
- Proportion of annual billed amount paid on time by any party.

Appendix A provides a detailed description of how these metrics were calculated.

Total Cost Metrics

Two cost components related to unpaid utility bills:

- Costs of unpaid bills recovered through rates (estimated as the product of days in arrears and PSE cost of capital).
- Administration of non-payment-related activities (e.g., shut-offs, reconnects, payment plans).

These costs can be avoided through low-income weatherization, which represents an economic benefit to the overall utility system. Cadmus contrasted the following cost metrics between treatment and comparison groups for 12 months prior to and 12 months after participation:

- **Disconnect metrics:**
  - Average number of reconnects per year; and
  - Proportion of households receiving any reconnects.
- **Arrearage metrics:**
  - Change in carried arrearages from beginning to end of year;
  - Average carried arrearages; and
  - Average annual capital costs to PSE.

Appendix A provides a detailed description regarding how these metrics were calculated.

Findings

As shown in Table 5, many metrics analyzed were significant at the 90% confidence level. Of particular interest were impacts on average arrearages and total billed amounts, where the treatment group not only had lower values, but trended in the opposite direction of the comparison group.

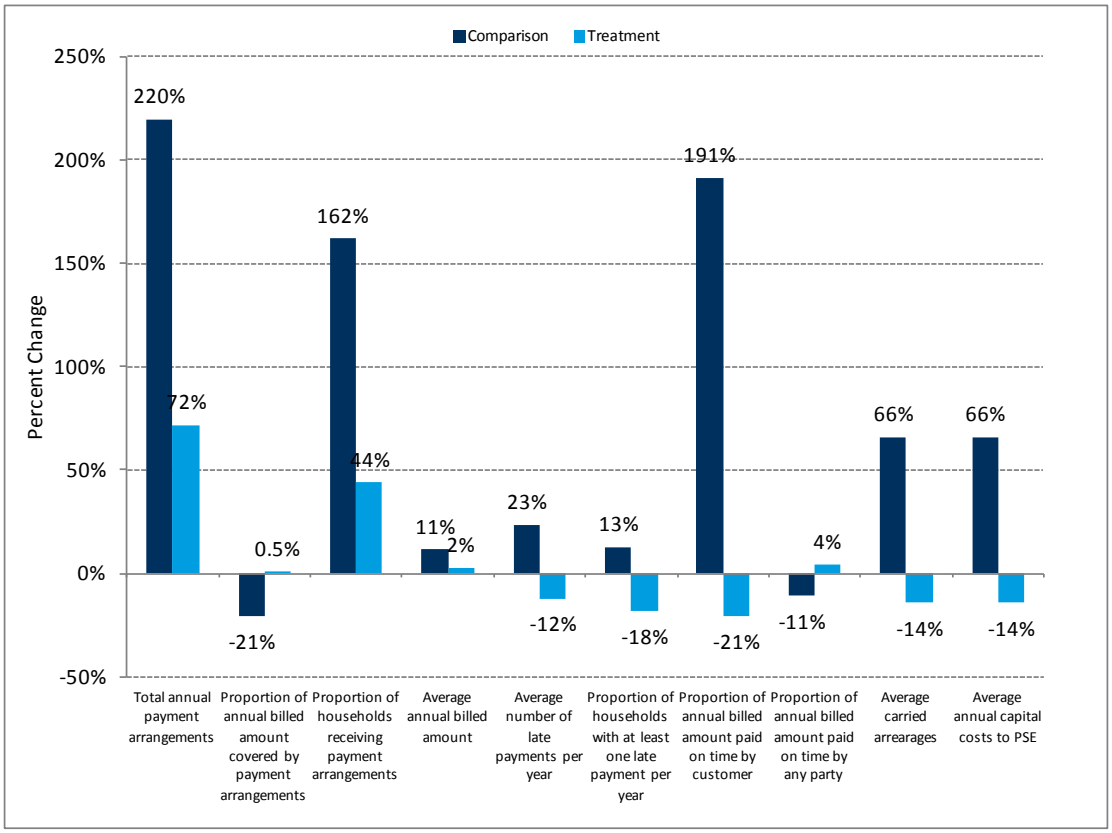
Table 5. Summary of Payment and Cost Impacts

Metric	Description	Change		
		Comparison	Treatment	Difference
Payment	Average annual payment arrangements (in dollars)	$372.61	$162.49	($210.12)*
	Proportion of annual bill covered by payment arrangements	-0.18	0.00	0.19*
	Proportion of households receiving payment arrangements	0.37	0.14	-0.24*
	Average annual billed amount	$172.22	$32.66	($139.57)*
	Average number of late payments per year	0.84	-0.43	-1.27*
	Proportion of households with at least one late payment per year	0.09	-0.14	-0.23*
	Proportion of annual billed amount paid on time by customer	0.07	-0.01	-0.09*
	Proportion of annual billed amount paid on time by any party.	-0.09	0.03	0.12*
Cost	Average number of reconnects per year	0.03	0.04	0.01
	Proportion of households receiving any reconnects	0.03	0.04	0.01
	Change in carried arrearages from beginning to end of year	($47.34)	($30.03)	$17.31
	Average carried arrearages	$35.94	($7.61)	($43.55)*
	Average annual capital costs to PSE	$2.91	($0.62)	($3.53)*

* Significant at the 90% confidence level.

Figure 2 shows statistically significant impacts expressed as a percent of the pre-period value. For instance, total payment arrangements increased by 220% in the comparison group, while only increasing 72% in the treatment group.

Figure 2. Selected Payment and Cost Impacts (Expressed as Percent of Pre-Period Value)



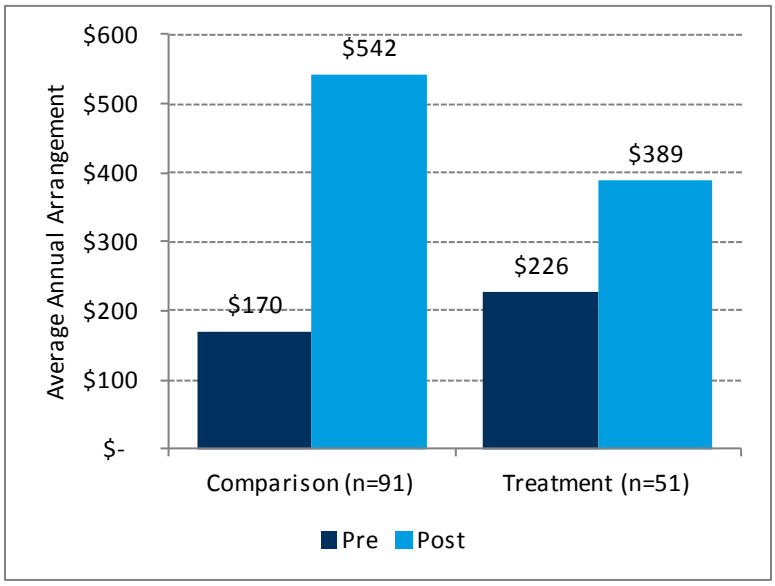
The following subsections discuss these impacts in further detail.

Arrangements

Total payment arrangements, defined as the total dollar amount of a customer's bill paid by an outside party within a given year, increased in both treatment and comparison groups. This effect most likely resulted from two economics factors: decreases in household income due to the 2007–2009 U.S. recession; and an influx of funding for the Low-Income Energy Assistance Program (LIHEAP) from the 2009 American Recovery and Reinvestment Act (the Recovery Act).[1]

Despite increased in both groups, Cadmus' analysis showed participation in the program resulted in customers requiring $210 less outside payment arrangements per year than the comparison group. Figure 3, below, shows this difference.

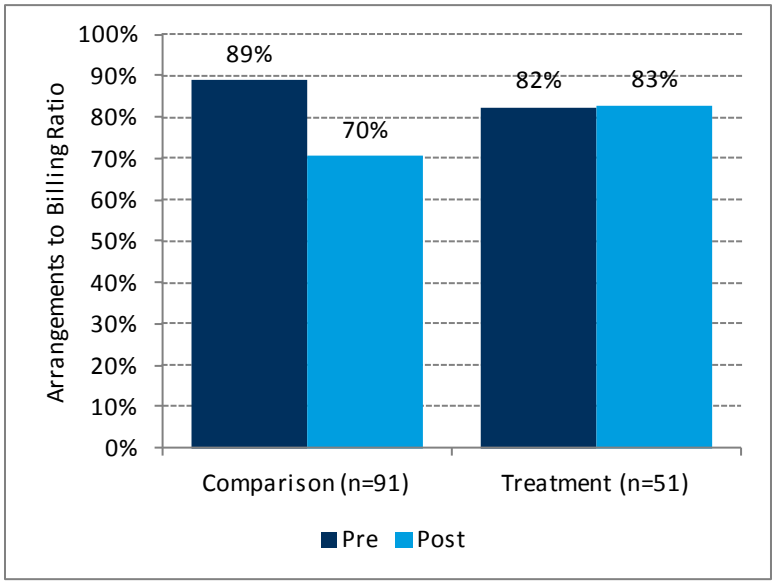
Figure 3. Comparison of Total Arrangements



Notably, however, the ratio of total arrangements to total billed amounts remained flat in the treatment group, while decreasing in the comparison group. That is, the proportion of billings for which the customer was responsible increased for households not participating in the program, despite their receiving even additional outside payment assistance.

[1] LIHEAP funding effectively doubled, starting in 2009: http://liheap.ncat.org/news/sept10/wap.htm

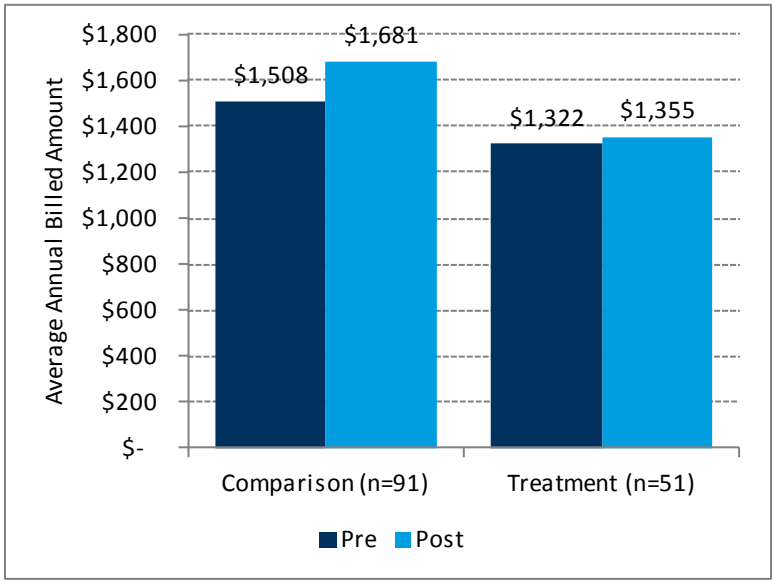
Figure 4. Comparison of Arrangements to Billing Ratio



Payment and Billing

The program also significantly affected the total amount billed to participating households and, subsequently, these households' payment behaviors. Figure 5 shows annual total billed amounts customers faced remained relatively flat for the treatment group, while a marked increase occurred in the bills from the comparison group. This analysis shows that the participants incurred $140 less in electric bills per year due to the program.

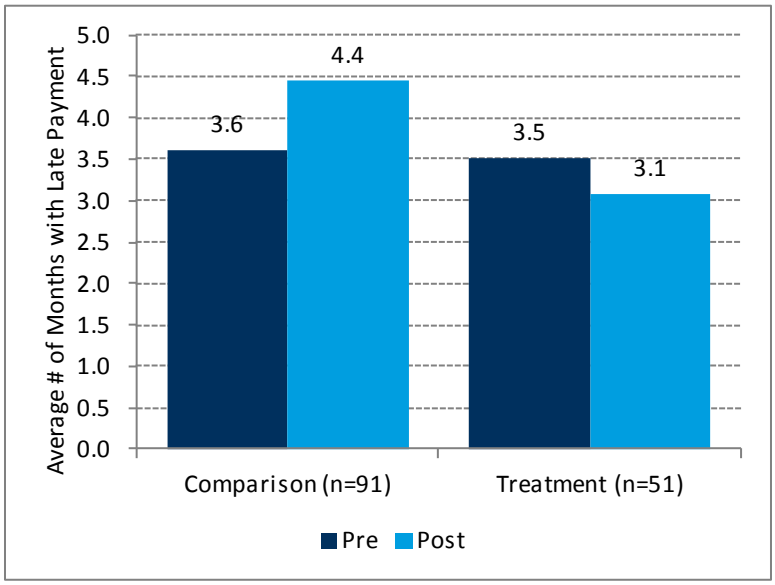
Figure 5. Comparison of Total Billed Amount



Changes in late payment behaviors proved even more striking. While the proportion of customers with at least one late payment increased 12% in the comparison group, it declined

14% in the treatment group. As shown in Figure 6, the program also affected the number of late payments.

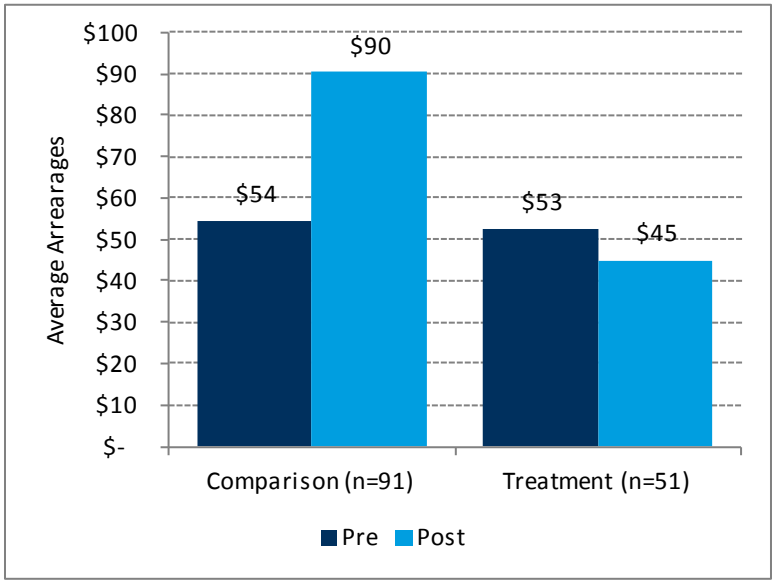
Figure 6. Comparison of Months with Late Payment



Arrearages

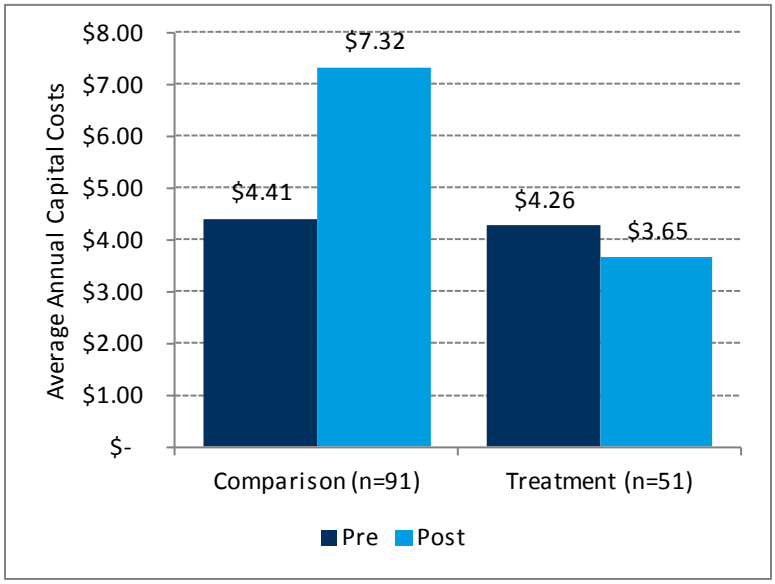
Low-income weatherization programs can provide tangible cost impacts at the arrearage level, with implications for cost-effectiveness. These impacts take place both at participant and utility levels. For participants, a reduction in average arrearages impacts their total liabilities. As shown in Figure 7, the program reduced average arrearages, resulting in cost savings of $44 per household.

Figure 7. Comparison of Average Arrearages



In addition to participant impacts, PSE experienced savings by reducing amounts of debt carried. Multiplying average arrearages by PSE's cost of capital (8.1%) provided per-household cost savings to the utility. That is, this value represented PSE's average annual opportunity cost of carrying arrearages incurred by low-income customers. Figure 8 shows the program resulted in a per-household reduction of $3.53 in capital costs incurred to PSE.

Figure 8. Comparison of Capital Costs



Benchmarking

Though capital costs have not been factored into past evaluations, average arrearages provide a common metric in payment analyses. Table 6 compares results from this analysis to those seen in two evaluations Cadmus conducted in the northwest.

Table 6. Benchmarking Average Arrearages

Evaluation	Net Change in Average Arrearages	
	Dollars	As a Percent of Pre Period
PacifiCorp Washington (2003-2005)	($64.00)	-31%
PacifiCorp Idaho (2007-2009)	($31.00)	-31%
PSE (2008)	($43.55)	-83%

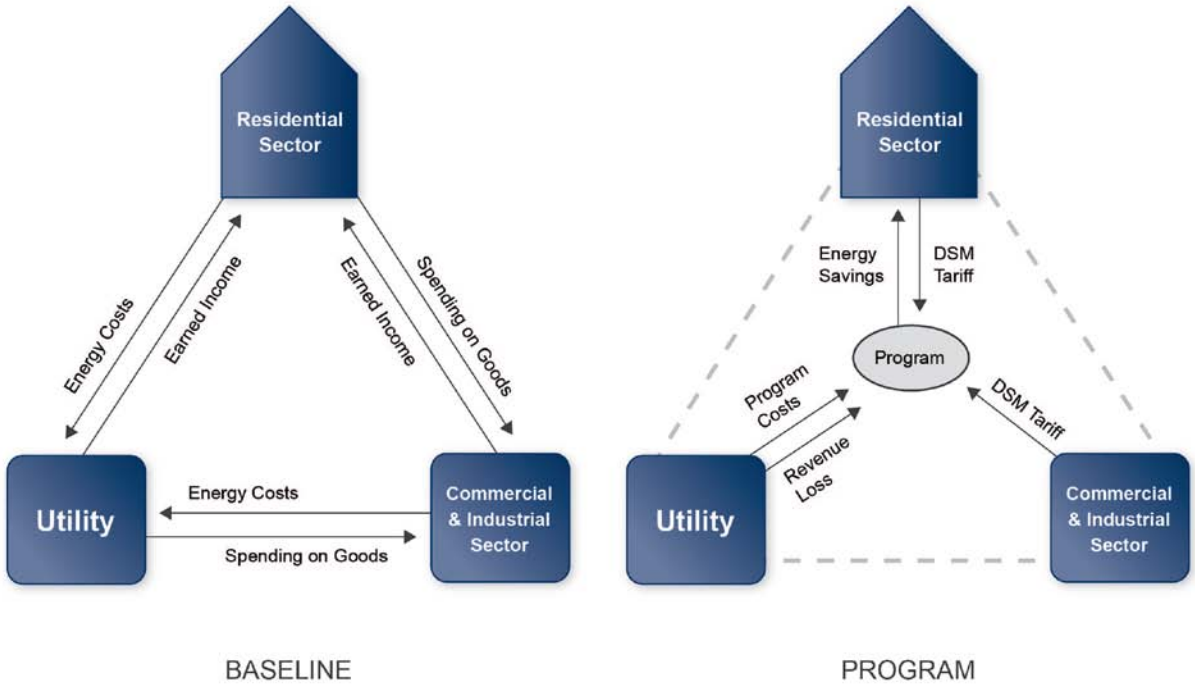
In dollar terms, PSE's program's impact fell between those in the other evaluations. When expressed as a percentage of arrearage levels in the pre-period, however, PSE's program experienced more than double the impact of those found elsewhere.

Economic Analysis

PSE's low-income weatherization program affects the flow of money through the regional economy in multiple ways. In this section, Cadmus analyzes associated economic impacts of

PSE's 2009 and 2010 program using IMPLAN (IMpact analysis for PLANning) v3.0, an input/output model, characterizing spending patterns and relationships between households and industries, and tracing how money spent in one sector flows through the local economy. Figure 9 illustrates these relationships.

Figure 9. Baseline and Program Scenarios



The IMPLAN analysis captures the underlying economic relationships characterizing the region. In the baseline scenario, the residential sector spends money on energy and other goods, and receives money from all industries (including the utility) in the form of earnings. This relationship persists in the program model, but some residential sector spending on goods and services (in addition to commercial and industrial sector spending) is diverted to the program tariff, and some residential sector spending on energy routes sent back through program-based energy savings. The model accounts for the baseline scenario when calculating program effects; so all effects presented are net of what would have occurred absent the program.

Model Inputs and Methodology

Table 7 summarizes model inputs used in the economic impacts analysis[2] for PSE's electric and gas service territories.

[2] As spending occurred *within both 2009 and 2010 program years*, all values have been converted to 2010 dollars using the Consumer Price Index published by the Bureau of Labor Statistics

Table 7. Inputs for the Electric and Gas Economic Impact Models

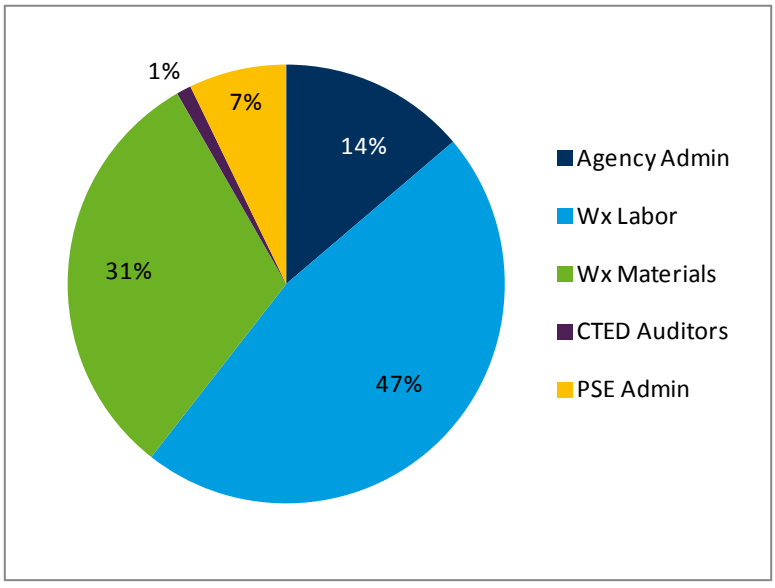
Category	Event Description	Electric	Gas
Program Spending	Agency administrative costs	$932,307	$304,676
	Agency weatherization costs*	$5,283,071	$1,726,495
	Evaluation expenses	$75,059	$75,059
	CTED auditors	$73,950	$28,050
	Utility administrative costs	$486,828	$160,438
Program Costs	Costs to ratepayers: tariff collections	$4,903,960	$1,379,326
	Costs to PSE: shareholder funds and evaluation expenses	$548,860	$206,019
Net Energy Savings for Participants	Program participants' avoided energy costs	$6,183,444	$487,871
Revenue Loss for PSE	Value of energy payments avoided by program participants before they are recovered in normal rate adjustments	$6,183,444	$487,871

* Analysis assumes costs are allocated between labor (60%) and materials (40%).

Model inputs have been organized into four categories:

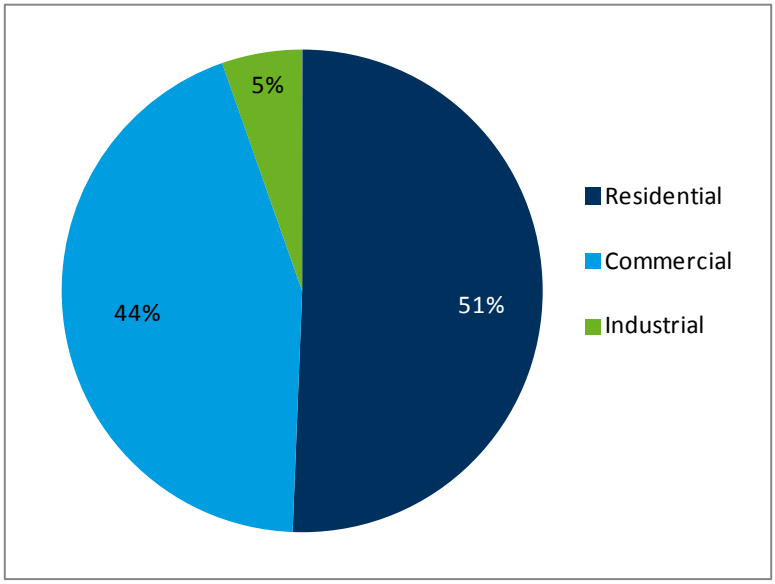
1. **Program Spending:** Total spending *within the region* on all program aspects, including administrative costs, labor, and materials. PSE's expenditure tables noted agency funds included a fixed share (15%) for administrative costs; so this portion was assigned to the IMPLAN industry category for "office." The balance of agency spending was allocated to weatherization labor ("construction") and materials (purchased from the "other commercial" industry), based on the 60% and 40% shares reported by the agencies during interviews. Evaluation expenditures have not been included as these funds flow directly out of state. Figure 10 illustrates the spending breakdown (which is the same for both electric and gas models).

Figure 10. Program Spending



2. **Program Costs:** Program expenditures funded by ratepayers appear in the model as costs to these customers.[3] Tariff collections have been allocated across residential, commercial, and industrial sectors, in proportion to total electricity and natural gas load shares, displayed in Figure 11 and Figure 12, respectively.[4] Within the commercial and industrial sectors, load shares have been used to allocate tariff costs across industries. Within the residential sector, tariff costs have been allocated across household income groups in proportion to total residential spending on energy.

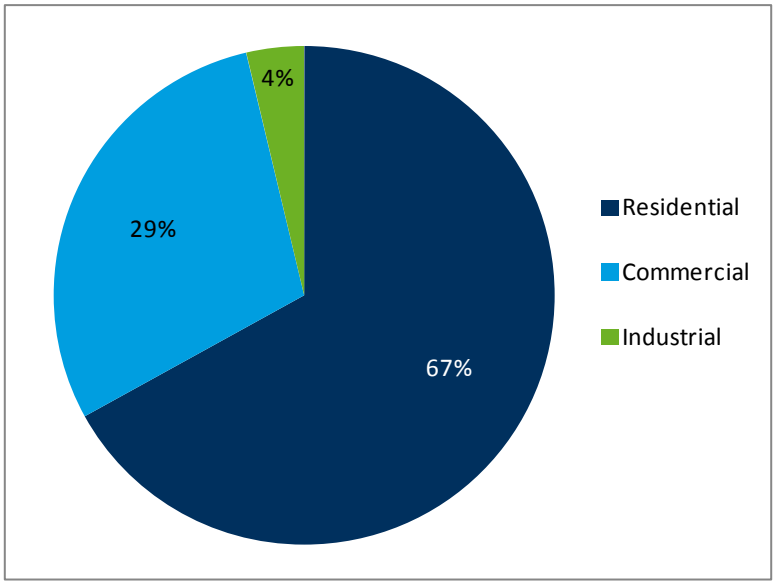
Figure 11. Electricity Load by Sector



[3] A program participant may pay part of home weatherization costs, or may have some costs covered by another program. Due to lack of data regarding these contributions, however, the model assumed weatherization costs were fully covered by PSE's reported expenditures. Therefore, participants have been modeled as paying only the tariff and not additional weatherization costs.

[4] The primary distinction between electric and gas load distributions occurs within the commercial sector, where water and waste water industries represent 47% of the electric commercial load. Aside from these commercial segments, load distributions are nearly identical in percentage terms for gas and electric.

Figure 12. Gas Load by Sector



While the majority of program dollars were funded through tariffs applied to all sector ratepayers, some program spending was covered by a non-ratepayer category of funds (Attorney General) distributed to the agencies. These dollars have not been charged as costs to ratepayers or the utility as they have been attributed to external stakeholders from outside the region. Shareholder funds and evaluation expenses, however, have been modeled as costs to PSE rather than costs to ratepayers, as these expenses were not covered by low-income program tariffs.[5] Figure 13 displays funding source shares for the electric model, and Figure 14 displays shares for the gas model.

[5] Though evaluation expenses divide equally across the two models, qualitative results remain robust to changes in this allocation rule, thus total effects for combined electric and gas models would be unchanged. As these expenditures flow out of state, evaluation costs only enter the models as losses to the utility.

Figure 13. Electric Program Funding Sources

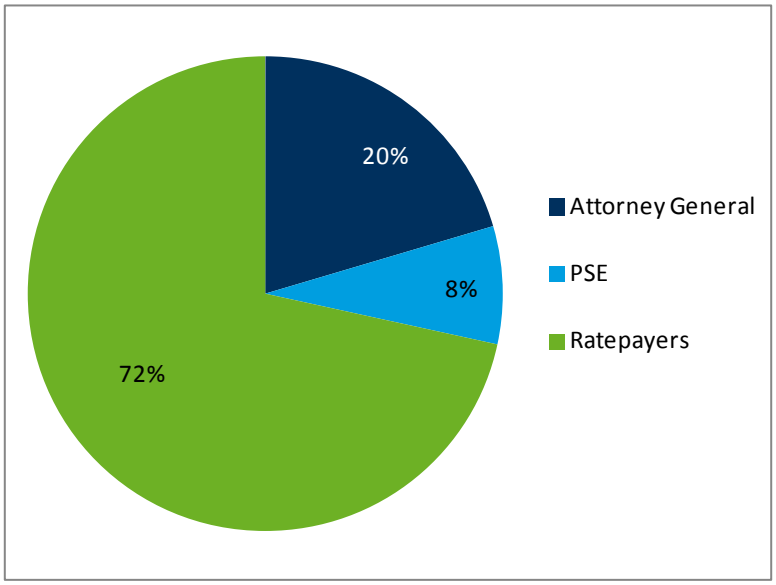
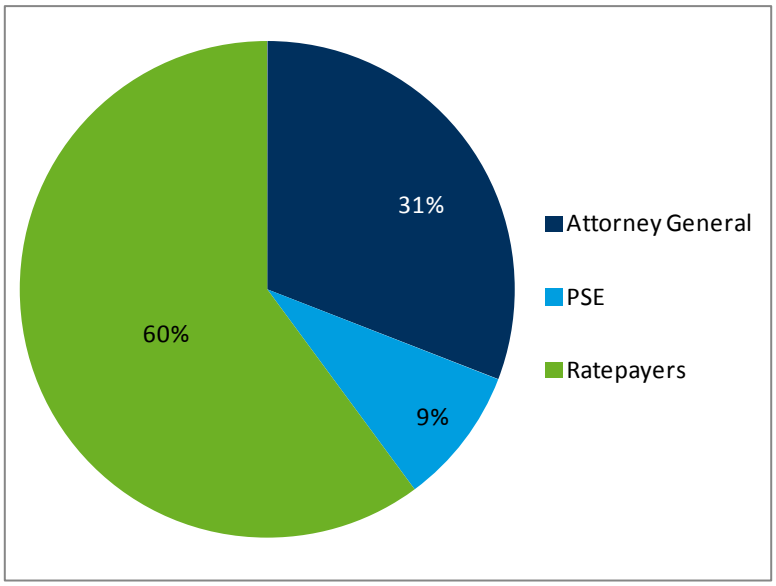


Figure 14. Gas Program Funding Sources



3. **Energy Savings:** When program participants install measures to conserve electricity or gas, they spend less on energy, retaining more money for other expenses. They continue to save on energy as long as the efficient measures installed continue working. To calculate total energy savings, savings have been translated from energy units to dollar values over these measures lifetimes.[6] These dollar values have been discounted to be

[6] For this analysis, impacts have been considered for only 30 years post-installation.

easily compared to spending concurrent with the program.[7] Savings have been assigned to household income group categories, based on program eligibility guidelines.[8]

4. **Revenue Loss:** When program participants receive energy-efficiency measures, they purchase less energy and the utility experiences this as a revenue loss over the lifetime of the installed measures. For this analysis, such lost revenue has been discounted to constant dollar terms. [9] Losses are assigned to the "electric distribution" industry in the electric model and to the "natural gas distribution" industry in the gas model. In PSE's case, revenue losses only continue until the next rate adjustment (reflected in forecasted rates) and, as such, reflect a conservative estimate of the impact on the utility industry.

As these spending and income changes ripple through the economy, they result in three types of regional impacts: direct, indirect, and induced effects:

- ***Direct effects*** include program spending (for example, labor and materials used in construction projects).
- ***Indirect effects*** result from changes in demand for factor inputs resulting from program activities (for example, increased demand for glass used in manufacturing windows for weatherized homes).
- ***Induced effects*** result from the ways households and workers spend newfound energy savings or labor income on general consumer goods and services, leading to impacts on industries not involved with the program or its factor inputs.

Effects of these inputs have been analyzed in tandem, using IMPLAN to characterize spending patterns and relationships between households and industries, and tracing ways money spent in one sector flows through the local economy. As such relationships closely depend on regional characteristics, Cadmus purchased county-level data from 2010 (the most recent IMPLAN data release) to reflect PSE's service territory, and used these data with assumptions specific to PSE's program (see Appendix B). Regions used for the electric and gas models differed according to

[7] Participant savings and utility revenue loss were discounted using 8.1% (PSE's cost of capital). Had a 4% discount rate (the prevailing average 30-year fixed mortgage rate) been used for discounting participant savings, the economic impact for gas and electric programs would have been 18% and 105% higher, respectively (Appendix G).

[8] Program eligibility has been based on federally established poverty guidelines, which rely on an income threshold corresponding to the number of people living in the home. Cadmus used the 2009 program eligibility guidelines, converting these to 2010 dollars using the Consumer Price Index. Phone survey participants' reports of how many people typically lived in each home over the past year were used to compute an average program eligibility income threshold of $32,095. Using this average income threshold as an upper bound for participants' incomes, Cadmus allocated energy savings to the four household income group categories containing these participants: less than $10,000; between $10,000 and $15,000; between $15,000 and $25,000; and between $25,000 and $35,000. As with tariff collections, household energy savings were assigned in proportion to each income group's share of total residential spending on that type of energy. This produced results robust to assigning energy savings only to lower income groups or expanding the range of income groups receiving savings; induced effects were the only impacts differing across the methods, but these small changes did not affect the qualitative results.

[9] PSE specified 8.1 percent as the utility cost of capital.

counties served by PSE for each energy type. All tables that follow have been based on models with regions restricted to PSE territory.

IMPLAN Results

IMPLAN produced a summary table for each model, showing program impacts on employment, labor income, total value added, and output in the region.[10] Table 8 and Table 9 summarize these effects. Each impact category has been divided into direct, indirect, and induced effects, as discussed, providing the present values of impacts generated over the lives of measures installed, not just impacts from when the weatherization program was being implemented.

Table 8 summarizes economic impacts for PSE's electric territory.

Table 8. Electric Economic Impacts Summary for PSE Territory

Impact Type	Employment	Labor Income	Total Value Added	Output
Direct Effect	5.9	$8,843	-$3,464,492	-$2,377,424
Indirect Effect	6	$356,912	$633,747	$1,023,846
Induced Effect	38.5	$2,089,141	$3,203,011	$4,989,659
Total Effect	50.5	$2,454,897	$372,265	$3,636,081

* Participant savings and utility revenue loss were discounted using 8.1% (PSE's cost of capital). Had a 4% discount rate (the prevailing average 30-year fixed mortgage rate) been used for discounting participant savings, the economic impact for gas and electric programs would have been 18% and 105% higher, respectively (Appendix G).

The electric model displayed negative direct effects for value added and output, capturing program costs borne by industrial and commercial ratepayers and the utility's lost revenue due to participants' energy savings. Together, these losses overcame the positive direct effect of program spending, directly resulting in a net decrease in these measures of economic activity. The induced effects, however, proved large in relation to total effects, and were positive, as one would expect from energy savings of such magnitude in comparison to program costs. Though the induced effect included a smaller positive component from program spending, the effects shown here have been driven by energy bill savings experienced by program participants. These savings flowed back into the region through household consumption, stimulating activity across the local economy.

Estimated impacts from the electric model could be compared to total electric program spending to gauge program impacts. Dividing each entry in Table 8 by total spending in the electric model ($6,851,214) resulted in an estimate that each dollar of program spending resulted in $0.53 of

[10] **Employment** is given in units of job-years. One job-year equals 12 months of full-time or part-time employment for one person.

Labor income: This includes all employment income (wages and benefits) as well as proprietors' income.

Value Added: This is the difference between gross output (income plus inventory change) and intermediate inputs (goods and services imported or bought from other industries). The value added includes employee compensation, tax payments, and gross operating surplus.

Output: An estimate of production in producer prices. In manufacturing, this equals sales plus the change in inventory. In retail and wholesale industries, this equals the gross margin, not gross sales.

total output in the region. This interpretation also yielded an estimate of one job-year created per $135,668 dollars spent.

Table 9 summarizes economic impacts for PSE's gas territory.

Table 9. Gas Economic Impacts Summary for PSE Territory

Impact Type	Employment	Labor Income	Total Value Added	Output
Direct Effect	7.8	$580,735	$786,715	$1,070,209
Indirect Effect	3.2	$192,191	$333,695	$518,467
Induced Effect	2.3	$124,941	$191,212	$292,840
Total Effect	13.4	$897,867	$1,311,623	$1,881,516

* See Appendix G for alternate impacts using a 4% discount rate for the present value of participant energy savings.

Dividing each entry in Table 9 by total spending in the gas model ($2,294,718) yielded an estimated $0.82 of total output in the region per dollar spent through the program. This interpretation also provided an estimate of one job-year created per $171,248 dollars spent.

Distinctions between the electric and gas model results primarily resulted from two factors: energy savings from gas measures were much lower in proportion to program costs than in the electric model; and the multipliers associated with direct effects for the natural gas distribution industry were smaller than those for the electric distribution industry. The gas model did not display negative direct effects on value added and output, nor did it yield induced effects larger in magnitude than the direct or indirect effects.

Scale of energy savings is another important distinction between models. One way to put regional energy savings in perspective is to compare participants' savings to program costs borne locally by ratepayers and PSE. In the gas model, energy savings by program participants presented 31% of these program costs, whereas, in the electric model, energy savings accounted for 113% of the cost burden.[11] As noted, the flow of participants' energy savings back into the local economy served as the main driver of induced effects across the four economic impact categories; so lower energy savings necessarily resulted in lower induced effects. Relatively low energy savings also resulted in low utility revenue losses in the gas model, as PSE's losses were assumed equal to the value of energy savings by program participants.

This difference in utility revenue losses between gas and electric models has been magnified by translating losses in each case into regional economic effects. The IMPLAN input/output system used industry-specific multipliers to convert industry gains or losses into direct, indirect, and induced effects for each of the four impact categories. Multipliers were based on inter-industry monetary flows *within the region*. If all else remains equal, an industry's multipliers will be smaller if a greater share of the industry's outlays leaves a region through imports. Figure 15 and Figure 16 illustrate outlay shares for the electric and gas industries in PSE territory.

[11] This results from the mix of measures installed. Using the PSE participant database, the average gas-saving measure installed in participant homes would cost nearly twice that of the average electricity-saving measure ($2,068 compared to $1,098), and would reap annual energy savings of just $68, exactly half the average annual energy savings of electric measures.

Figure 15. Electric Industry Outlays

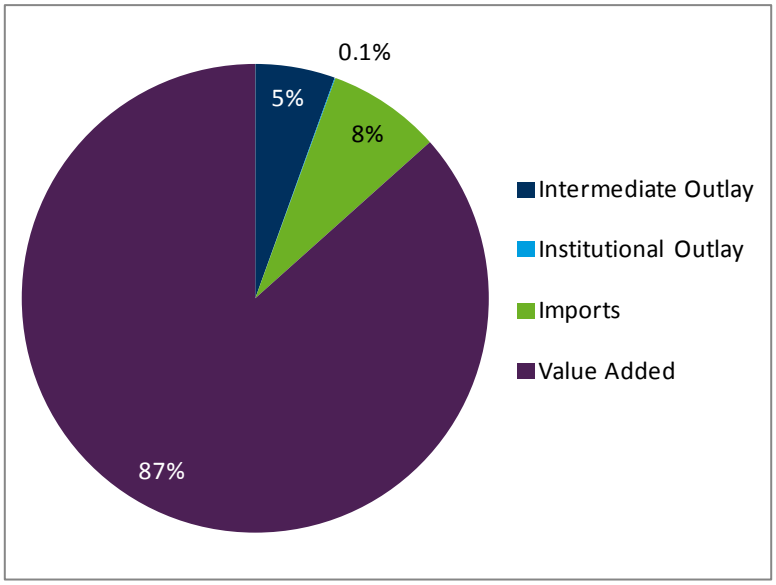
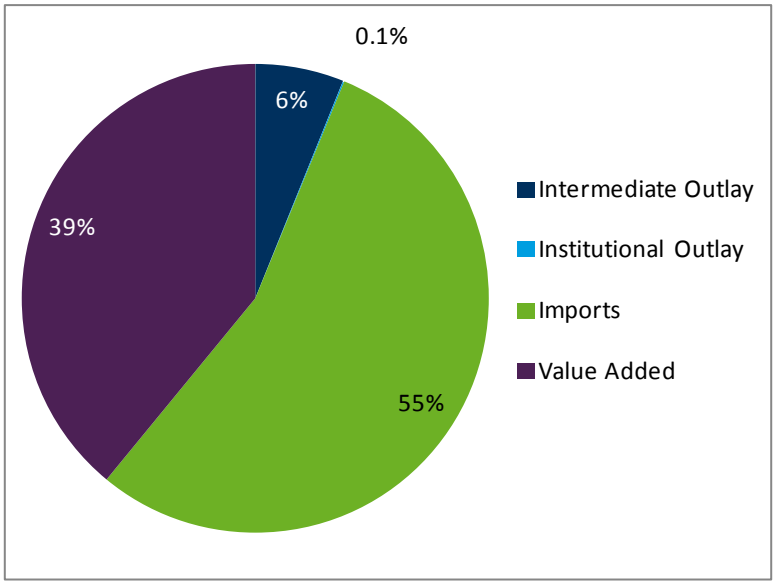


Figure 16. Gas Industry Outlays



The natural gas distribution industry experienced more than half its total outlays (55%) leaving the region through imports, whereas, in the electric industry, only 8% of outlays left the region through imports, implying multipliers for the gas industry would be smaller than those for the electricity industry.

In fact, direct effect multipliers for the natural gas distribution industry are smaller than those for the electricity distribution industry (e.g., 0.39 versus 0.87 for direct effects on value added). These multipliers can be interpreted as dollars-per-dollar; so a dollar gained or lost by the natural

gas distribution industry has less than half the direct effect on value added than a dollar gained or lost by the electricity distribution industry.[12] Consequently, the gas model not only resulted in lower utility losses, but each dollar of lost revenue had a smaller direct effect on economic impacts. Taken together, the smaller scale of revenue loss and smaller multipliers meant direct effects of the natural gas industry's losses were not large enough to overwhelm the direct, positive effects of program spending in the region.

Table 10 and Table 11 list the top 10 industries experiencing the greatest employment increases from the electric and gas measures installed.

Table 10. Top 10 Industries by Employment Increase Induced by Electric Measures in PSE Territory

IMPLAN Sector	Description	Total Employment	Total Labor Income	Total Value Added	Total Output
354	Office	20.3	$1,257,406	$2,252,055	$3,077,164
34	Construction	19.7	$1,282,967	$1,541,107	$3,137,528
319	Commercial other	11.2	$894,470	$1,728,836	$2,649,325
394	Ambulatory health care	3.6	$269,020	$290,419	$450,430
427	Government & non NAICs	2.5	$187,342	$240,924	$292,224
320	Dry goods retail	2.0	$71,383	$103,693	$158,869
398	Nursing & residential care	1.6	$56,574	$64,592	$92,693
399	Social assistance	1.4	$39,248	$39,841	$58,460
413	Food services & drinking places	1.3	$26,782	$40,500	$71,671
426	Private households	1.1	$11,126	$11,126	$11,126

* See Appendix G for alternate impacts using a 4% discount rate for the present value of participant energy savings.

Table 11. Top 10 Industries by Employment Increase Induced by Gas Measures in PSE Territory

IMPLAN Sector	Description	Total Employment	Total Labor Income	Total Value Added	Total Output
34	Construction	6.5	$427,728	$513,305	$1,042,183
354	Office	4.7	$296,197	$533,535	$729,441
319	Commercial other	3.2	$261,479	$507,464	$772,412
427	Government and non NAICs	0.4	$32,112	$40,643	$49,612
320	Dry goods retail	0.3	$11,323	$16,413	$25,053
394	Ambulatory health care	0.2	$15,536	$16,738	$25,773
153	Nonmetal mineral products	0.1	$5,101	$8,611	$21,297
335	Truck transportation	0.1	$5,420	$6,401	$11,233
398	Nursing & residential care	0.1	$3,275	$3,732	$5,330
399	Social assistance	0.1	$2,387	$2,429	$3,566

* See Appendix G for alternate impacts using a 4% discount rate for the present value of participant energy savings.

[12] Labor income and output multipliers can also be interpreted as dollars-per-dollar. Employment multipliers capture the number of jobs per $1,000,000 of industry output.

That office, construction, and other commercial[13] industries saw the largest employment effects was expected, as all program spending (except for CTED auditor expenditures, which were assigned to the government industry) was modeled as flowing directly into these industries. Effects on other industries, such as health care or dry goods retailers, resulted from indirect and/or induced impacts of program spending.

Benchmarking

When comparing economic impact results to results from other studies, such comparisons can be subject to many caveats. Benchmarking can often provide perspective on understanding distinctions between various program impacts, but, due to substantial differences between regions, programs, and modeling assumptions, such comparisons cannot be used to rank results.

Important differences to consider in comparing results include:

- A region's demographics and industry composition;
- The size of the region modeled (i.e., state-level analysis versus a cluster of counties);
- Ratepayer types;
- Underlying economic assumptions (e.g., the discount rate);
- Program type and measures included;
- Impact horizon used in the analysis;
- Relative magnitudes of spending and savings; and
- Funding sources (e.g., costs borne locally versus those covered by federal funds).

Table 12 provides some context for comparing economic impacts across programs by electric utilities.

Table 12. Comparison of Economic Impacts for Electric Utilities

Consultant	State	Region of Analysis	Years	Ratepayers	Program Type	Output Effect / Costs	Output Effect / Savings	Output Effect per Participant*
KEMA/PA	WI	state	2001-2009	Residential	Residential Portfolio	89%	11%	n/a
Cadmus	WA	state	2003-2005	Residential	Low-Income Weatherization	n/a	n/a	$1,470
Cadmus	ID	state	2007-2009	Residential	Low-Income Weatherization	24%	19%	$556
Cadmus	WA	PSE territory	2009-2010	Residential, Commercial, and Industrial	Low-Income Weatherization	53%**	59%**	$2,836**

* The estimated output effect per participant is given in 2010 dollars.

[13] The "other commercial" category includes industries such as wholesale trade, waste management, repair and maintenance, and personal and laundry services.

** Participant savings and utility revenue loss were discounted using 8.1% (PSE's cost of capital). Had a 4% discount rate (the prevailing average 30-year fixed mortgage rate) been used for discounting participant savings, the economic impact for gas and electric programs would have been 18% and 105% higher, respectively (Appendix G).

In 2011, Cadmus analyzed a low-income weatherization program by an Idaho electric utility, and used those findings to benchmark PSE's economic impact results. The Idaho analysis differed from the PSE model in several key aspects: it ran at the state level; only residential ratepayers funded the Idaho program; and the magnitudes of spending and savings differed greatly from the PSE program. Comparing the models required normalizing summary results from each analysis using total spending as a measure of program scale. The PSE electric model showed relative program effects of larger magnitude than those reported for the Idaho analysis, and the PSE program's total effect on output relative to program spending proved twice as large as the Idaho program's.

Analysis of a 2003–2005 low-income weatherization program in Washington also differed from the current model in several key respects, with impacts modeled using state-level data, whereas the PSE model focused on counties in the utility's electric distribution territory. Multipliers were driven by the region's industrial and demographic makeup; so multipliers associated with a subset of counties differed from those for the entire state. The other analysis also differed in the mix of measures installed, costs assigned to local ratepayers, and discount rates used to convert energy savings to present values.

Literature Review

Cadmus compiled a catalogue of existing research on non-energy benefits, providing an overview of estimated values for benefits relevant to low-income weatherization efforts. The literature review was developed as an Excel matrix (provided separately to this report as supplementary documentation). Such benefits can be assigned to categories based on the group they affect: the utility, program participants, and (more broadly) society.

Utility perspective examples include:

- Reductions in arrearages;
- Reductions in administrative costs associated with shutoffs, reconnects, and bill collection; and
- Reductions in subsidy payments to low-income households.

While participants benefit from some of these actions, they also see:

- Improvements in property values, comfort, and indoor air quality;
- Reduced dependence on state assistance; and
- Lower incidences of being forced from their homes due to financial shortfalls.

From society's perspective, in addition to benefits seen by the utility and by program participants, non-energy benefits include:

- Economic development;
- Tax effects;
- Reductions in emissions; and
- Improvements in socioeconomic indicators, ranging from school absences to employment income.

The literature review included the 2010 study, co-authored by The Cadmus Group, providing a survey of existing research.[14] This report assigned non-energy benefits to the three groups discussed above, and provided empirical examples of their estimated values. The review included specific studies by Cadmus and others (listed in Table 13), including non-energy benefit values estimated.

[14] Skumatz, Khawaja, Krop. 2010. "Non-Energy Benefits: Status, Findings, Next Steps, and Implications for Low Income Program Analyses in California."

Table 13. Non-Energy Benefits Literature Review References

Title	Author(s)	Year
Non-Energy Benefits: Status, Findings, Next Steps, and Implications for Low Income Program Analyses in California	SERA, The Cadmus Group	2010
Idaho Low-Income Weatherization Program Evaluation (2007-2009)	The Cadmus Group	2011
Assessment of Green Jobs Created by the OPA Multifamily Buildings Program	The Cadmus Group	2009
Analysis of Low-Income Benefits in Determining Cost-Effectiveness of Energy Efficiency Programs	John Howat, Jerrold Oppenheim	1999
Impact Evaluation from the 2009 California LIEE program	EcoNorthWest	2009
User Guide for the Low-Income Public Purpose Test	TecMarket Works Skumatz Economic Research Inc., Megdal and Associates	2001
Northwest Natural Oregon LIEE program evaluation	Quantec LLC	2005
Indiana REACH Evaluation	Quantec LLC	2001
Ohio Home Weatherization Assistance Program Impact Evaluation	Quantec LLC	2006
Ohio Home Weatherization Assistance Program Year 2003 Process Evaluation	Quantec LLC	2006
Energy Smart Program Evaluation (OR-HEAT)	Quantec LLC	2008
2004-2006 Oregon REACH Program: Final Evaluation	Quantec LLC	2008
PacifiCorp Low-Income Arrearage Study	Quantec LLC	2007
Utah HELP (Home Energy Lifelife Program): Program Evaluation	Quantec LLC	2005
PacifiCorp Washington Low-Income Weatherization Program Evaluation	Quantec LLC	2007
Nonenergy Benefits From The Weatherization Assistance Program: A summary of the findings from the recent literature.	Oak Ridge National Laboratory	2002
Cost Effectiveness of the Oklahoma Smoke Alarm Giveaway Program. Injury Prevention	Haddix, Mallonee, Waxweiler, Douglas	2001
Poisonings in the USA	Carbon Monoxide Safety and Health Association (COSHA)	1997
Mobility Value Estimate	Cadmus Group	2011

Health, Safety, and Repair Benefits

PSE held of particular importance non-energy benefits associated with health, safety, and repair costs spent through the program. These dollars have been used on a range of different measures, including:

- Smoke or carbon monoxide detectors;
- Combustion safety testing;
- Health-related home repairs (e.g., lead or asbestos abatement);
- Repairs to home ventilation or moisture control;
- Health-related equipment repair or replacements (e.g., water heater, heating system); and
- Range of other repairs (e.g., electrical, plumbing, structural, roof).

The literature review provided a wide range of benefit types as well as dollar values attributed to these measures. Benefit categories for health, safety, and repair measures may include improvements to: comfort, safety, health of occupants, home aesthetics, property values, equipment performance or lifetimes, indoor air quality, and reduced instances of fire, death, or insurance damage. The literature review found some studies reported dollar values for these

benefits, citing a wide range, between a few cents to hundreds of dollars per participant. Not all, however, provided quantitative results, and many cited a need for further investigation.

While such benefits can be difficult to quantify, they provide genuine benefits for participants. While specific aspects of health, safety, and repair benefits can be shared out and considered separately, Cadmus recommends, at a minimum, setting benefits associated with these measure equal to costs. This approach assumes that, if the benefit of the health and safety work did not at least equal costs, the work would not have been performed.

Additional information on benefits from different stakeholder perspectives can be found in the literature review matrix.

Non-Energy Benefits for Cost-Effectiveness Testing

The following are approaches for possible inclusion of various non-energy benefits to cost-effectiveness tests:

- Tier 1: Run cost-effectiveness based strictly on California Standard Practice Manual (TRC).
- Tier 2: Add non-energy benefits with the most defensible monetary values (e.g., payment effects, economic impacts, environmental impact).
- Tier 3: Add additional NEBs that are more difficult to quantify and monetize.

Table 14 highlights NEBs recommended for incorporation into the Tier 2 cost-test scenario.

Table 14. Non-Energy Benefits for Tier 2 Cost-Effectiveness Testing

Non-Energy Benefit	Per Participant Impact*		Perspective Adjusted
	Gas	Electric	
Economic Impact**	$5,917	$2,836	TRC
Arrearage Reduction	n/a***	$43.55	UCT, RIM, TRC
Capital Cost Savings	n/a***	$3.53	UCT, RIM, TRC
Environmental	PSE-specific calculation****		TRC
Health, Safety, and Repair	Set equal to costs paid by PSE		PCT, TRC

* Economic impacts reflect the present value over the lifetimes of the installed measures, and payment impacts are annual values.

** Participant savings and utility revenue loss were discounted using 8.1% (PSE's cost of capital). Had a 4% discount rate (the prevailing average 30-year fixed mortgage rate) been used for discounting participant savings, the economic impact for gas and electric programs would have been $6,962 and $5,826, respectively (see Appendix G).

*** Unable to measure due to insufficient sample sizes.

**** PSE indicated that they have the internal capability to identify these impacts.

Regarding Tier 3 benefits, Cadmus recommends considering values highlighted in the literature review matrix. A range of regional and national studies have indicated dollar amounts PSE can cite in additional cost-test scenarios.

MARKET ASSESSMENT

Introduction/Goals

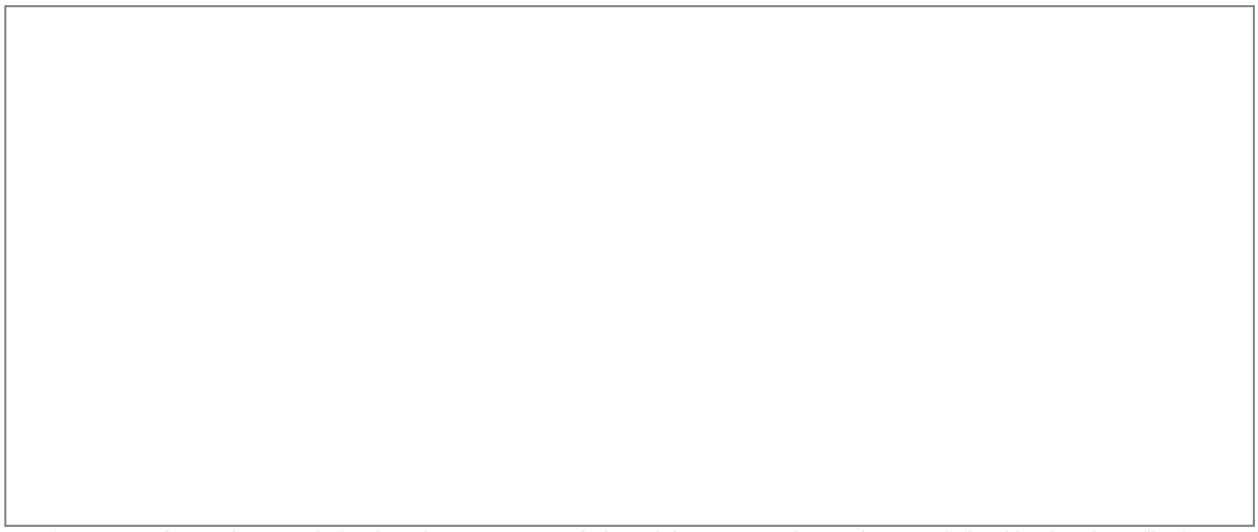
The market assessment served a twofold purpose:

- First, using a geographic information system (GIS), Cadmus developed maps of historical and eligible participants for PSE's low-income weatherization program. This allowed spatial evaluation of prior program involvement and created a framework for identifying and exploring underserved areas within PSE's service territory.
- Second, Cadmus focused on targeting eligible participants and regions using multivariate vector data within the GIS and a set of prioritization criteria. By overlaying underserved areas (e.g., no historical participation), areas showing evidence of higher need based on demographic information, and nonparticipants with high-energy intensities,[15] Cadmus established a dynamic system to be used for efficient and accurate targeting throughout PSE's service area.

Service Territory

PSE's service territory extends over 11 counties in Washington. Gas and electric territories are not identical, and, as such, historical and eligible participants may not subscribe to both service types from PSE. The service territory's extent plays an important part in the targeting process. PSE provided a map of its service territory through its Website, and provided Cadmus with a set of shapefiles defining that area, as shown in Figure 17.

Figure 17. PSE Service Territory*



* Left: PSE service territory as defined on the company Website. Right: PSE service territory as defined by the shapefile data.

[15] Energy intensity has been calculated by dividing weather-normalized annual energy consumption by building square footage.

Upon receiving the PSE territory shapefile from the utility, it became apparent service areas notably differed. The shapefile provided contradicted intuition (e.g., the electric service territory boundary extended into counties PSE does not serve) and omitted detail necessary for a cohesive, accurate mapping framework. To account for these issues, Cadmus defined all maps to include the full extent of the 11 counties PSE serves. This ensured no part of PSE's service territory has been excluded, and provides a clean boundary for visual display. For individual targeting and identification of service type, Cadmus georeferenced (i.e., assigned geographic location to) the Website map, allowing both versions to be used in the GIS. In some cases, verification of service types for eligible participants will require further delineation of the exact service area.

Methodology

Data Sources

Cadmus collected data from a variety of sources in compiling a comprehensive GIS for mapping and targeting purposes. Initial data provided by PSE included information for identifying a potential nonparticipant group, billing data for these nonparticipants, and a list of historical low-income weatherization participants. These data included house addresses and limited physical characteristics of houses (e.g., home types).

Cadmus identified nonparticipants based on site IDs for customers receiving billing assistance payments (such as from LIHEAP), and not participating in weatherization for the years provided in the participant database (2008 to mid-2011).

For display and spatial binning purposes, the GIS required geographic boundaries, such as census tracts and counties. These data, built into the Environmental Systems Research Institute's (ESRI) ArcMap program, have been used as the background for all maps.

To calculate energy intensity, a metric normalizing energy consumption relative to home square footage, Cadmus obtained square footage data through a batch download process from the real estate Web service Zillow (www.zillow.com).

Lastly, Cadmus identified variables to establish areas of high need. These demographic data included: poverty status, presence of children, and population age and disability characteristics. Cadmus sourced all demographic values from the U.S. Census Bureau, accessed from: http://factfinder2.census.gov/main.html.

Sample Selection

The dataset of historical participants included 2,029 unique sites, weatherized from 2008 to mid-2011. Cadmus' maps of historical participants differentiated participant sites by service type, which included: 1,572 electric customers, 270 gas customers, and 187 customers receiving both services.

Cadmus developed the sample frame of likely eligible nonparticipants using records of customers receiving outside payment assistance (such as through LIHEAP). Consisting of 56,705 unique customer sites, this frame drew from 2010 payment assistance records for customers where PSE deemed eligibility for billing assistance consistent with eligibility requirements for

the low-income weatherization program. These data were checked for completeness of billing records, address accuracy, and availability of square footage data. From this, Cadmus drew a simple random sample. The final qualifying sample used in our study included 10,712 electric customers and 7,907 gas customers.

Map Development

Cadmus built a base map for the GIS using the polygon vector data from ESRI. For display purposes, Cadmus used Universal Transverse Mercator Zone 10 projection, which is longitudinally centered on the Puget Sound region. This projection used the WGS 84 geographic coordinate system. With the base layers established, Cadmus geocoded all participant and nonparticipant addresses using the North America Geocode Service (version 10.0), which is an online offering through ArcGIS. Billing data and other potentially relevant housing characteristics were joined to the geocoded addresses, creating a substantial point dataset of historical participants and eligible participants.

Using square footage data from Zillow and annual weather-normalized usage data, Cadmus calculated energy intensities for the eligible participant sample. Energy intensity provides an extremely important aspect of the targeting process, as it evaluates building efficiency based on a normalized metric, controlling for household and usage characteristics. Households were removed from analysis returning square footage values greater than 3,000 square feet.

With the final historical and eligible participant datasets intact, Cadmus downloaded the demographic data, bringing it into the GIS for use in the mapping and statistical processes. These census data were processed to analyze four categories:

- The number of households below 200% of the poverty level;
- The number of households with children under 18 years of age;
- The number of people over the age of 65; and
- The number of people with a disability.

Demographic data were collected at the census tract level to allow small-scale targeting of regions and neighborhoods that might qualify as high need. To preserve the small-scale resolution and to allow direct comparisons and calculations, historical participants were binned at the census tract level. Standardizing data at the census tract level allowed normalized rankings and comparisons of disparate data across PSE's service territory.

The only category Cadmus could not evaluate at the census tract level was energy intensity, as many census tracts did not contain the eligible population sample. Consequently, average energy intensity was calculated and ranked at the county level. The county level ranking was then normalized, and the value for a given county was assigned to each census tract within it. This allowed comparison and evaluation of energy intensity with other census tract level data.

Cadmus then compiled the six metrics (four demographic categories from census data, historical participation, and energy intensity) to identify trends, hotspots, and outliers. Values in each category were normalized, ranking census tracts from 1 to 860 (the total number of census tracts within the 11-county area). Tracts were always ranked so, for a given category, a rank of 1

corresponded to the prioritization target of "high need" (e.g., the fewest historical participants, the highest energy intensity, the most households below 200% of the poverty level), while a rank of 860 corresponded to the lowest priority ranking. These ranks were summed to provide a total unweighted value to each census tract, with census tracts having the lowest sums corresponding to those having the highest need. Cadmus then identified the top 50 tracts with the lowest scores, or "highest need."

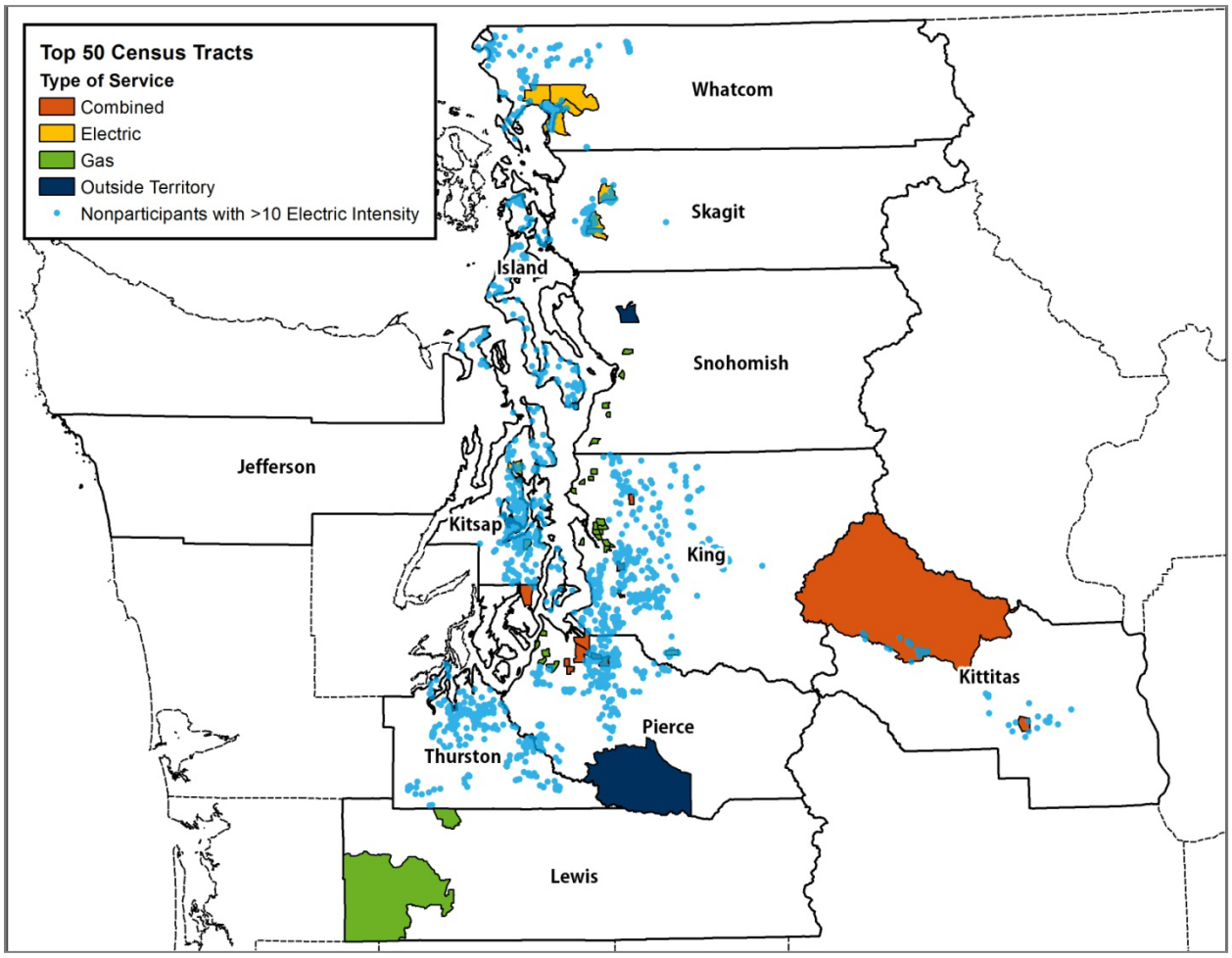
Using the georeferenced service territory from the PSE Website, Cadmus identified the service type for each census tract (i.e., gas, electric, combination). If even part of a census tract was served, the tract was associated with this service type.

With the top 50 "high need" census tracts identified, Cadmus overlaid eligible participant energy intensity data to identify clusters of potentially eligible participants within these census tracts, with intensities set above a specified threshold. The sample was first restricted to show only customers with energy intensities above 10 kWh per square foot, which Cadmus identified as the threshold associated with intensities in approximately the highest quartile of the sample (24.3%). These individual houses were further restricted to produce a list of only customers living in one of the top 50 census tracts. This method identified ideal candidates most likely to meet all program qualifications, and to rank highly in other prioritization categories.

Mapping Results

GIS outputs consist of a series of maps. Figure 18 provides a final map, with the top 50 census tracts and high-energy users within the region.

Figure 18. The Top 50 Census Tracts with High-Energy Use Eligible Participants*



*The final map product shows the top 50 census tracts, classified by service type, overlain by all eligible participants who, according to the billing analysis, have an electric intensity of more than 10 kWh/sqft. Houses intersecting the top 50 census tracts are probable low-income weatherization program candidates.

Appendix C contains a collection of additional maps leading up to the development of Figure 18, including:

- Households below 200% of the poverty level summed at the census tract level.
- Households with children summed at the census tract level.
- Number of people over the age of 65 summed at the census tract level.
- Number of people with a disability summed at the census tract level.
- Average electric energy intensity (kWh per square foot) of houses at the county level.
- Number of historical participants summed at the census tract level.
- The sum of the rankings from each of the six preceding variables.
- Normalized bar graph representation of the variables and sums at the county level.

- The sum of the rankings with the top 50 most in need census tracts highlighted.
- Classification of service type for the top 50 census tracts.

Recommendations

Using the map in Figure 18 primarily for demonstration purposes, Cadmus discussed results with PSE staff, and presented strategies for efficiently targeting future program participants. Methods employed for identifying underserved or high-need areas approximated a gap analysis, allowing PSE to target specific areas (e.g., census tracts, ZIP codes) for expanding program offerings. At the same time, incorporating high consumption as a means of targeting or prioritizing participation focused on identifying individuals meeting specific criteria. Cadmus offered the following recommendations for methods to integrate efficient targeting into the low-income weatherization program's delivery. A database of information underlying the mapping effort (e.g., nonparticipant sample, energy intensity, census tract, ZIP codes) was provided to PSE as a supplementary excel file along with this report. In addition, a list of the top 50 census tracts, including the associated ZIP+4 information for nonparticipants, is provided in Appendix H.

Develop targeted high-consumption weatherization pilot program.

Opportunity exists to design a pilot program not only around targeting high-usage customers for weatherization, but localizing delivery to specific neighborhoods where these customers cluster. A pilot study will allow PSE to test for differences between their standard weatherization program and one focused on high-consumption households, particularly regarding differences between pre-period usage and overall energy savings. As a pilot program, PSE can separate delivery from the state's Weatherization Assistance Program, and avoid constraints surrounding agency's typical program delivery (e.g., leveraging multiple funding sources). Targeted high-usage pilot weatherization programs have been implemented by other states and utilities, including Pennsylvania (PPL, Philadelphia Gas Works) and Indiana (Indiana Power & Light, Citizen's Gas).

Program delivery can be targeted to specific neighborhoods with pockets or clusters of high-usage customers. This approach allows advantages in focusing on localized delivery, such as reduced transportation costs, and likely increased efficiencies for expedient delivery. PSE might also partner with one or multiple community action agencies, or serve as the lone delivery vehicle. In either case, a normalized metric for high consumption (i.e., energy intensity) should be used to control for variations due to household size, number of occupants, and, to some degree, usage patterns.

Along with whole-house weatherization, energy education provides another component that should be included. While usage patterns and awareness serve as intuitive contributors to energy consumption, a high-usage pilot study in Pennsylvania cited occupancy behaviors (i.e., a lack of

understanding about how energy usage relates to energy bills) as a key finding, attributable to higher usage.[16]

Work with agencies to integrate high consumption into their prioritization calculations.

The Washington State Low-Income Weatherization Manual cites the following instruction regarding inclusion of high-energy use and high-energy burdens as priority categories:

> These are in no way mandatory and may be used in lieu of, or in any combination with, the existing priority categories. With these additional categories, local agencies may be better able to partner with utilities and other programs to leverage additional resources into their programs.[17]

PSE should work with local delivery agencies to help integrate a high-consumption metric, such as energy-intensity or energy burdens, into their prioritization calculations.

PSE could take several approaches in providing this assistance. One would be to work with agencies to help identify high-consumption customers at the time of enrollment. If agencies could provide PSE with periodic lists of applicants, the utility could analyze customers on the waiting list to determine energy-intensity levels for prioritization.

In another approach, PSE could ensure agencies have the ability to calculate energy intensity at the time of enrollment, integrating this criterion up front. As cited in this report's Process section, at least one agency could not access PSE's customer billing information in-house, presenting a barrier to calculating high-usage. Maintaining agency access to billing histories and developing protocols for assessing high-usage provide critical components for agencies integrating new prioritization methods based on energy consumption.

Alternatively, PSE could identify geographies (e.g., neighborhoods, ZIP codes) with high concentrations of high-usage customers, submitting these to agencies as part of a watch list. Agencies could then inform PSE when participants from these areas enrolled in the program. PSE would then have an option of analyzing energy intensity of these targeted participants.

The utility could then decide whether to treat high-usage customers differently, perhaps by changing their incentives levels (i.e., increasing available PSE dollars due to higher assumed savings), or earmarking PSE funding to guarantee they will fund (and claim savings for) specific high-savings measures.

Calculating weather-normalized annual consumption and creating an energy-intensity threshold (e.g., 12 kWh/sqft) for "high" consumption are two criteria important for standardization. Agencies will need to be able to measure high-consumption for prioritization across different years and participant types, requiring methods for universal comparison. PSE may develop such

[16] http://www.affordablecomfort.org/images/Events/22/Courses/804/IMP3_Soto_HighUseTargetProgramsResults_sec.pdf

[17] http://www.commerce.wa.gov/DesktopModules/CTEDPublications/CTEDPublicationsView.aspx?tabID=0&ItemID=10233&MId=870&wversion=Staging

criteria with agencies, or could use guidance from other policy makers (i.e., Washington Department of Commerce, Energy Project) to develop state standards for incorporation.

Work with agencies to highlight high-need or underserved areas within their service territories.

PSE should work with agencies to identify clusters of high-need areas within their individual service territory. Resource constraints, smaller capacity of some agencies, insufficient marketing, or even remote geographies present factors that may contribute to areas of need identified through analysis. Collaborating with agencies and other stakeholder groups will best identify specific implementation barriers and determine optimal ways to deliver program services to these customers.

Increase agency budget allocations to help target high-need or underserved areas.

In some cases, high-need or underserved areas occur in parts of PSE's territory with agencies having smaller crews and capacity for production. Some agencies have very few in-house staff, and must contract out much weatherization work. PSE may consider adjusting budget allocations for some smaller agencies, providing sufficient resources for reaching more eligible customers in identified underserved areas.

Increase marketing and program awareness in high-need or underserved areas.

Additionally, higher densities of underserved areas could arise from lower levels of marketing or program awareness. PSE could work with agencies to highlight these areas, focusing more program marketing towards these communities.

PROCESS EVALUATION

Cadmus' process evaluation of PSE's 2009–2010 low-income weatherization program included four primary activities:

- Development of a program logic model;
- Participant tracking database review;
- Stakeholder interviews; and
- Participant surveys.

The process evaluation research assessed the following:

- Program expectations and successes;
- Program design and delivery;
- Bottlenecks in program delivery;
- Participant characteristics and satisfaction; and
- Opportunities for improvements.

Process evaluation data collection was conducted primarily through surveys and interviews. Additional information was derived from a review of PSE's participant tracking database, and from initial development of a logic model illustrating program process flow. Cadmus drew on experience conducting evaluations of low-income programs across the country to help benchmark results from PSE's low-income program against other, similar programs.

The process evaluation also provides conclusions and recommendations regarding program processes, communication, and delivery improvements, where applicable.

Methodology

Table 15 summarizes activities Cadmus performed for the process evaluation.

Table 15. Process Evaluation Activities

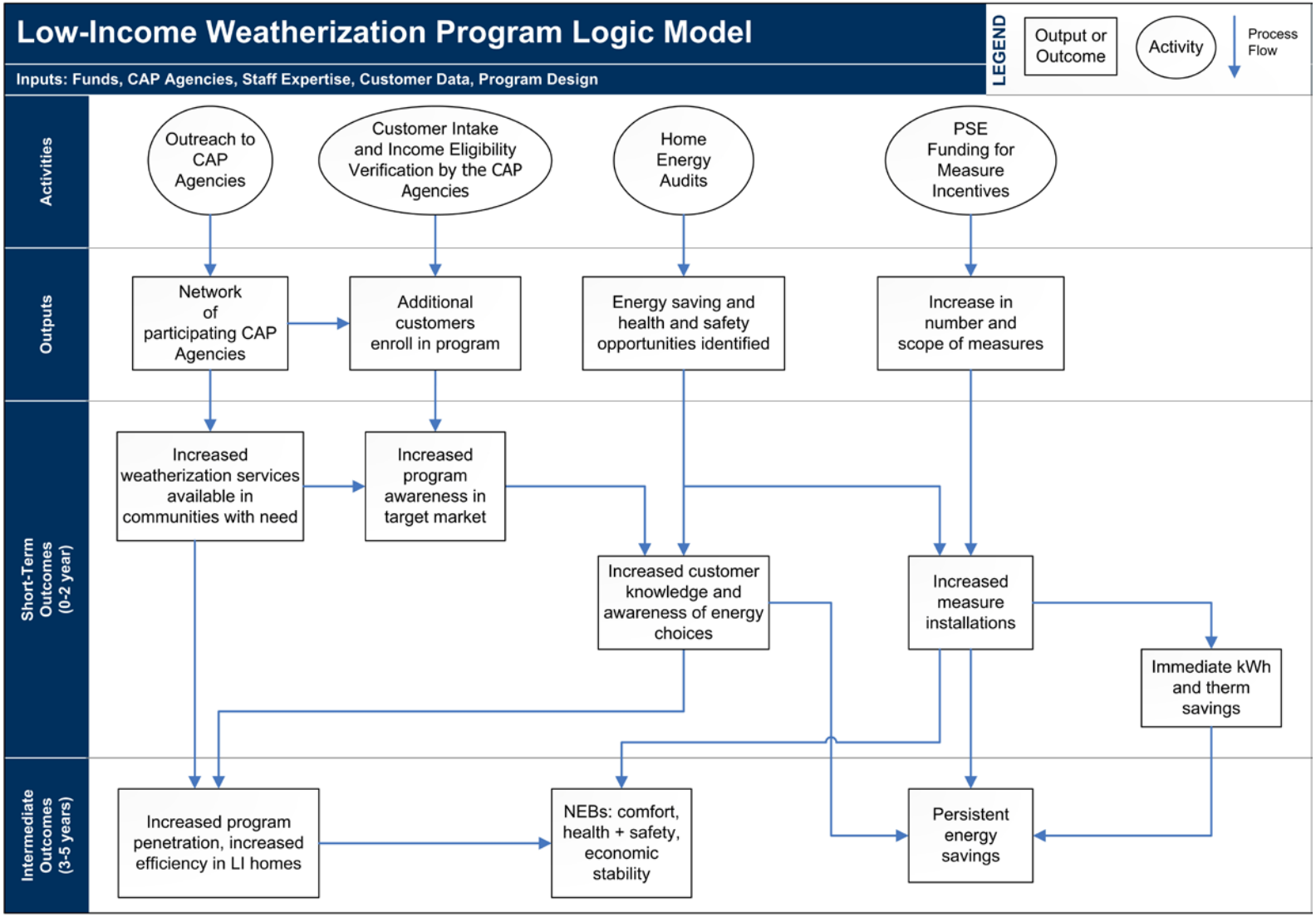
Activities	Purpose
Logic Model	Provide an initial depiction of program flow and theory, and illustrates points of evaluation inquiry.
Database Review	Provide an overview of program delivery, goals, progress, and participants.
Participant Surveys	Verify measure satisfaction and awareness, determine demographic and building characteristics, and investigate program non-energy benefits (n=120).
Stakeholder Interviews	Gauge a variety of stakeholder perspectives on a range of program-related issues, including communication, goals, program implementation, barriers to delivery, and more.

Logic Model and Process Flow

After reviewing program material from PSE, Cadmus created a logic model to reflect program theory, goals, and delivery systems. The model, reviewed with program managers, was used in developing process strategies and survey instruments.

Figure 19, below, presents the logic model developed for PSE's low-income weatherization program, and describing program implementation process flows.

Figure 19. Low-Income Weatherization Program Logic Model



Key Indicators:
Outreach – Number of participating customers, length of CAP waiting lists, participant awareness of PSE funding
Home Energy Audits & Measure Incentives – Number/type of measures installed, energy savings, incentive amounts, quality control inspection results

Sampling Approach

Cadmus conducted a telephone survey with 120 participant households. Assuming a proportion of 0.5,[18] the survey would produce estimates within 90% confidence intervals of ±7.5 percentage points. While this precision level exceeds industry standards, the sample size helped account for non-response and other data attrition. In addition, a larger sample size allowed more intergroup comparisons, such as comparing characteristics among home types.

Cadmus drew samples from participant tracking data provided by PSE for 2009–2010 participants. Using the most recent gas and electric billing data (2011), Cadmus checked for changes in premise IDs among participant account numbers, verifying participants still resided in weatherized homes. Participants that moved were removed from the sample. Table 16 shows counts of eligible customers, with eligible contact information, included in the phone survey.

Table 16. Call List Summary

Record Type	Total
Total unique project numbers	1,442
No premise ID	458
No billing data provided	19
No phone number	10
Moved/changed account number	107
Eligible participants in call list	848

Cadmus achieved the targeted 120 completes for the participant phone survey, achieving particularly high response and cooperation rates. Table 17 further details the participant population, and details the final survey sample.

Table 17. Low-Income Participant Details and Survey Sample

	Quantity
Total Participants	1,442
Eligible Participants in Call List	848
Screened out due to change in occupancy or bad phone number	626
Completed Surveys	120
Number of Calls Required to Achieve Sample	1,093
Response Rate*	30%
Cooperation Rate**	42%
Sample Size Goal	120

* Response rate defined as: the number of customers completing a survey, divided by the number of eligible participants in the call list.

** Cooperation rate defined as: the number of customers completing a survey, divided by the number of customers reached by phone.

[18] In conducting surveys, one has to make an assumption of the proportion of respondents falling in any category of interest (e.g., installed a measure). Assuming a 0.5 value for a proportion proves most conservative, implying one knows nothing about the population studied. Any other value would be better than 0.5 (50/50 chance). As such, any value found during the survey lead to higher confidence and precision levels than the planning values.

To address potential non-response bias, Cadmus split the sample in half, and provided the sample separately to the hired survey firm, Discovery Research. Phone surveys were conducted with calls at different times during weekdays and weekends. After five unsuccessful calls, contacts were removed from the sample.

Stakeholder Surveys

For stakeholder interviews, PSE provided names and contact information for the different stakeholders:

- Energy Project staff;
- Weatherization Assistance Program (WAP) program managers from the Washington state Department of Commerce (Commerce); and
- Weatherization leads from four of the implementing agencies delivering 2009 and 2010 program services.

Process Findings

Participant Database Review

Cadmus performed an in-depth participant database review as part of the process evaluation. This review sought to provide feedback on overall data quality and structures, and provided information for other, broader evaluation tasks, including:

- Program information for the participant survey instrument (e.g., measures, installation dates, agency information);
- Participant contact information for sample selection;
- Historical participation data for the Market Assessment; and
- Annual energy savings (2009, 2010), used as inputs for economic analysis under the Non-Energy Benefit Assessment.

In reviewing the participant database PSE provided, Cadmus determined 1,442 unique program participants (based on premise IDs) in the 2009 and 2010 program years. As shown in Table 18, distributions of sites weatherized (by agency) shows the King County Housing Authority as responsible for the most weatherization, using PSE funds across program years 2009 and 2010. The Opportunity Council and the Housing Authority of Skagit County also participated substantially.

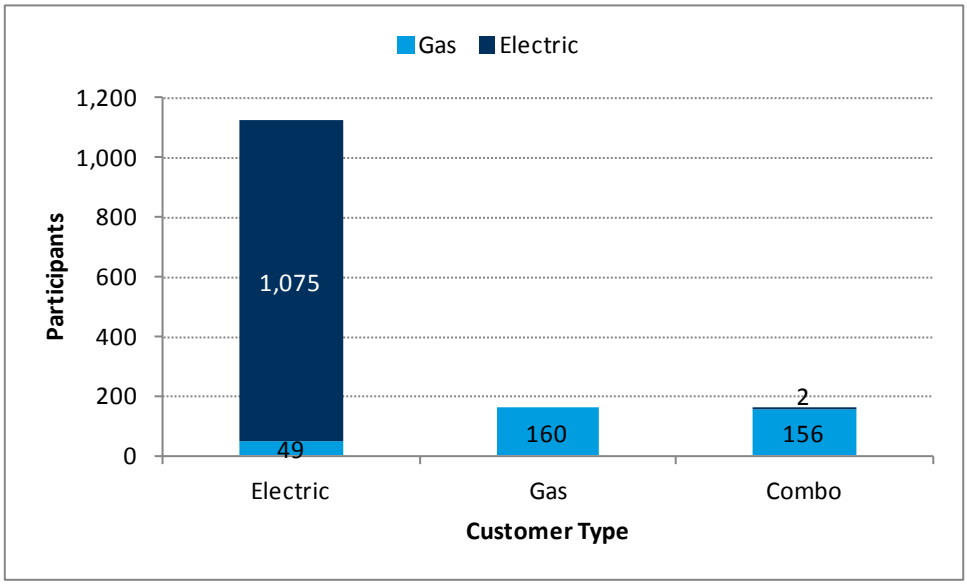
Table 18. 2009–2010 Program Participation by Agency*

Agency	2009	2010	Total
King County Housing Authority	185	221	406
The Opportunity Council	108	184	292
Housing Authority of Skagit County	47	147	194
Community Action Council of Lewis, Mason, and Thurston Counties	79	71	150
Kitsap Community Action Program	69	70	139
Pierce County CAA	25	68	93
Metropolitan Development Council	36	36	72
Olympic CAP (Clallam-Jefferson Community Action Council)	18	32	50
Snohomish County HSD	19	18	37
HopeSource	0	8	8
City of Seattle DHHS	0	1	1
Total	586	856	1,442

* Program participants are unique participant households. Participation is calculated using measure completion data drawn from the PSE participant database. Where measures were installed for a project in both 2009 and 2010, participants were counted as 2010 participants.

As shown in Figure 20, approximately three-quarters of homes receiving weatherization funding from PSE listed electricity as their primary heating fuel.

Figure 20. 2009–2010 Distribution of PSE Participants by Customer Fuel Type and Primary Heating Fuel*



* Cadmus determined customer type by the presence or absence of account numbers for a given fuel.

Approximately 78% of weatherized homes were electric-only PSE customers; of those homes, 95% primarily used electric heat.

As shown in Table 19, Cadmus' initial review of the 2009–2010 participant database found insulation and compact fluorescent lamps (CFLs) accounted for more than half of all electric savings.

Table 19. 2009–2010 Frequency and Savings Distribution by Measure Category*

Measure Category**	Quantity	Proportion of Participants	Electric Savings		Gas Savings	
			kWh	Percent	Therms	Percent
Insulation	828	57%	1,717,324	36%	39,174	48%
CFLs	19,435	44%	1,192,966	25%	0	0%
Infiltration	757	52%	632,786	13%	7,326	9%
Windows	69	4%	469,343	10%	21,997	27%
Refrigerator Replacement	575	16%	338,164	7%	0	0%
Duct Sealing	356	25%	247,211	5%	2,651	3%
Aerators/Showerheads	687	20%	68,401	1%	8	0%
T-Stat Setback	205	14%	54,907	1%	0	0%
Water Heater Wrap	43	3%	17,100	0%	10	0%
Pipe Insulation	502	35%	9,660	0%	29	0%
Water Heater Replacement	33	2%	800	0%	60	0%
HVAC Replacement	265	5%	0	0%	10,727	13%
Total	23,755		4,748,663	100%	81,983	100%

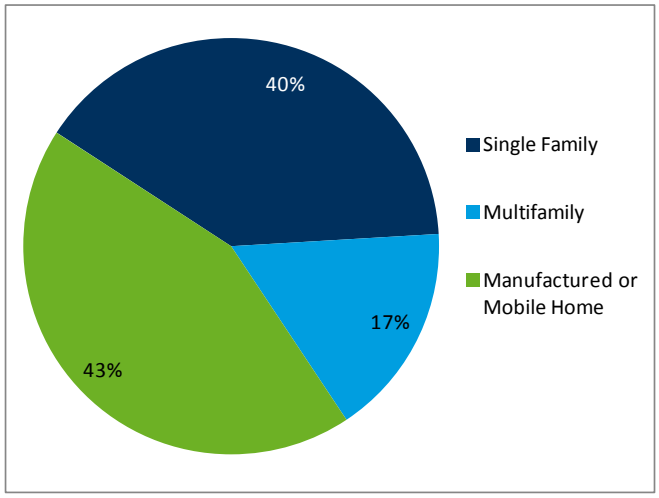
* Measure quantities listed provide instances of per-unit installation; insulation measures have been based on numbers of projects, rather than square footage.

** Database records indicating measures not paid for by PSE have not been included in the table.

Insulation measures, installed in over half of participant homes, accounted for almost half of gas savings.

As shown in Figure 21, multifamily and manufactured homes account for the majority of participants.

Figure 21. 2009–2010 Distribution of Participation by Building Type



Most weatherization programs around the country primarily serve single-family, detached homes; however, PSE's program proves itself unique by serving more manufactured/mobile homes and a good portion of multifamily properties. Discussed in more detail under the

interview findings, some agencies indicated lower single-family participation due to eligibility issues surrounding higher health, safety, and repair needs required prior to weatherization.

Cadmus also reviewed costs and expected average savings per participant. Table 20 shows costs and savings data for the 2009 and 2010 program years.

Table 20. Comparison of Average 2009–2010 Participant Costs and Savings

Year	Avg. Participants*	Avg. Cost per Participant**	Avg. Expected kWh Savings per Participant	Avg. Expected Therm Savings per Participant
2009	654	$3,430	2,863	38
2010	856	$5,709	3,360	67

* Based on the participant tracking database, calculated using the unique project numbers per year.

** Based on dollars paid per measure installation from the participant tracking database, including non-energy efficiency measures (e.g., health, safety, repairs).

PSE had an average cost per participant higher than other utilities' contributions to low-income weatherization programs;[19] however, increased costs from 2009 to 2010 also reflect increases in average energy savings per participant. Higher PSE dollars spent per home likely resulted in part from a 25% budget increase in 2010, arising from the attorney general settlement with Enron and an increased health and safety budget.

Program Goals and Objectives

According to PSE program staff, the low-income weatherization program seeks to provide energy-efficiency improvements for customers that otherwise could not afford them. Staff also indicated providing these services to underserved populations proved equally important as achieving energy savings as a function of reducing customer energy bills. Program staff had a clear understanding that funding could be spent (e.g., through repairs, health, and safety) to help prevent turning away potential applicants when other funding could not cover repairs allowing full weatherization. Additionally, the PSE program considered increasing contributions when agencies had additional capacity and need, but had exhausted their initial funding.

Stakeholders agreed, overall, the program sought to improve the lives of low-income customers through reductions in their energy costs as well as through non-energy benefits associated with weatherization (e.g., increased comfort, safety).

PSE outlined energy-savings goals for both electric and gas savings attributed to their low-income weatherization program. Defined in kWh and therm savings, these goals have been calculated using deemed savings estimates, largely based on the Regional Technical Forum (RTF). For the program years 2009 and 2010, PSE reported achieving savings goals in both cases, as shown in Table 21, below.

[19] A comparison of six utility low-income weatherization programs showed a range of approximately $1,500 to $5,000 per participant. Many factors contributed to this range, including rebate levels set by the utility, whether delivering gas and electric measures, and time periods (especially considering Recovery Act influence, starting in 2009).

Table 21. PSE 2009–2010 Savings Goals Comparison*

Savings	2009			2010		
	Goal	Actual	% Achieved	Goal	Actual	% Achieved
kWh	1,342,000	1,872,410	140%	1,380,000	2,876,253	208%
Therms	22,207	24,702	111%	27,075	57,281	212%

* Actual savings were calculated using PSE's program tracking database, while savings goals were provided by PSE.

Program Delivery

Program Overview and Design

PSE's low-income weatherization program, modeled on the federal WAP, is delivered alongside Washington-state's low-income weatherization program, leveraging state and federal funding sources and local delivery systems. Throughout the utility's service territory, 13 community action agencies operate the program on behalf of PSE. Until 2007, PSE contracted with Commerce in coordinating with agencies, including allocation of utility funding and program delivery. Starting in April 2007, PSE began contracting directly with individual agencies, with the objective of getting more involved in the program for increased accountability.

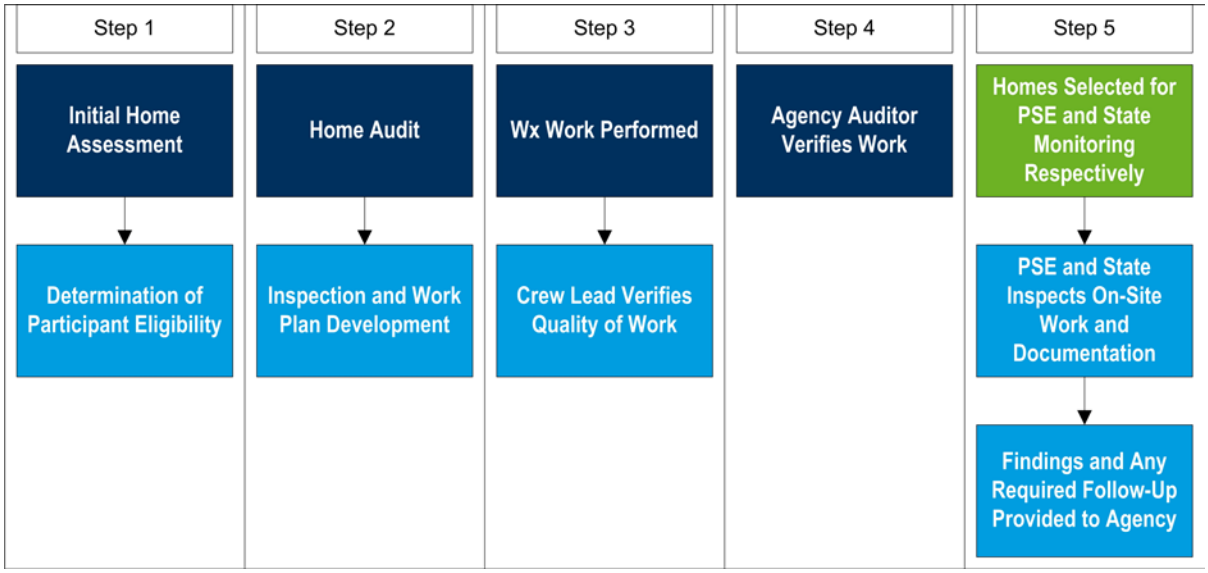
Despite direct contracting with the agencies, PSE's program remains closely aligned with the state's low-income weatherization program in several ways, including participant eligibility and prioritization, delivery protocols and procedures, implementer certifications, and measure identification.

Potential participants are recruited by their local community action agencies through enrollment in the Energy Assistance Program (EAP), which provides income-qualified applicants assistance with their energy bills. Low-income weatherization income eligibility is set at 200% of the federal poverty level (or 60% of the state median income, whichever is higher). Once enrolled in EAP, individuals automatically qualify for enrollment in low-income weatherization.

After enrollment, participants are prioritized using a point system, based on U.S. Department of Energy (DOE) protocols, with priority primarily given to households with elderly, disabled, or children under the age of six. While high-energy consumption is another prioritization category defined through DOE, none of the agencies have incorporated this criterion into their practices. Once enrolled and prioritized, participants are placed on a waiting list to be served by local weatherization agencies (e.g., community action agencies).

Once an eligible participant approaches the top of the agency's waitlist to be weatherized, the agency will visit the client's home, and perform a pre-assessment to determine whether the home serves as a good candidate for weatherization services. Figure 22, below, illustrates steps in the weatherization and quality assurance process.

Figure 22. Low-Income Weatherization Delivery and Quality Assurance Flow



Many agencies use the initial home assessment (or pre-assessment) to determine whether an eligible customer's home meets weatherization requirements. During pre-assessment, the agency staff collects information on the customer's home (e.g., building and usage characteristics). In some cases, extensive repairs not covered by available funding sources, or significant health and safety issues, may result in a potential participant being turned away. For example, a home in need of extensive roof repairs would have to address those issues before program funding could be spent on attic insulation.

Most agencies also have auditors speak with residents, providing energy-saving education and potentially installing low-cost energy-saving measures,[20] such as CFLs and energy-efficient showerheads. A standardized energy-education curriculum[21] has been developed in Washington, which includes energy-educational materials to leave with participants; however, it appears agencies and individual contractors may take different approaches in delivering energy education to clients.

If pre-assessment determines the need for weatherization, an agency auditor will be scheduled to perform a home audit.[22] The state of Washington requires all auditors to be Building Performance Institute certified, which has been adopted by the agencies interviewed. While on-site, auditors perform combustion and safety diagnostics, a blower-door test, collect information on existing conditions or equipment, and recommend weatherization and health and safety measures to be installed through the program.

[20] http://www.commerce.wa.gov/DesktopModules/CTEDPublications/CTEDPublicationsView.aspx?tabID=0&ItemID=8050&MId=870&wversion=Staging

[21] http://www.commerce.wa.gov/uploads/housing/conedmanual.pdf

[22] One agency indicated it does not include a separate step in the process for pre-assessment, but simply assesses a home during the audit.

Measure Determination

In Washington, Commerce developed a preapproved measure list to help assist agencies in determining what is approved for installation, based on DOE protocols. Measures included on the list satisfy DOE requirements. Agencies consider these requirements the most stringent funding source, and are, on average, cost-effectively installed. DOE generally approves state-level preapproved lists to allow agencies to easily install measures in homes without running individualized cost-effectiveness tests or audit software, such as the Targeted Retrofit Energy Analysis Tool (TREAT), for the majority of projects.[23] Each agency interviewed reported primarily following the state preapproved measure list for determining measures for installation in participant homes.

While PSE aligns with state protocols for measure determination, the utility has defined cost constraints based on measure cost-effectiveness and amounts PSE is willing to pay. Within PSE's reporting tool, the LIW Online System, agencies can easily calculate PSE funding levels available for individual measures with specific household conditions. Currently, measure savings are based primarily on RTF-designated deemed savings estimates, with some non-RTF savings assumptions drawn from evaluation reports. PSE uses a Total Resource Cost (TRC) test of 0.667 as the cost-effectiveness threshold for screening measure installations through the LI Online System.[24]

The Energy Project

An advocacy group operating in Washington, the Energy Project that works with a variety of low-income weatherization program stakeholders to assist in program planning and policy decisions. The Energy Project was developed to support Washington agencies in securing sufficient funding to serve the low-income community.

One central Energy Project function is working with utilities and agencies to identify program funding levels required to meet agency needs, recognizing capacity constraints, and helping utilities with long-term planning. In the past, the organization has worked with stakeholders to standardize program aspects and to alleviate some agencies' administrative burdens. For example, the Energy Project worked to standardize lists of eligible measures and protocols for how such measures should be installed.

Funding Distribution

As noted, prior to 2007, PSE contracted the program through Commerce, which allocated PSE funding to agencies using methods similar to those used to distribute federal weatherization dollars throughout the state (based on heating degree days (HHD) and the poverty population in the agency's territory). PSE staff reported the decision to begin independently contracting with agencies sought to heighten PSE's accountability for its low-income weatherization funding.

[23] In a few circumstances, agencies must run auditing software: 1) multifamily buildings; and 2) if recommended installations are beyond standard levels outlined in the pre-approved list (e.g., installing to R49 insulate, rather than up to the standard R38).

[24] Program staff indicated this cost-effectiveness threshold was set by the state for programs with difficult to quantify non-energy benefits (e.g., low-income weatherization).

When PSE began independently contracting with agencies in 2007, the program's budgeting process resulted from direct communication with agency staff, determining reasonable allocations each agency would be expected to expend. Through these conversations, and through review of past production levels, PSE developed the program budget.

Throughout the year, PSE and agency program staff have remained in communication to discuss budget levels, track spending, and reallocate dollars when agencies estimated they could not spend their full PSE disbursement. Additionally, agencies have returned to PSE mid-year to request more funding upon exhausting initial allocations, or to deal with a few situations unique to specific projects. In many cases, agencies reported PSE has accommodated these requests and provided extra funding.

Agency Staffing

Agency staffing strategies ranged from maintaining crew-based staff, and performing all auditing and weatherization work directly by agency staff, to subcontracting different project aspects (including some auditing and weatherization work, but, more commonly, any HVAC, electrical, or plumbing repairs).

Due to the influx of Recovery Act[25] funding going toward weatherization between 2009 to March 2012, many agencies increased in-house staff or contracted with more third-party providers to meet increased production demands. As Recovery Act funding has become exhausted, agencies have had to scale back hiring to account for expected future funding levels. Further, potential exists that other federal funding sources may not rebound to pre-Recovery Act levels, further reducing staff and subcontractors. The absence of Recovery Act funding and cutbacks in usual federal weatherization allocations also will result in reduced production across all participating agencies.

Delivery Changes

Changes to the Repairs Budget

In 2010, the Washington Utilities and Transportation Commission issued an order allowing PSE to use ratepayer money to fund health, safety, and repairs measures in low-income homes, provided the work enabled installation of weatherization measures and the application proved cost-effective. PSE increased repair budgets from 15% to 30% of each community agency's total budget, with the increased percentage calculated at a program level, based on 2010 production data to determine the amount that could be spent on health, safety, and repairs while maintaining the program's cost-effectiveness. While this percentage may change (as PSE intends to recalculate it annually), changes in policy allowing tariff dollars to be allocated for health, safety, and repair costs remain ongoing.

Additionally, the budget increased 25% in 2010 due to funding from the attorney general settlement with Enron. These dollars had no stipulations regarding energy-efficiency measures, and agencies could also spend them on health, safety, and repair work.

[25] Recovery Act dollars increased the typical amount of annual funding available to Washington agencies by nearly 700% over the three-year allocation period. Participant eligibility also increased to 200% of the federal poverty level, and limit on spending per home for DOE and Recovery Act funding increased to $6,500.

All agencies regarded these changes positively. One agency cited the increased flexibility and repair funding made targeting more single-family homes possible, which have found to need greater repair dollars to become viable for weatherization. Other agencies cited the importance of health, safety, and repair dollars, given other funding sources have limitations in covering these costs. Without sufficient funding for health and safety services, agencies often have to reject eligible participants. For example, homes in need of significant roof repair would, without PSE health and safety dollars, be ineligible for home weatherization. Additional repair money allowed agencies to more fully serve households in need and reduce numbers of walkaways.

According to the Energy Project, increased funding for health and safety and repairs proved very beneficial in ensuring full service for the low-income community. Energy Project staff, however, still felt it important to work with agencies to outline reasonable health and safety or repair costs, as agencies are most likely to provide homes with all benefits available.

Delivery Challenges

Interviews identified a few areas that may prevent optimal delivery of PSE's program.

Recovery Act Funding Influx

In some cases, agencies reported difficulty in spending PSE funding due influxes in Recovery Act funding over the last few years. With the Recovery Act funding levels introduced to agencies, and with a March 2012 deadline to exhaust all funding, many agencies prioritized spending these dollars. PSE staff also noted this issue, finding some agencies left their dollars unspent in 2011.

While this issue has been magnified due to the scale of Recovery Act funding, increasing state weatherization budgets by 500% to 700%, agencies always must balance funding sources, which may have competing deadlines. While PSE funding is allocated by the calendar year, other state and federal funding sources have different funding cycles, potentially resulting in agencies prioritizing spending for a particular source prior to its exhaustion.

Post-Recovery Act Structure

As noted, the March 2012 end of Recovery Act funding for weatherization will result in job losses or reduced subcontracting at the agency levels. Weatherization funding through other federal sources (i.e., DOE, U.S. Housing and Human Services) fells during the Recovery Act spending period; however, some stakeholders discussed the possibility that these sources will not be renewed to pre-Recovery Act levels.

Prevailing Wage Laws

Another Recovery Act legacy in Washington relates to extension of prevailing wage laws under the Davis Bacon Act to work performed through the low-income weatherization program. Under this provision, pre-established wage rates and fringe benefits were stipulated for all work directly funded or assisted using Recovery Act dollars.[26] In most cases, the primary impact occurred in increased labor costs paid to different contractor categories (e.g., weatherization worker, HVAC contractor, electrician), significantly raising average weatherization and repair costs per project. While the Davis Bacon prevailing wage laws applied specifically to Recovery Act funding, and

[26] http://www.caplaw.org/StimulusPackage/ARRA_DBA.html

expire in March 2012, Washington State adopted similar prevailing wage rates to be applied to future low-income weatherization activities. Table 22 compares wage rates for Washington weatherization workers from the pre-Recovery Act period (2008) to current levels under Washington's prevailing wage requirements (2010).

Table 22. Wage Rate Comparison

Year	Average State Wage Rate Increase from 2008 to 2010						
	Residential Laborer	Residential Sheet Metal Worker	Residential Insulator Applicators	Residential Carpenter	Residential Electrician	Residential Plumber & Pipefitter	Heat and Frost Insulator & Asbestos Worker
Y2010	$18.91	$33.42	$17.14	$30.69	$29.87	$30.41	$52.07
Y2008	$11.91	$28.40	$15.55	$18.90	$25.45	$21.48	$46.46
Difference	$7.00	$5.02	$1.59	$11.79	$4.42	$8.93	$5.61
Percent Difference	59%	18%	10%	62%	17%	42%	12%

Agencies expressed concerns regarding increased project costs and wage rate structures specified through legislation. One agency cited dozens of different job classifications, within both the Davis Bacon legislation and the State's wage rate regulations, requiring a contractor to be paid different rates, corresponding to multiple categories for a single project. This increases administrative burdens. Another agency reported they did not offer certain program measures (e.g., aerators, energy-efficient showerheads) as plumber wage rates, required for measure installation, makes them too expensive to install. Agencies' understanding of requirements was these wage laws applied, even if federal or state dollars did not directly pay for the measure, but were used on any aspect of a particular project.

Agency Cost Recovery

In a discussion related to the increase in contractor wage rates, agencies provided varying feedback when asked whether costs recovered by PSE were sufficient. Some agencies indicated the PSE measure-specific funding levels were adequate, with PSE rebates covering nearly 100% of costs of measures installed. Other agencies differed, reporting PSE rebates did not approach 100% cost recovery. This means agencies had to find additional funding to cover complete costs. Given wage rates are county-specific, they trend higher in urban areas, resulting in PSE funding covering a smaller percentage of measure costs for urban agencies.

Given PSE cost-recovery has been rooted in the reporting tool's embedded cost-effectiveness calculations, variations between agencies likely resulted from labor or material costs charged for measures, further driven by differences in wage requirements by county, and may vary based on agency staffing arrangements (e.g., in-house staff vs. third-party subcontractors).

Standardized Delivery

Interviews with agency staff revealed certain program delivery aspects potentially vary between different agencies, and between different agency staff performing the work.

First, agencies reported variations around processes for providing energy-saving education, low-cost measures (e.g., CFLs), and pre-assessments prior to full audits and weatherization. Some agencies indicated a low-cost bundle of measures was provided to all participants during the pre-assessment walkthrough, along with delivering the energy-savings' educational component (both

through speaking with participants and providing handouts). Other agencies did not provide a low-cost measure bundle, but likely provided these similar measures when crews performed weatherization at the homes.

Second, while all agencies performed audits and assessed measures to be installed in a home on an individual project basis, not all agencies considered the same mix of energy-efficiency measures, nor would install them in the same way.

A primary example of this occurs in CFL installation. The Washington State manual for weatherization protocols indicates CFLs should be replaced using wattages of equal or greater output, considering all sockets that are used three or more hours per day.[27] The total CFL number provided to each customer can vary, depending on parameters such as home age, size, occupancy number, customer age(s), customer habits, total hours of occupancy per day, and lighting configurations. According to one agency, occasional internal restrictions may occur on the total number of CFLs provided to the customer, based on program funding availability.

Additionally, protocols mandate these bulbs should be directly replaced by agency staff, rather than leaving CFLs behind for participants to self-install. Most agencies indicated they followed this approach, though some indicated they also had to consider the occupants and their needs in making these decisions. For example, one agency indicated they would likely install higher wattage bulbs in spaces frequented more by the occupant, or for older homeowner requiring more light to see. Another agency said they installed new CFLs anywhere requested by the participant. Finally, another agency indicated they did not direct-install all CFLs, particularly if occupants were able-bodied, and left some behind uninstalled. Variations in agency installation procedures became evident in participant survey results, with 45% of respondents (n = 24) receiving CFLs indicating agency staff directly installed the CFLs, while 49% (n = 26) reported agency staff left CFLs behind to be installed by participants.

Another agency reported they did not test or replace refrigerators or freezers, operating under the rationale that available funding should be spent on measures with higher perceived benefits for homeowners (e.g., insulation, shell measures), and that were more difficult to install on one's own. Additionally, this agency cited PSE reimbursement amounts not covering full costs of refrigerator replacement as another factor contributing to their decision not to offer this measure.

Of those agencies providing refrigerator replacements, some indicated they metered units while on-site, and calculated its cost-effectiveness to determine whether it should be replaced. Other agencies reported using a pre-approved lookup form to determine replacement, using the refrigerator information (e.g., type, size, make, model) found on-site to determine whether it was appropriate for replacement.

Finally, as noted, one agency does not provide any water heating measures (such as aerators or energy-efficient showerheads), primarily due to wage laws requiring a certified plumber for this work. The agency also indicated too much liability exists for home plumbing and related appliances. They believed participants could blame agencies for any sort of plumbing-related

[27] PSE may want to consider discussing with Commerce other conditions for light bulb installation (e.g., sockets less than 3 hours of use per day), given the potential for cost-effective savings.

damages if this work was pursued, leading to the agency spending non-conservation funding to fix participant plumbing issues. Another agency indicated they offered these measures, but customers rarely accepted them, citing frequent dissatisfaction with showerheads (in particular).

Upfront Funding

According to agencies, the reimbursement process for administrative tasks proved to be a challenge to day-to-day business operations. PSE pays 15% administrative costs for each paid monthly invoice; however, agencies reported they had to pay staff and other administrative costs up front, and found this difficult, as they had to wait for reimbursement as PSE production ramped up. For example, one agency indicated they received reimbursement after completion of all project work; so the agencies initially paid all labor and material costs themselves.

The Energy Project also indicated some agencies felt the PSE administrative percentage was inadequate. Staff compared the 15% paid for by PSE to Commerce's weatherization contracts of 25% to 30% of the program budget set aside for overhead.

Health and Safety Repair Needs

PSE and agency staff both cited conditions of existing housings stock within the territory as barriers to program participation.

Federal funding sources maintain certain implementation protocols, requiring a home to meet certain criteria for receiving weatherization. For example, a home in need of a roof repair would have to complete that repair before DOE funding could be spent towards weatherizing the home. Agencies encountering homes requiring substantial repairs may not have sufficient repair dollars to bridge this gap, resulting in agencies walking away from projects. Agencies expressed frustration at this dilemma, stating it is critical to receive sufficient resources to fully serve all eligible, low-income families. Even accounting for increased repair levels and health and safety funding offered in recent years by PSE, agencies reported they had an internal goal to continue to increase these budgets in the future.

Tribes

Washington's tribal community is considered a difficult to reach market. According to program staff, agencies typically serve customers not on reservations. Though PSE has established separate contracts with tribes in the past for delivering the program on reservations, they have also experienced many implementation barriers, in particular regarding participants trusting program services. For example, challenges have been encountered regarding the application process, as many tribal residents have not been willing to provide personal information (e.g., income eligibility).

Communication

Program staff and agency energy directors most commonly conducted communication regarding the PSE low-income weatherization program over the phone. Program staff reported communication occurred on an as-needed basis, though efforts are underway to formalize communications. Agencies indicated they felt no barriers in picking up the phone and calling the PSE program manager if they had any questions or concerns.

Both the utility and agencies felt communications have improved since PSE began contracting directly with agencies. One agency staff perceived an increased effort from the utility to collaborate with agencies and to gain a better understanding of the program from the agencies' perspective. A few agencies reported the ease in contacting PSE directly with requests for additional funding or other project-specific requests. The agencies also rated PSE highly on responsiveness and willingness to work with agencies to meet program objectives.

Along with their new role in directly contracting with agencies, PSE discontinued paying Commerce for increased monitoring of PSE customer projects starting in 2011 (as discussed in greater detail below). Consequently, Commerce indicated much less direct communication with the utility. Based on these interviews, however, no barrier appeared between PSE and Commerce in contacting one another; rather, changes in program delivery have reduced the need for communication.

Program Tracking and Reporting

As noted, in 2007, PSE developed the LIWx Online System, a utility-specific, Web-based tool, providing a variety of program functions. Primarily, this tool serves as a reporting system for agencies to submit project information to PSE, and then receive reimbursement. The tool provides: standardized data collection, captured through agency audits and installations; and tracking information, including measure names, quantities, costs, pre and post installation data, and building characteristics.

Additionally, the data collection form allows agencies to determine rebate levels PSE will reimburse per measure, based on embedded cost-effectiveness calculations (with a 0.667 TRC).

Agency staff input project information into this system on an ongoing basis. PSE draws monthly reports to determine agency reimbursement amounts. PSE pays agencies that amount, along with 15% of each total invoice, to help cover agency administrative costs.

Agency staff each provided positive feedback regarding the LIWx Online System, indicating they found it easy to use, and that PSE had been very responsive to making the software more user-friendly. One agency commented that PSE annually seeks feedback from agencies to continually update the reporting tool and incorporate agency suggestions. The Energy Project also cited PSE's reporting tool as working particularly well for both smaller and larger agencies implementing the program.

Quality Assurance and Control

Overview

In 2007, when Commerce's role in the PSE program changed, utility program staff sought to retain them as a business partner. PSE contracted with Commerce to conduct additional post-weatherization monitoring, specific to PSE-funded projects. At that time, PSE did not have the resources to perform quality control on its own, given these resources were composed primarily of on-site inspections in addition to a review of agency invoicing and paperwork. From 2008 to

2010, Commerce conducted not only their own monitoring and inspections of weatherized homes, but included monitoring for PSE projects.[28]

Starting in 2011, PSE discontinued its contract with Commerce, and began monitoring approximately 15% of completed projects itself. Neither PSE nor Commerce expressed any dissatisfaction that lead to this decision, or resulted from PSE monitoring projects themselves; this occurred as a means for PSE to more fully engage in the program. As Commerce continued inspections alongside PSE, some agencies commented the increased monitoring activity resulted in added administrative burdens; however, they did not find these particularly onerous, and agencies expressed willingness to comply.

In addition to quality assurance provided on completed projects, either through PSE or Commerce, agencies incorporated several review levels throughout the delivery process. As shown in Figure 22 (above), each stage of agency delivery included quality assurance checks, either through paper reviews of project information (e.g., audit report, costs) or on-site, through direct supervision or final project inspection by agency staff.

State Monitoring

At the time of project completion, homes could be selected for review by state auditors (and, more recently, PSE), involving on-site reviews of work as well as documentation reviews. Monitored agency projects each received a summary report, detailing findings and recommendations for improvements. According to Commerce, under contract with PSE, state monitors would inspect homes in all PSE agency territories receiving utility funding, and then would provide PSE with their monitoring reports.

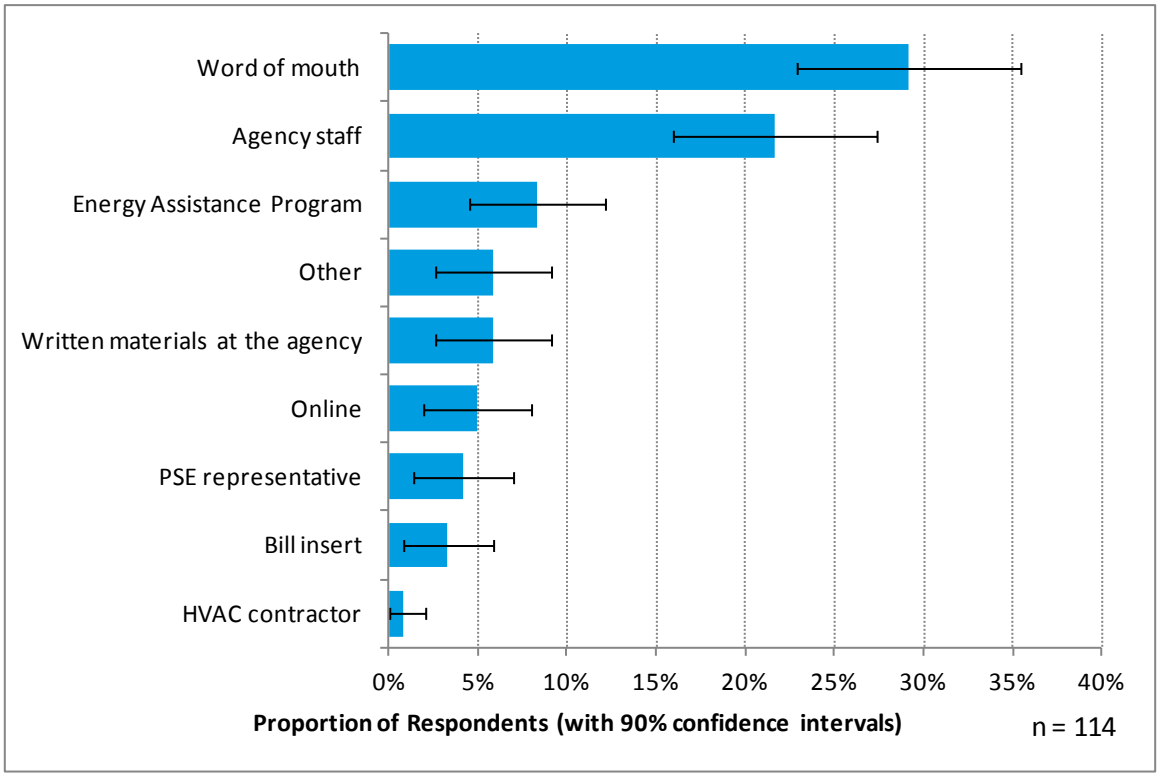
Participant Findings

Participant Awareness

As illustrated in Figure 23, participants reported learning about the program through multiple sources.

[28] Commerce reported monitoring was typically performed on 5% of completed projects; however, due to increased production starting in 2009, resulting from Recovery Act funding, Commerce increased monitoring to approximately 20% of completed projects.

Figure 23. How Participants First Heard about the Program*



*In presenting results, "don't know" and "refused" responses were removed from calculation of percentages, unless otherwise noted.

Participants most commonly learned of the program through word of mouth, family, or friends (29%), or through their local community agency staff (22%).

Forty-five percent of participants surveyed reported being aware PSE helped pay for some services they received. Table 23 compares participant awareness of utility involvement in low-income weatherization programs.

Table 23. Utility Sponsorship Awareness Comparison

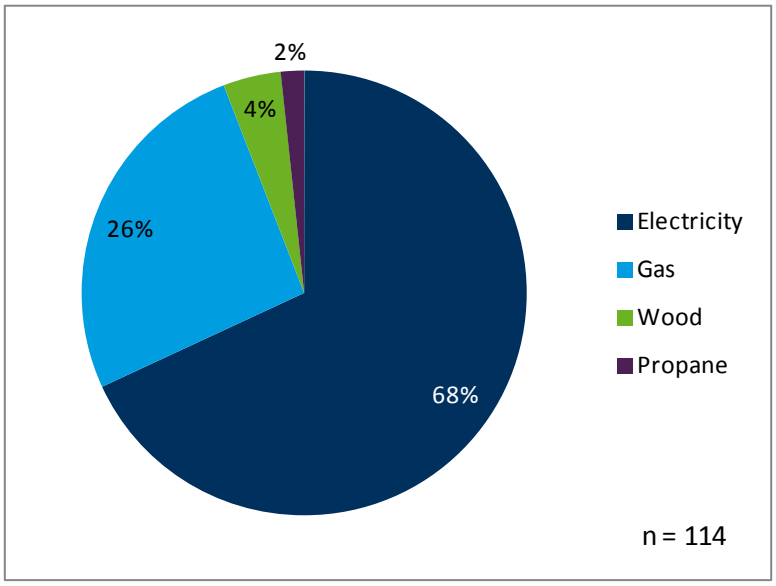
Utility Study	Study Period	Proportion
PSE	2009–2010	45%
NW Utility (1)	2003–2005	14%
NW Utility (2)	2010	50%
NW Utility (3)	2007–2009	26%
W Utility (1)	2007–2009	47%
Midwest Utility (1)	2011	37%
Midwest Utility (2)	2010	29%
NE Utility	2010	60%

Participant expressed above-average awareness of PSE's program sponsorship, compared to results from a series of recent low-income weatherization evaluations from across the country. In speaking with utility staff, participant awareness of PSE sponsorship provided to be an important issue for the utility.

Participant HVAC Equipment Characteristics

Figure 24 illustrates distributions of primary heating fuels, reported by respondents.

Figure 24. Participant Distribution of Primary Heating Fuel



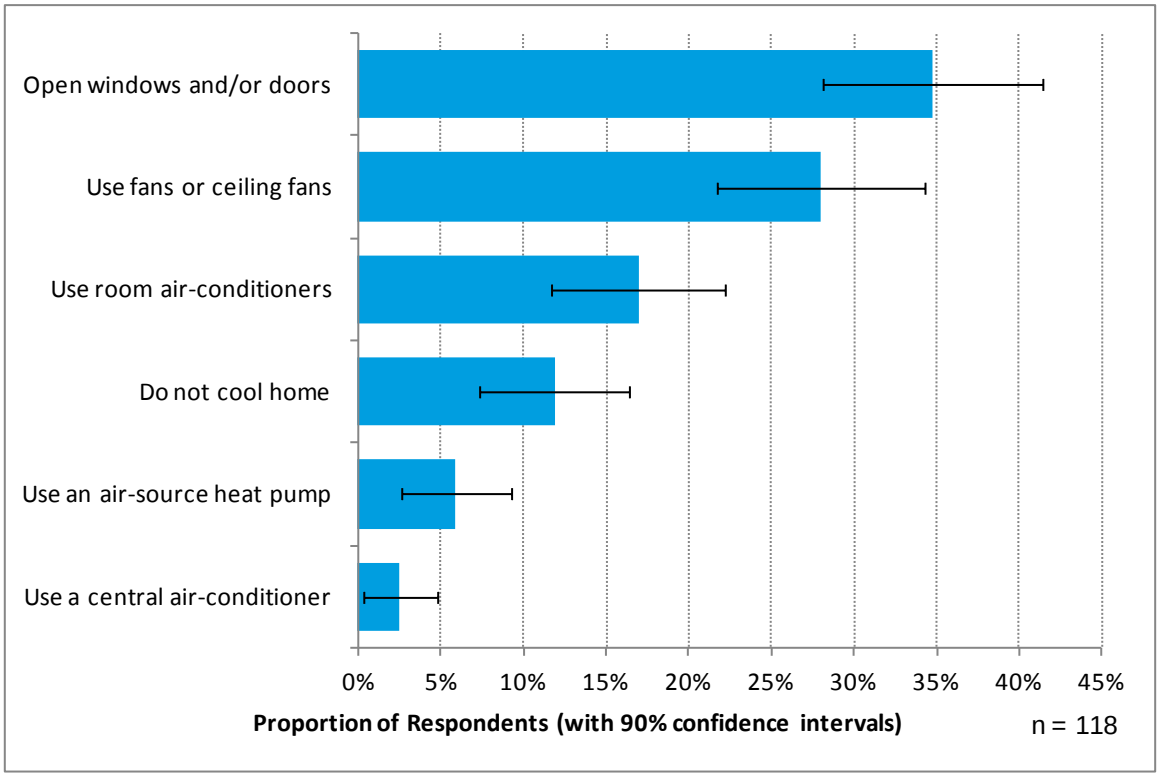
The majority of respondents reported heating their homes with electricity, while 25% used natural gas. The remaining 11% used alternative sources, such as wood or propane.

In addition, 47% of respondents (n = 52) supplemented their primary systems with additional heating sources. Among those using secondary heating, most common methods included wood heat from a stove, oven, or fireplace (44%), and electric space heaters (42%).

Of respondents citing non-electric or gas primary heating methods, six primarily using wood fireplaces also received shell measure installations (e.g., insulation, duct sealing, infiltration controls, furnace repair/replacement) through the program. These households, while likely experiencing cost savings from reduced need to purchase wood, would not exhibit expected electric or gas savings levels.

Figure 25 illustrates distributions of cooling methods reported by respondents.

Figure 25. Participant Cooling Methods



Respondents most often cooled their homes by opening windows and/or doors (35%). However, respondents also reported using fans or ceiling fans (28%) and room air-conditioners (17%).

Take-Back

The survey asked participants several questions designed to identify take-back effects, including changes in usage patterns or household activities.

Fifteen percent of respondents (n = 14) increased temperature settings on their thermostats; 38% (n = 36) decreased this setting; and 47% (n = 45) left it the same.

The majority of respondents indicated no changes in the number of people present in their homes and/or numbers of rooms used. Only 6% of total respondents (n = 7) had family or roommates move in after the work's completion, while 10% (n = 12) had family or roommates move out. Only one respondent used more rooms in their house after work was performed, while two used fewer.

Energy-Saving Education

Overview

During delivery process's pre-assessment or audit stages, agency staff provided participants with varying levels of energy-saving education. Agencies reported Washington used a standardized energy-education curriculum to guide this process; based on agency interviews, however, it appeared variations may have occurred in the delivery. According to agencies, the energy education curriculum can include:

- A discussion of how the client's energy bill is calculated;
- An assessment of the clients' energy usage over the past 12 months;
- Client and equipment-specific energy-saving tips to help reduce energy costs; and
- State-provided, leave-behind materials for participants to read and reference in the future.

Based on agency interviews, most agencies discussed energy-saving tips with participants during walk-throughs or home audits.

One agency cited some difficultly in accessing customer billing histories to include in the project's client education portion. The agency's weatherization office was a satellite of the main office, where PSE billing information could be accessed for the billing assistance program. The agency hoped PSE could provide their weatherization office access to customer billing histories for future program activity.

Participant Response

The majority of respondents (78%, n = 94) remembered receiving energy-saving tips from agency staff visiting their homes. Of respondents who received tips, 74% (n = 67) reported the agency staff providing information.

Sixty-one percent (n = 73) of these respondents also recalled agency staff providing leave-behind materials (a booklet or pamphlet) with information on how to save energy. Of participants recalling having received the booklet, 96% (n = 70) read or reviewed the materials after agency staff left their homes.

Eighty-one percent (n = 82) of survey respondents who recalled receiving energy education reported implementing some tips learned. Table 24 lists the most common energy-saving tips reported as implemented by respondents.

Table 24. Participant Implemented Energy Saving Tips

Energy Saving Tip	Proportion
Switch to Energy Efficient Lighting	33%
Adjust Heating	33%
Turns Lights Off When not in Use	28%
Keep Windows/Doors Sealed Tight	21%
Unplug Appliances When not in Use	18%
Reduce Hot Water Use	13%
Adjust Hot Water Heater	11%
Keep Windows/Glass Doors Covered to Minimize Heat Loss	10%
Keep Windows/Doors Shut	10%
Keep Filters Clean	7%
Adjust Air Conditioning	6%
Decreased Shower Time	6%
Keep Refrigerator Full	6%
Keep All Registers/Vents Open	6%

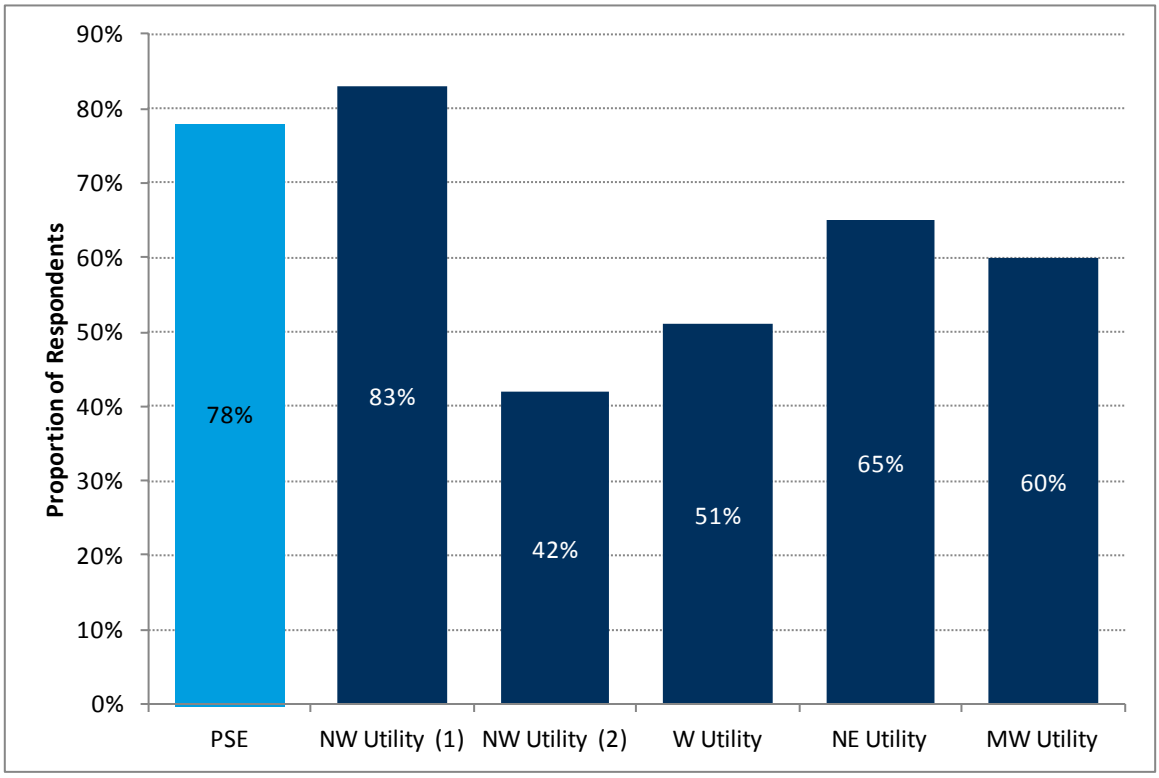
As shown, installing energy-efficient lighting, adjusting heating thermostats, and turning off lights when not in use were most commonly cited. One-third of participants adjusted heating

temperatures, providing one of the most effective ways households can save additional energy and money on their utility bills.

Benchmarking

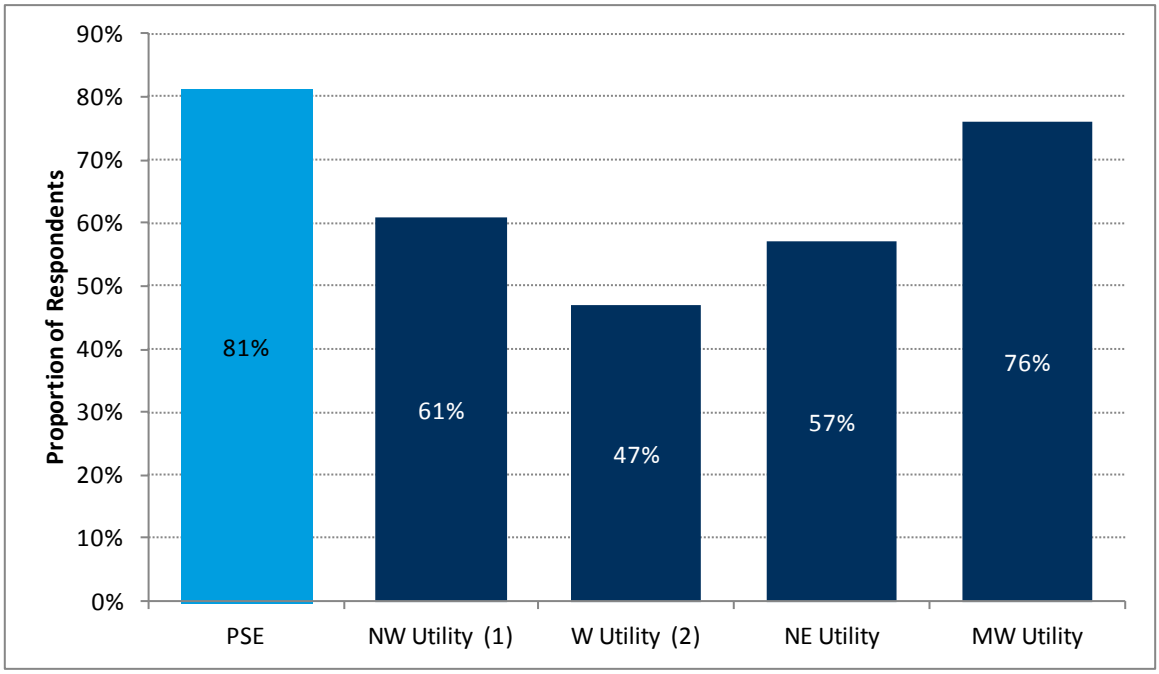
To provide comparison points, Figure 26 provides energy education levels recalled from a range of different low-income weatherization utility programs.

Figure 26. Energy Education Recall Comparison



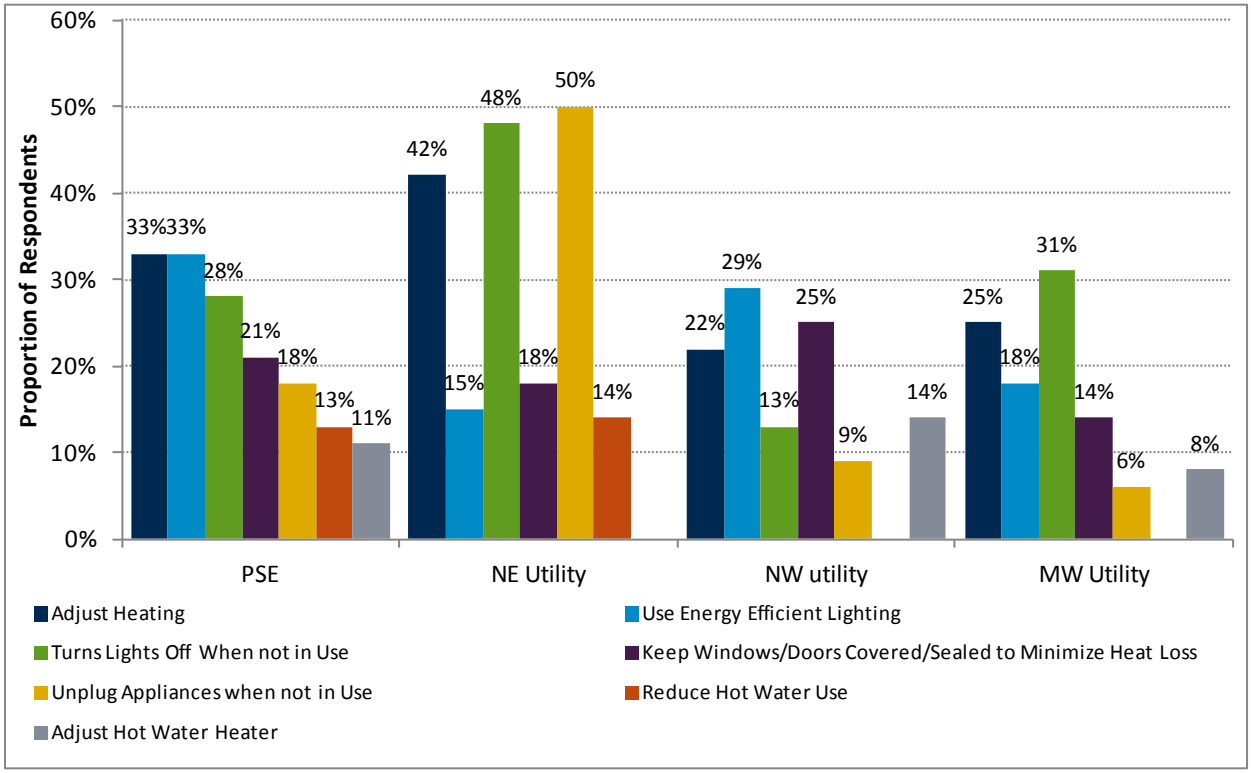
By comparison, PSE participant survey results ranked among the higher participant recall levels regarding energy-education provided through agency staff. Figure 27 compares PSE participants as among the highest percentage for reporting specific energy-savings behaviors put into practice.

Figure 27. Energy Education Implementation



Of participants that recalled receiving tips, Figure 28 compares energy-saving behaviors across different studies participants reported adopting due to the program.

Figure 28. Energy-Savings Behavior Changes Comparison



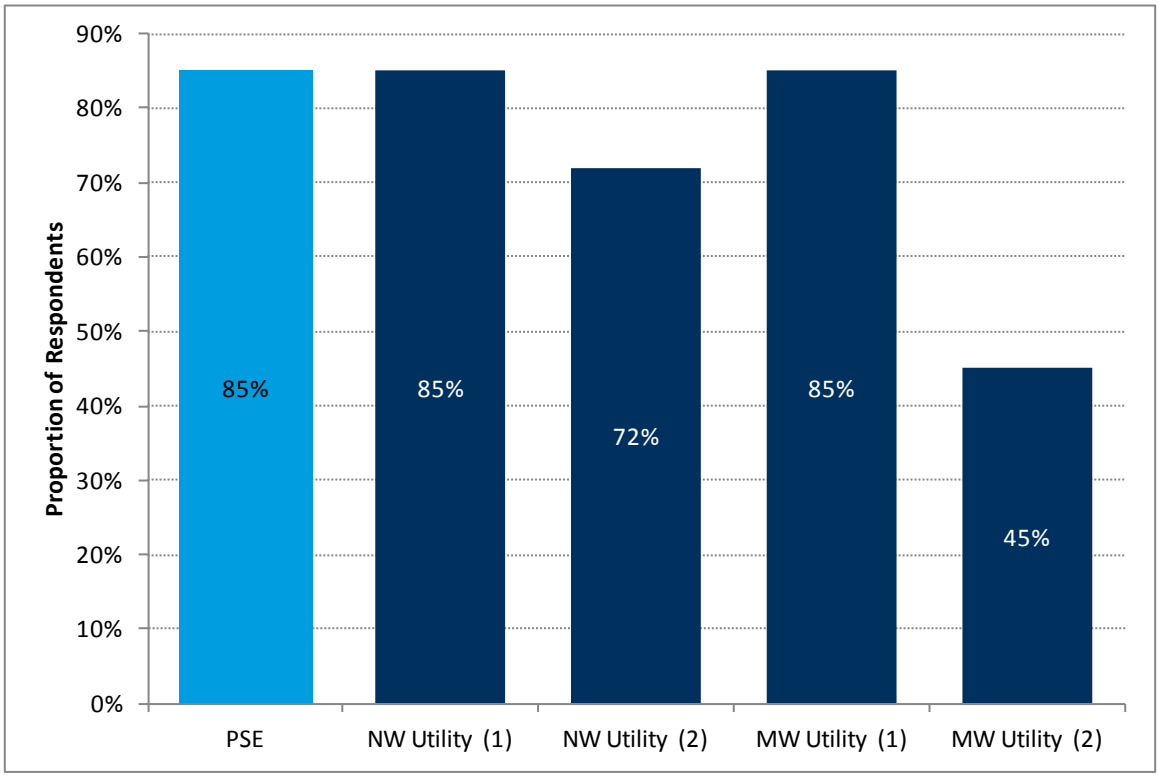
Participant Non-Energy Benefits

A series of survey questions sought to measure certain participant-specific, non-energy benefits, including:

- Increased comfort;
- Improved health;
- Reduced forced mobility;
- Reduced noise; and
- Increased affordability.

Eighty-five percent (n = 99) of respondents found their homes to be more comfortable to live in following the work, and incidence of improved comfort comparable to results from other studies, as shown in Figure 29.

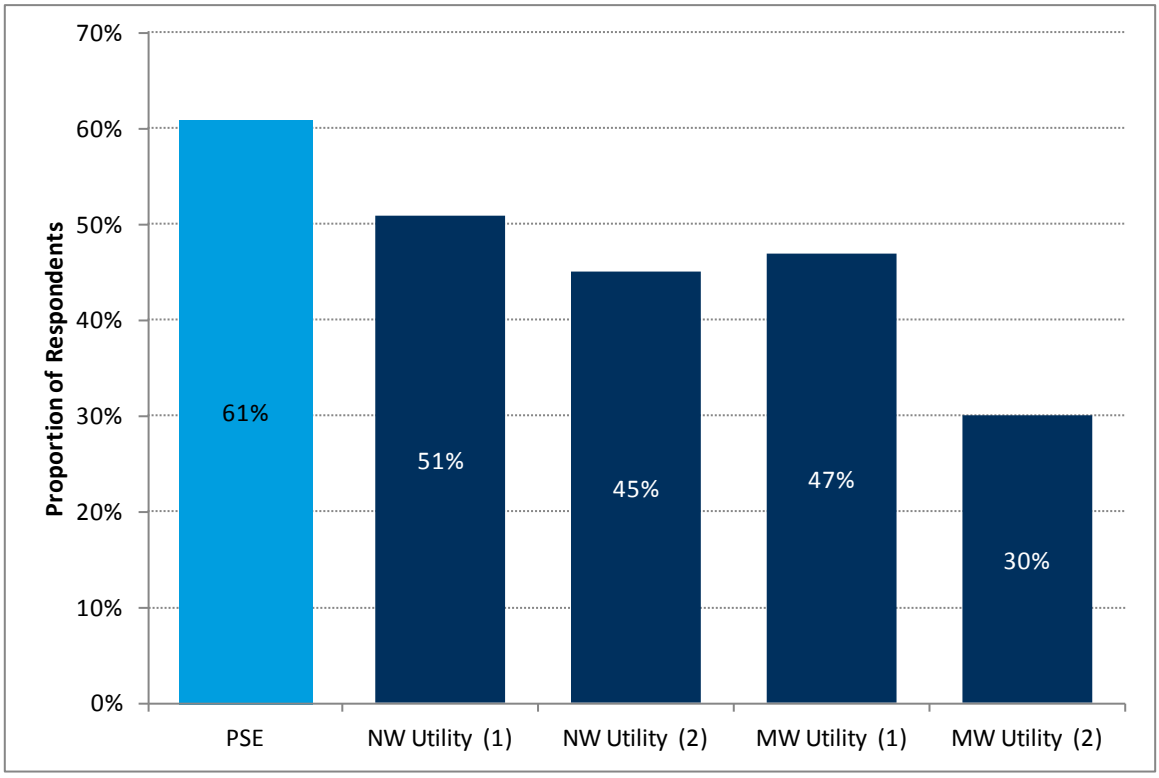
Figure 29. Increased Comfort Comparison



Forty-one percent (n = 46) of respondents indicated they heard less noise after having work done.

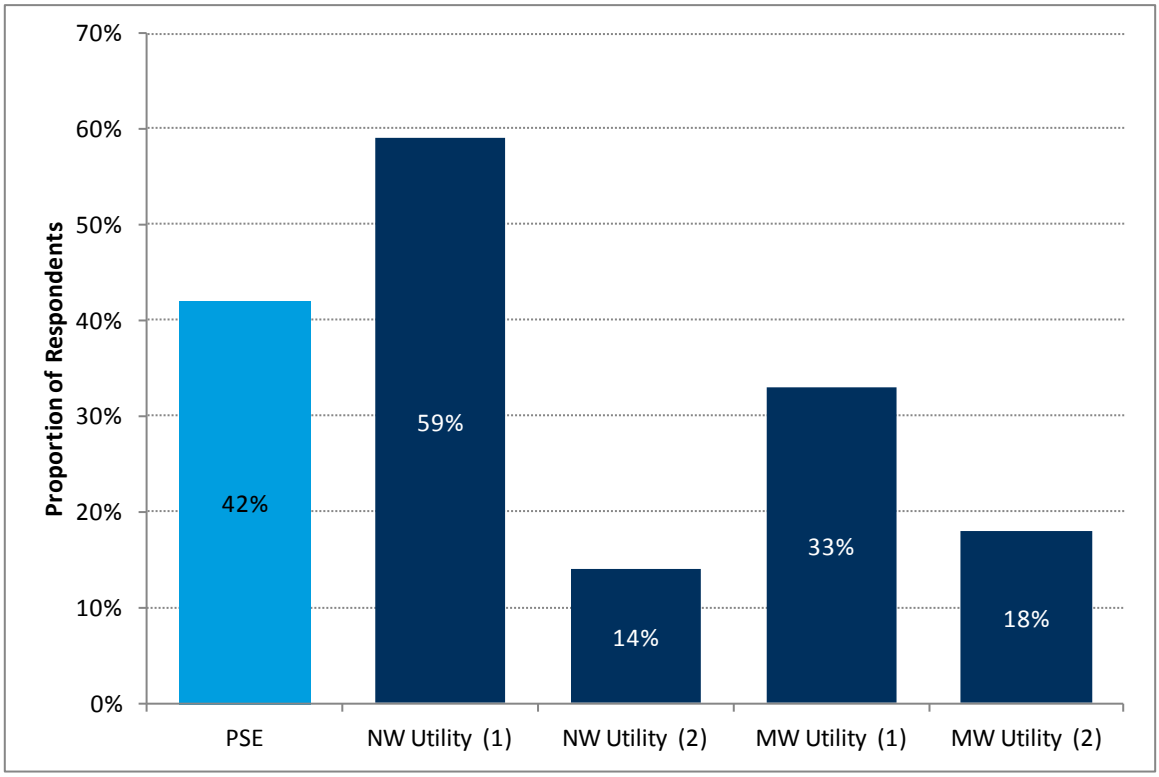
Sixty-one percent (n = 67) reported their electric bills became more affordable following the work's completion. Aside from one other study, PSE participants observed higher affordability than others compared in Figure 30.

Figure 30. Improved Affordability Comparison



Forty-four percent (n = 48) reported better health after having the work done, with 16% (n = 18) experiencing fewer sick days. PSE customer responses reflected the median, when compared to results from other studies, shown in Figure 31.

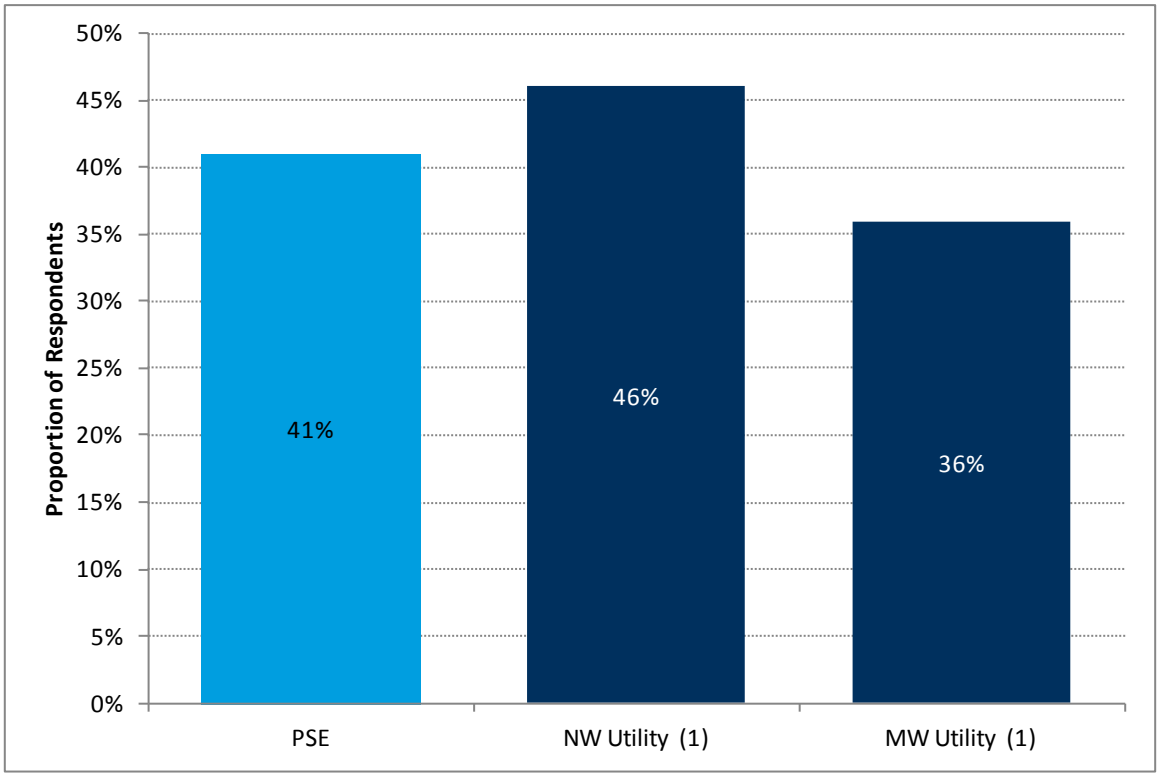
Figure 31. Improved Health Comparison



While PSE participants' perceived health improvements were not comparable with the highest percentages, differences should be considered between these studies to help contextualize results. Higher-ranking studies occurred within territories with higher average heating degree-days than PSE, which may explain some discrepancies.

Weatherization programs also have been associated with helping reduced situations of forced mobility, helping participants stay in their homes. Forced mobility can have associated financial implications (e.g., moving costs) as well as increased school or work absences, and generally increased stress to homeowners in this situation. Figure 32 compares PSE participant responses to other program results surrounding forced mobility.

Figure 32. Reduced Forced Mobility Comparison



When all participants were asked whether the work performed reduced their likelihood for moving, 41% (n = 47) indicated they were less likely to move, while 4% said they were more likely.[29]

Participant Satisfaction

Overall Program Satisfaction

Surveyed participants expressed strong satisfaction levels with various aspects of their program experience. Almost all participants (97%, n = 119) reported agency staff coming to their homes were very courteous and respectful. All but five participants (96%, n = 112) expressed overall satisfaction with services provided through the program. Of those expressing dissatisfaction, only two respondents provided feedback, each indicating poor quality of work and that they did not receive light bulbs.

In addition, all participants (n = 62) reporting more affordable energy bills following work performed in their home expressed satisfaction with savings seen.

Only 12% of respondents (n = 14) reported experiencing any problems or difficulties from participating in the program. Of those reporting issues, most common complaints involved weatherization workers, noting staff did poor quality work or were unpleasant. As noted above,

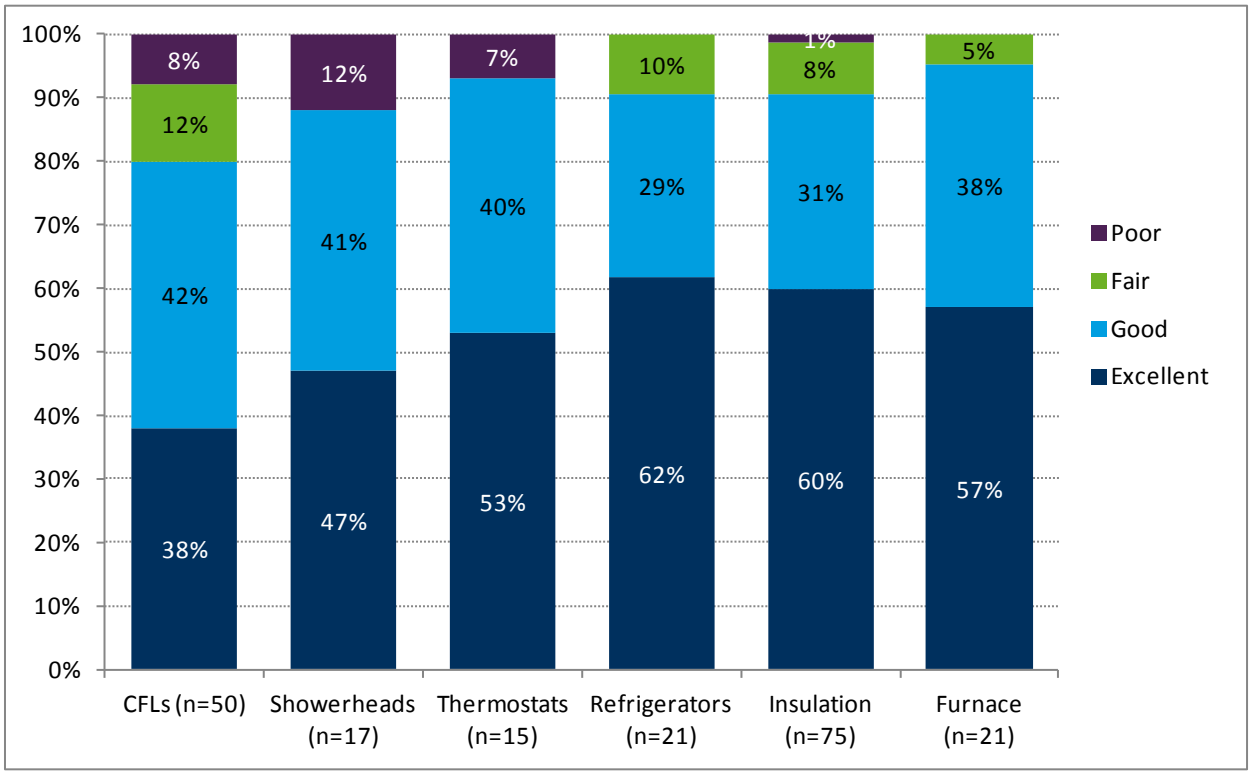
[29] Twenty percent (n = 24) of respondents considered moving prior to the program; due to weatherization work, nearly half those respondents indicated they were less likely to move.

only two participants reporting lower overall satisfaction provided feedback in regard to their rating; of the 12% that experienced problems, all but those same two participants provided positive satisfaction ratings despite encountering some difficulties.

Measure Satisfaction

The survey asked customers to rate different measures installed in their homes.[30] Figure 33 presents measure-specific satisfaction ratings, with response data detailed in the sections that follow.

Figure 33. Measure Satisfaction Ratings

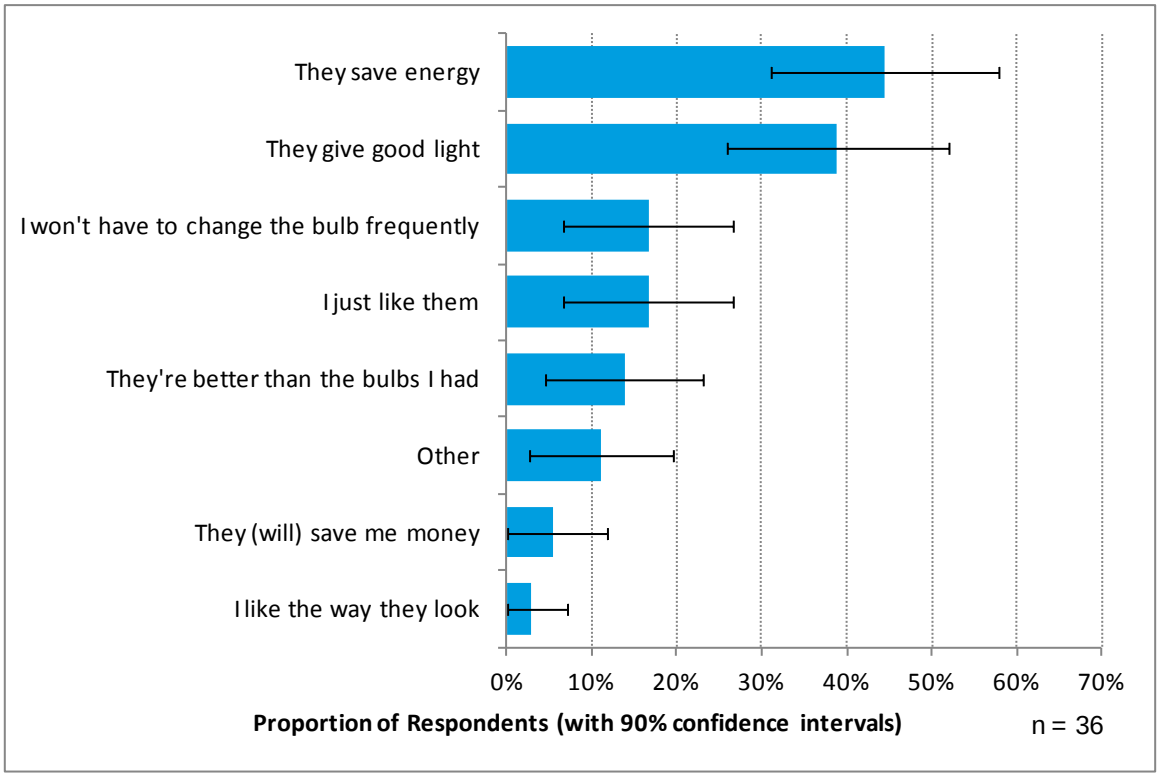


CFLs

The majority of surveyed participants (80%, n = 40) receiving CFLs rated the bulbs as "excellent" or "good." The most common reasons participants reported for positive ratings were: bulbs saved energy (44%, n = 14); and gave good light (39%, n = 7). Figure 34 illustrates a full distribution of participant reasoning.

[30] In this section, participants may provide multiple responses when asked reasons why they assigned measures specific satisfaction ratings.

Figure 34. Reasons Participants were Satisfied with CFLs



Reasons participants rated CFLs as "poor" (8%, n = 4) included: dissatisfaction with the bulbs' brightness (specifying bulbs were too bright or too dim); and noting bulbs burned out too quickly.

One-quarter (n = 12) of participants receiving CFLs mentioned removing at least one bulb since its installation. In these cases, participants reported bulbs had burned out, were not bright enough, broke or stopped working, or had been placed in a fixture with a dimmer or three-way switch. Six participants (55%) who removed a CFL from a fixture replaced it with another energy-saving light bulb; the others replaced it with an incandescent.

Showerheads

Despite agencies' reporting customers dissatisfied with energy-efficient showerheads provided through the program, all but two of the 17 surveyed participants receiving showerheads rated their new equipment as "excellent" or "good." Two participants who rated the showerhead as "poor" reported removing the measure a few weeks after installation.

Thermostats

Fifteen surveyed respondents reported the agency installed a new thermostat and changed thermostat settings to help them save energy. All but one of these respondents rated the thermostat as "excellent" or "good." Reasons participants reported for liking the new thermostats included: "it's easier" (42%); and "it saves electricity and/or gas" (33%). The one participant, who rated the thermostat as "poor" reported dissatisfaction with the temperatures set by the

agency. In fact, more than half (60%) of all respondents receiving a thermostat reported changing thermostat settings after the agency staff made their adjustments.

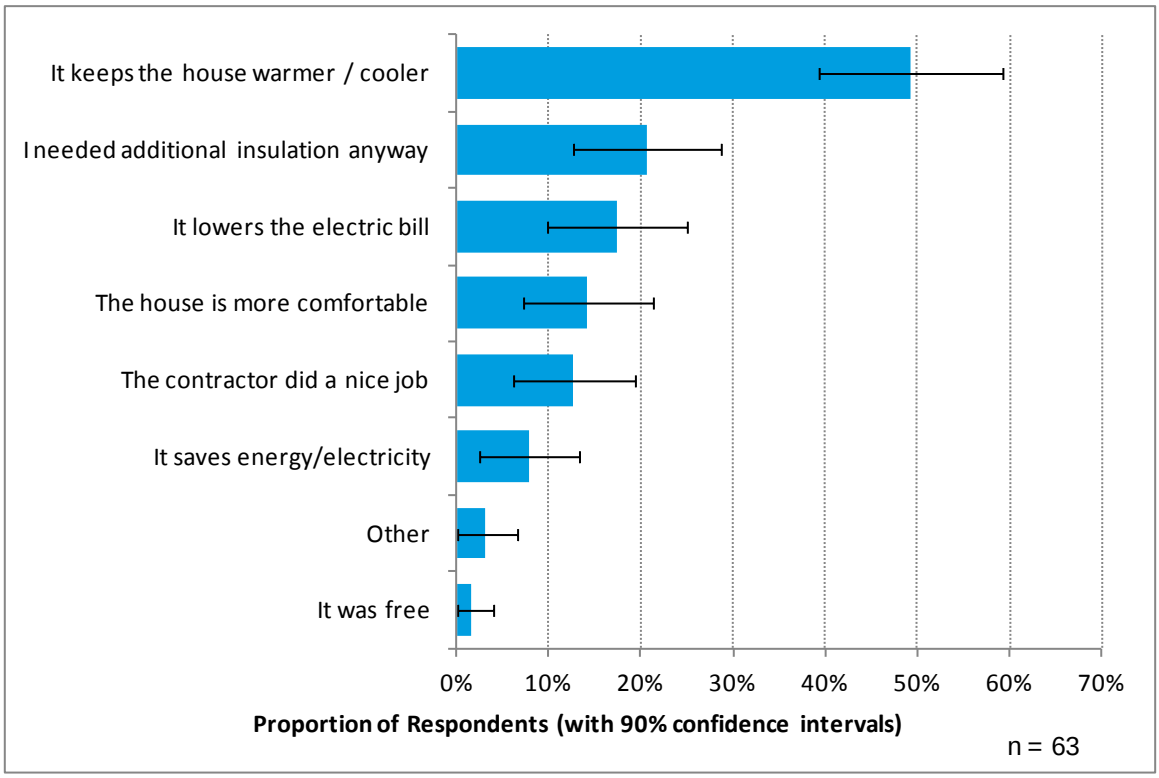
Refrigerators

Almost all participants receiving refrigerators (n = 21) were happy with the replacements. Over 90% of respondents rated their new refrigerators as "excellent" or "good." The most common reason participants reported satisfaction with their new equipment was simply because it worked (26%). Other reasons reported included: the new unit keeps food at the right temperature (16%); it saves energy (16%); and the refrigerator is a good size (11%).

Insulation

Almost all participants receiving insulation (n = 68) reported high satisfaction levels. More than half (60%) reported the insulation as "excellent." As shown in Figure 35, 49% of respondents receiving insulation reported satisfaction due to the insulation keeping their home warmer in winter and cooler in summer. One-quarter of respondents reported rating the insulation as "excellent" as it saved energy or lowered electric bills.

Figure 35. Reasons Participants were Satisfied with Insulation



Less than 10% of respondents receiving insulation expressed dissatisfaction with insulation installed. Issues reported included: the contractor left a mess (n = 1); not enough insulation was installed (n = 2); and the contractor did not finish the work (n = 1).

Heating System Repair and Replacement

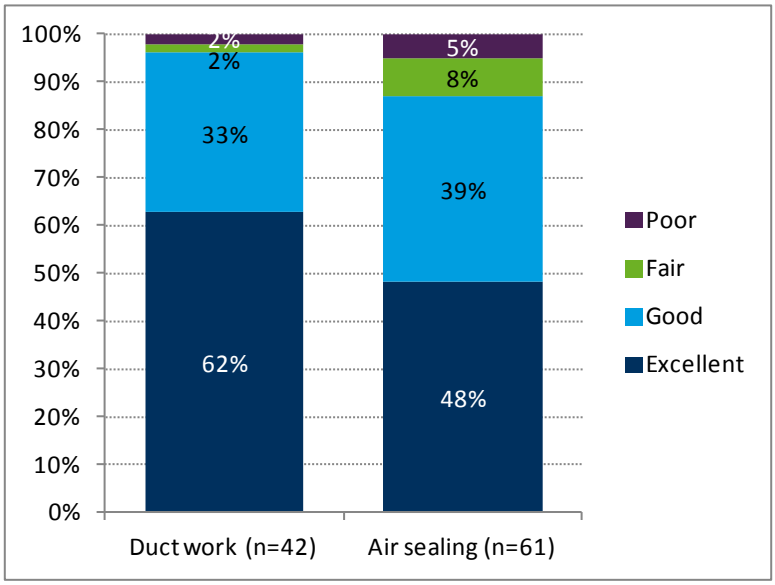
Ninety-five percent of participants who had their furnace replaced or had repairs through the program (n=20) reported the work as "excellent" or "good." The most common reasons for

satisfaction included: the contractor did a nice job (31%); or the updated heating system kept the house warmer than before (25%). Further, 64% of respondents recognized they needed a new furnace, reporting their old equipment worked poorly or not at all.

Other Services

Respondents were asked to rate other services provided through the program, including: water heater replacement (n = 2); work done on the heating ducts (n = 42); and cracks sealed where outside air previously leaked in (n = 61). Figure 36 illustrates participant ratings of duct work and air sealing services.

Figure 36. Service Satisfaction Ratings*



*Ratings for water heater replacement have not been included, as the sample proved too small to draw meaningful inferences (n = 2).

Conclusions and Recommendations

Program Goals and Objectives

Conclusions

- PSE's program objectives appear to more closely align with agencies than those of typical, utility low-income weatherization programs, as became evident through discussions with utility and agency staff, and through program policy changes (i.e., increased percentage allocations for repair and health and safety budgets).

Program Delivery

Conclusions

- Increasing PSE's health and safety and repairs budget provided a positive change for the program, from both utility and agency staff perspectives. This appeared to reflect PSE's goals in better serving its low-income customers from a total-benefits standpoint, while

helping agencies weatherize more homes that would have been turned away under standard funding sources.

- Regular, open communication with agencies emerged as a program strongpoint among all parties. This partly resulted from direct contracts with agencies, and partly due to the nature of the program PSE has cultivated in recent years. Both agencies and the utility appeared comfortable calling directly with questions or requests for assistance. Of particular importance appeared to be agencies' comfort and willingness to contact PSE with requests for additional funding, and that the utility proved willing and able to meet their requests.
- Despite state implementation protocols, variations appeared between agencies—and potentially agency staff—regarding installation procedures (e.g., CFLs, energy-efficient showerheads). Variations also appeared in types of measures offered through the agencies (e.g., refrigerator replacement).

  This lack of standardization presents two potential impacts. First, deviation from direct installation of CFLs or other low-cost measures calls into question the application of deemed savings estimates that assume direct installation. Second, due to agency policies, cost-effective, high-savings measures, such as refrigerator replacements, are not being considered for installation in some cases. This prevents an opportunity to achieve cost-effective energy savings, as it is unlikely these savings will be achieved through other energy programs.
- While some agencies chose not to offer (or rarely offer) low-cost water heating measures (e.g., aerators, energy-efficient showerheads), with one agency indicating associated low customer satisfaction, participant survey results appear to contradict this assumption: 88% of customers receiving energy-efficient showerheads provided positive satisfaction ratings.
- Agency variations in providing potential weatherization participants with a bundle of low-cost measures during pre-assessment reveals another potential missed opportunity, both in terms of providing benefits to customers not qualifying for full weatherization, and in PSE achieving easy, cost-effective energy savings.
- Reduced agency capacity, in conjunction with lower-than-average federal funding levels, may seriously constrain agencies' abilities to maintain production or delivery on par with pre-Recovery Act levels.

  A few possibilities exist for improved future delivery when considering changes to the delivery system. First, if agencies maintain the same average cost per home and scale back operations, production levels could decrease, resulting in fewer PSE customer homes weatherized. Second, agencies may be required to maintain more aggressive production levels (by state or federal sources) and may refine their weatherization work to include fewer measures or home repairs per home. If the former case prevails, PSE could expect to achieve average savings per household similar to pre-Recovery Act levels. If the later occurs, savings per home could potentially diminish, given the lower level of comprehensive weatherization performed per home.
- All agencies interviewed cited Washington's state prevailing wage laws as a concern, posing a barrier to delivering a wider range of measure installations (e.g., energy-efficient

showerheads), and to delivering the same holistic program approach in a cost-effective manner. Wage rates were reported as making some measures too expensive to install. One agency interpreted wage laws to require specific contractors to perform certain types of installations (e.g., plumbers for energy-efficient showerheads); as they did not keep such contractors staffed, they did not offer these measures.

As labor costs rise and savings remain constant, PSE will, in effect, pay less of the measure cost than they would prior to Davis-Bacon requirements. Given the cost-effectiveness constraints and reduced funding levels, agencies will need to supplement project costs with other non-PSE funding sources. While this may result in spreading PSE funding across more measures than otherwise would be possible (resulting in higher claimed savings), it will also place a greater strain on agencies trying to piece funding levels together to complete a comprehensive project.

- While DOE and Washington state protocols list high energy consumption as a factor allowed in participant prioritization, agencies have not been able to integrate this criterion. Possible reasons for this barrier include a lack of access to PSE billing data (in the case of one agency), and an inability to easily calculate usage, let alone determine a threshold for "high" usage. While some agencies should have access to PSE customer billing histories, one agency indicated these data were not available from their office, while others reported they simply had not considered this criterion.
- Existing conditions of homes, with repairs to be addressed prior to weatherization approval, present a barrier to program delivery and participation of income-eligible customers. Despite PSE paying higher portions of health, safety, and repair costs, some agencies reported the need for repairs continues to play a limiting role in their territories, resulting in walking away from homes when repair costs cannot be met.
- While PSE has offered some past programs within tribal lands, revisiting program delivery to these customers and overcoming previous delivery barriers will be important, as these areas represent significant opportunities to address both high-need customers and to achieve energy savings.

Recommendations

- Continue direct communication with agencies regarding mid-year funding reallocations.
- PSE should continue working with agencies to identify potential, unspent funding, which can then be reallocated to agencies with greater potential for spending within a program year. As the Energy Project also works with agencies to track reasonable production estimates, this may offer a favorable opportunity for collaboration.
- Consider working with agencies to integrate high-energy consumption as prioritization criteria.
- As high-consumption is a prioritization criterion approved under federal weatherization program and state guidelines, agencies do not appear to have the means to easily incorporate this into their targeting. Details of this arrangement would need to be discussed among stakeholders; however, PSE should be able to work with the agencies to either provide usage data or to actually calculate energy intensities (i.e., annual weather-

normalized energy consumption per square foot), which agencies could then incorporate into their prioritization calculations.

- By targeting customers with high-energy consumption, not only will these participants realize higher energy savings, but will be relieved of the disproportionate burden of their energy bills due to abnormally high usage. While calculating energy intensity controls for home size, other analyses can be performed to incorporate effects of other demographic indicators on high usage (e.g., number of people per household, household income, poverty level).
- Work with stakeholders to standardize delivery.

  Particularly, standardizing specific measure offerings (e.g., refrigerator replacements) and installation protocols (e.g., direct install CFLs) should increase program benefits for both participants and the utility. PSE should work with directly with agencies, and potentially with Commerce or the Energy Project, to determine barriers to changing certain delivery aspects discussed in the program findings.

  For some measures, such as refrigerator replacements, PSE may be able to earmark rebates or determine protocols with agencies; so every PSE-electric customer home receives refrigerator testing and an opportunity for replacement, upon the participant's consent.

  For other measures, such as energy-efficient showerheads affecting domestic water heating, increased client and agency education may prove beneficial. Cadmus evaluation research has found variations in satisfaction surrounding different types or brands of energy-efficient showerheads offered through programs. A specific brand of showerhead used by agencies may be associated with lower customer satisfaction. Working with agencies to identify high-quality brands could address this barrier.

  Regarding wage regulations that require plumbers for water-heating related installations, this may be a misconception of the particular agency that reported this concern, or it may be a genuine barrier to delivery; if the latter, it should be discussed with Commerce policy makers.
- Work with stakeholders to standardize low-cost measure bundles for initial home inspections.

  Regarding low-cost kit bundles, PSE did not appear to fund these measures directly. This could be a collaboration area between agencies and PSE. Standardizing delivery, so all customers receive low-cost measure bundles (including CFLs, aerators, etc.) upon initial inspection, would ensures even PSE customers not qualifying for full weatherization would receive some energy-savings benefits. If PSE covered partial kit costs for customers, agencies not currently offering them in this manner may be encouraged to do so, and PSE would be able to claim savings for these low-cost measures, with potentially high cost-effectiveness.
- Provide education to customers about benefits of energy-efficient domestic hot water equipment.

  Conservation educators can serve as a low-cost communication channel regarding energy-saving benefits provided by energy-efficient showerheads and aerators. To

achieve greater savings from these measures, conservation educators and auditors should be provided with facts to help mitigate customers' objections to their installation.

Additionally, PSE should work with agencies to help identify specific energy-efficient showerhead and aerator brands that work well and that agency staff feel comfortable installing through the program. One way to get agencies on board would be for PSE to provide agency crews with a multitude of models to test and provide feedback. Ideally, agencies will find models they can stand behind, moving past their aversion to installing some water-saving measures.

- Work with stakeholders to make program adjustments that address changes in funding levels and state wage requirements.

  As outlined in the findings, lower state and federal weatherization budgets, along with increased labor costs due to state wage requirements, potentially could change PSE's impacts associated with this program. Higher wage rates will result in PSE covering lower percentages of measure costs, while diminished state and federal funding will mean fewer opportunities for leveraging funding among program sponsors. If all these funding scenarios materialize, there are likely two ways the program can go in the future, with neither option particularly desirable. Depending on agency production goals, the program may be restructured to focus on cheaper, easier-to-install measures or agencies could continue with comprehensive treatment, though seeking to complete fewer homes. In either case, associated savings relative to PSE funding may decrease.

  In any case, we strongly recommend working with all the key stake holders on a future solution. Discussing these issues with all stakeholder groups may reveal actions PSE can take to optimize the program, given a new delivery orientation. For example, increasing the proportion of clients with high energy intensity through better targeting may better achieve PSE objectives and meet energy-savings goals. PSE should be able to leverage the positive relationships they have cultivated with agencies to foster open conversations on this topic.

- Explore options for delivering weatherization to tribal areas within PSE's territory.

  PSE should work with program stakeholders as well as other utilities and regional entities to explore ways to overcome some past delivery barriers. One approach would be working with the Bonneville Power Administration to leverage its contacts or experience in tribal outreach. Another approach might involve soliciting assistance from tribal organizations or communities themselves. For example, Native American contractors may be available that PSE or agency staff could work with to deliver the program. Another approach, recently utilized by a BC Hydro energy-education program, would be to contract with college-age Native Americans to work within the community to increase marketing, program awareness, and solicit participation.

  Finally, PSE may want to consider the elimination of income eligibility requirements for tribal participants, particularly if verifying income eligibility has been difficult in previous program experience.

Communication

Conclusions

- Communications between PSE and agencies appears very effective, as noted. All agencies interviewed cited PSE program staff as very responsive, helpful, and in-tune with agency needs and objectives.
- PSE assuming a role in contracting directly with the agencies appears to have resulted in a understanding of the program and a desire for collaboration, regarding energy-saving objectives as well as in identifying participant and agency needs, and delivering a program seeking to aid underserved populations beyond just energy savings.

Program Tracking

Conclusions

- Agency satisfaction with PSE's LIW Online System reporting tool indicates the system works well for both small and large agencies, and is not overly burdensome.

Recommendations

- Consider collecting additional input assumptions for calculating more robust savings estimates.

  While the Savings Review section of report also offers this recommendation, the LIW Online System can track additional inputs to improve the deemed energy-saving estimates for PSE to calculating program savings. Additional information easily can be collected by agencies while on-site, with many appearing to be willing to provide PSE more data upon request. For example, determining types and efficiency levels of heating and cooling equipment will help refine savings assumptions for shell measures (e.g., insulation, infiltration controls, windows) installed by an agency.

Quality Assurance and Control

Conclusions

- Neither Commerce nor PSE identified significant or systematic issues affecting the program delivery process or finished projects, based on monitoring efforts conducted in recent years. Issues identified and discussed in interviews were project-specific and reported to be easily addressed by the agencies.
- Problems or issues did not arise regarding PSE's monitoring efforts alongside Commerce. Agencies did not appear to find requirements excessively onerous, Commerce had no opinion on the issue, and PSE appeared to appreciate the opportunity for on-site, first-hand program experience.
- Between PSE's monitoring 15% of its completed weatherization projects, and Commerce monitoring 20% (as of 2009), sufficient quality assurance activities appear in place.

Participant Findings

Conclusions

- When benchmarking awareness of utility contributions to other programs, PSE's participants ranked among higher levels of awareness of utility sponsorship (45%).
- With nearly 80% (n = 12) of participants receiving program thermostats and setbacks reversing set-points to pre-project levels, increased education surrounding temperature settings may be required. These participants may need to better understand how to use these thermostats' programmable functionality to maintain temperatures at more reasonable levels during primetime occupancy. Alternatively, agencies may need to work more closely with participants to determine appropriate setback levels.
- A significant portion of PSE's participants (43%) reported using secondary heating sources, including 18% indicating use of electric room heaters.

Recommendations

- Increase PSE sponsorship awareness through leave-behind materials.

  PSE could help increase participant awareness of utility program sponsorship by creating PSE-branded materials or products that agency staff could leave behind with participants. Items other utilities provide include LED nightlights and refrigerator magnets with energy-saving tips. PSE staff also suggested providing blankets or snuggies with PSE branding.

- Increase education surrounding thermostat setbacks to increase persistence.

  The high number of participants resetting thermostat indicates a need for more education surrounding temperature settings. While the survey did not probe to determine whether or not customers used programmable settings to increase temperature only for specific periods, or if increases were for constant, 24-hour temperature settings, participants apparently are not always satisfied with levels set by agency staff. PSE should convey this finding to contractors, and discuss methods for increasing emphasis on setting controls to allow for comfortable temperatures, while simultaneously taking advantage of programmable settings to reduce heating during lower occupation periods. Additionally, a PSE-developed sticker or refrigerator magnet with energy-saving tips could emphasize the importance of thermostat setbacks, either in terms of operational information, or through dollar savings associated with average setbacks (e.g., 72 F to 68 F).

- Work with agencies to increase education surrounding use of secondary heat sources.

  Due to the large number of participants still using secondary heat sources (particularly electric room heaters), PSE should consider ways to increase awareness to reduce use of potentially inefficient heating systems. A few actions might include working with agencies to highlight this issue, and including specific information about electric room heater usage in the energy-education curriculum.

Participant Non-Energy Benefits

Conclusions

- PSE participants reported a perceived value associated with each non-energy benefit asked about through the survey. The percentage of PSE participants identifying these benefits were equal or higher, in many cases, than those of the other studies cited in comparison. Perceived levels of non-energy benefits can fluctuate across participant populations, with variations resulting from geography, region, climate, measures installed, heating fuel, existing conditions, and more.
- Though non-energy benefits PSE participants cited have been valued in various studies (some of which have been listed in the non-energy benefit literature review performed for this project), many of these exhibit a wide range of values, making it difficult to isolate a single, defensible value to use for claiming additional program benefits.

Recommendations

- Consider exploring more detailed research in valuing some participant non-energy benefits.

  While this study explores certain non-energy benefits in some depth (i.e., payments and economic impacts), if PSE is interested, opportunity exists to perform additional research to develop more robust values for some participant non-energy benefits. Such other benefits include: dollar savings attributed to improved health; reduced forced mobility; increased home property values; and others (see the literature review for a full list). This research would require analysis of additional data sources (e.g., assessor data, medical costs) as well as further in-depth participant interviews.

Energy-Saving Education

Conclusions

- High response rates regarding recollection, reviewing materials, and adopting energy-savings behavioral changes all indicate the energy education curriculum and delivery have effectively encouraged behavioral changes. The PSE program ranked high in these categories when benchmarked against other regional and national low-income weatherization program participant survey results.
- Despite high rates of recollection, review, and adoption related to energy education materials and curriculum, opportunities exist to focus energy education on areas requiring improvements. Specifically, increased education could target certain behavioral changes with lower adoption percentages, which typically results in higher energy savings (e.g., thermostat setbacks, reduced shower and hot water use). Additionally, education apparently needs to be increased regarding: use of secondary heating sources (e.g., electric room heaters); thermostat programming and setback; and, potentially, energy-efficient showerheads (based on comments from an agency staffer).

Recommendations

- Focus energy education on actions resulting in high-energy savings.

  While energy-saving education occurs through provided materials or conservation educators performing initial inspections, an opportunity exists to focus the curriculum or targeted

materials on high-energy savings behaviors. Cadmus recommends placing a greater emphasis on reducing heating setpoints and reducing hot water use. These recommendations typically result in most households realizing higher savings levels.

- For areas of need, target energy education to increase awareness.

  As noted, an opportunity exists to target educational messaging to increase awareness in certain areas (e.g., high-energy saving behaviors, thermostat programming, secondary heating systems). Effective targeting may include developing PSE-specific materials, such as stickers or refrigerator magnets. Additionally, working with agencies to highlight areas for improvement could help address certain topics.

Participant Satisfaction

Conclusions

- Overall, participants reported high satisfaction levels with PSE's low-income weatherization program.
- Participants also expressed satisfaction with measure installations, with the majority indicating "excellent" or "good" ratings for each measure type.

SAVINGS REVIEW

Cadmus reviewed savings values PSE used for the low-income weatherization program. This section discusses our methodology and review findings.

Methodology

For the majority of measures, PSE referenced the RTF as the primary source for energy savings values. The methodology considered inputs used in single-family and multifamily measure-level estimates, and focused on reviewing factors differentiating low-income households (e.g., square footage, vintage of homes and appliances, fuel shares). Cadmus then determined whether these savings estimates applied appropriately for low-income program applications, or whether changes to variables within the algorithms would be required, based on low-income households' characteristics.

For measures not included in the RTF, Cadmus reviewed PSE's algorithms, where available, and used engineering equations or modeling to determine savings, keeping inputs as low-income specific as possible.

In performing this review, Cadmus relied on the following data:

- Regional low-income weatherization studies, and research specific to Washington-state deemed savings algorithms performed by Cadmus;
- Data collected through the participant survey and stakeholder interviews;
- The Washington State Low-Income Weatherization Manual;
- State TRMs providing low-income specific, measure-level savings estimates; and
- Results from Cadmus' RTF measure review for PSE's single-family weatherization program, which analyzed savings estimates using simulation modeling and billing analysis.

Findings

The review did not find a great deal of information available for energy savings in low-income households. Regional low-income weatherization studies and other Cadmus low-income program evaluation reports provided input for six equipment measures, including refrigerator replacements, pipe insulation, programmable thermostats, electric water heaters, energy-efficient showerheads, and CFLs. In reviewing state TRMs, the refrigerator replacement was the measure most commonly found with low-income specific savings. Other measures with low-income specific savings included CFLs and showerheads. Appendix D summarizes TRM review results.

The finding section includes:

- Overall program recommendations;
- An overview of adjustment types proposed for each measure; and
- A high-level discussion of suggested changes for each measure.

Appendix E provides a detailed discussion of calculation methodologies, energy savings changes, and suggestions for each measure.

Overall Recommendations and Considerations

The following suggestions refine future program energy savings values:

- **Additional data collection.** Collecting additional, site-specific or measure-specific information will improve the accuracy of energy savings. Suggested data can be easily collected while visiting homes or through a participant survey. Appendix E provides recommendations on variables to collect for each measure.
- **Monitor RTF calculator updates.** Energy savings for two measures—smart strips and ductless heat pumps—have been based on provisionally deemed RTF values. Currently, studies being conducted meter energy savings for these measures, and the RTF will update deemed values upon the studies' completion. Additionally, the Energy Independence and Security Act (EISA), which takes effect in October 2012,[31] will affect energy savings for CFLs and LEDs. Though the RTF currently accounts for EISA using a weighted average within each year (2011, 2012, and 2013), RTF deemed savings likely will be updated annually.
- **Billing analysis.** Energy savings for weatherization measures could be more accurately determined using billing analysis. Modeling or calculating energy savings for specific weatherization measures can be difficult due to variations in home characteristics and customer behavior, and due to measure interaction effects. A billing analysis, comparing pre- and post-install energy consumption, could more accurately represent energy savings for all measures as a whole. Energy savings for equipment measures, such as refrigerators, could be subtracted from total site savings to determine savings from weatherization or behavior measures.

Recommended Adjustments Types

Cadmus updated measure assumptions, based on participant and stakeholder interview data, regional data, the Low-Income Weatherization Manual, and previous Cadmus studies. Adjustments fell into three categories: updating methodology; updating assumptions with low-income specific values; and updating general assumptions. Low-income specific adjustments included updating variables from general residential values to low-income specific values (e.g., baseline efficiency of water heaters). This category also included adjustments to match PSE's program design or the Low-Income Weatherization Manual's guidelines. General assumption adjustments are those made to algorithms or assumptions that are not specific to any particular residential segment. Table 25 summarizes types of adjustments recommended for each measure.

[31] Starting January 2012, 100 watt incandescents will begin a scheduled phase-out. However, the final 2012 federal budget eliminated funding for enforcement of this measure, and funding will be delayed until October 2012.

Table 25. Summary of Recommended Updates for Each Measure

Measure	No Change	Update Methodology	Update with LI Assumptions	Update General Assumptions
Floor Insulation			X	
Attic Insulation			X	
Wall Insulation			X	
Roof Insulation			X	
Duct Insulation and Duct Sealing			X	
Structure Sealing			X	
Windows			X	
Refrigerator Replacement*			X	
Showerheads			X	
Water Heater Replacement			X	
Whole House Fans				X
Ductless Heat Pump		X		
Programmable Thermostat				X
Pipe Insulation	X			
Smart Strips	X			
CFLs, Light Socket Conversion, Fixtures*	X			
LEDs	X			

* Savings calculations for these measures included some low-income assumptions. Appendix E provides greater detail.

As shown above, nine measures should be adjusted for low-income specific values. Though energy savings for refrigerator replacements were already low-income specific, Cadmus recommends updating to a low-income specific value more specific to PSE territory. For two additional measures, Cadmus suggests updates to general assumptions.

Comparison of Current and Recommended Savings by Measure

The adjustments discussed above changed energy-saving calculations for some measures. This section summarizes recommended changes to measure-specific energy-savings calculations. Appendix E provides the detailed methodology for calculating new savings for each measure.

Shell Measures

Shell measures include all insulation and weatherization measures. PSE currently uses RTF energy savings values for shell measures. Energy savings for most PSE shell measures were available through the RTF's calculator, but not all (i.e., variations in insulation type, level of efficiency, and baseline). For unavailable measures, PSE requested RTF perform additional model runs to determine energy savings for these measures; so the methodology would remain consistent with the other shell measures.

Cadmus recommends PSE continue using RTF energy savings values, while collecting additional site data, which could be provided to the RTF to update the model specifically for low-income customers in PSE's territory. When possible, PSE should collect heating system types, using energy savings from the RTF corresponding to the heating system type. The RTF's average energy savings values, weighted by heating system type (as currently used by PSE), should not be used for low-income homes, as the distribution of heating systems assumed by the RTF differs greatly from the distribution found during PSE's low-income participant survey. Table 26 compares the distribution of heating systems used by the RTF to those reported in the participant survey.

Table 26: Comparison of Electric Heating System Distributions

Heating System Type	RTF Assumption	PSE Low-Income Program Participant Survey
Zonal	42%	14%
Electric Furnace	36%	77%
Electric Heat Pump	22%	9%

Seventy-seven percent of low-income customers participating in PSE's program had an electric furnace, compared to 36% of single-family homes in the RTF's distribution. Energy savings calculations assumed electric furnaces as heating systems result in higher savings than zonal or electric heat pumps.

Additional site data could be collected, summarized, and provided to the RTF to update the model, specifically for low-income customers in PSE's territory, including following variables:

- Capacity of heating system;
- Efficiency or age of heating system; and
- Home conditioned square footage.

Through the RTF model has other variables, these three are easiest to collect and have the greatest impact on energy savings.

Lighting Measures

Cadmus recommends PSE continues to use current savings values for all lighting measures. Additional information should be collected to refine future energy savings calculations. Appendix E provides additional suggestions.

- **Lamp Wattages.** In interviews with stakeholders, several agencies reported installing 13-Watt, 15-Watt, or 20-Watt CFL lamps. Agencies must replace incandescent lamps with CFL lamps of corresponding or higher lumens.[32] Additionally, some agency staff reported in interviews that customers' needs may result in higher CFL wattages replaced

[32] Washington Low-Income Weatherization Manual: http://www.commerce.wa.gov/DesktopModules/CTEDPublications/CTEDPublicationsView.aspx?tabID=0&ItemID=10233&MId=870&wversion=Staging

than CFL equivalents. If agencies record wattages of replaced lamps and wattages of CFLs or LEDs, energy savings will be more accurate. If baseline wattages are not recorded, Cadmus suggests PSE track RTF calculator updates, given EISA's implementation impacts on energy savings in October 2012.

- **Rooms Where Lamps were Installed.** Rooms of a home where the lamps have been installed can impact assumptions used to determine hours of use. Agencies must replace incandescent bulbs typically operating three hours or more per day.[33] While some agency staff reported following this guideline, other staff indicated replacements were driven by client needs, resulting in bulb replacements in sockets of potentially lower hours of use. On average, approximately six CFLs were installed per home,[34] according to the participant database provided by PSE, also suggesting the lamps were likely installed in high-use areas. However some customers received more than 10 lamps; so it is probable hours of fell below three hours (PSE's current assumption) for some lamps. The RTF Residential CFL Lighting calculator[35] includes a table of hours of use per room, which could be used to refine the energy savings estimate, if agencies record where lamps are installed. These hours of use, however, are not low-income specific. If PSE wants low-income specific hours of use per room, metering is recommended.

HVAC Measures

PSE's program includes two HVAC measures: ductless heat pumps, and programmable thermostats. Current PSE savings values for ductless heat pumps have been based on RTF assumptions, and thermostat savings have been based on the Planning, Tracking, and Reporting System (PTR).[36] Both measures adopted the same methodologies, where energy savings have been assumed as a percentage of baseline energy consumption for heating. RTF annual energy savings for ductless heat pumps are: 3,500 kWh; PTR deemed savings value for programmable thermostats are: 435.8 kWh.

Much uncertainty exists concerning savings for ductless heat pumps and programmable thermostats. As ductless heat pumps are relatively new residential measures in the U.S., insufficient research has been conducted for the RTF to deem savings for this measure; thus, savings currently are provisionally deemed until further data become available. The Bonneville Power Administration, Northwest Energy Efficiency Alliance, and other electric utilities in the Northwest[37] currently are conducting studies to determine a more accurate savings value. Until the RTF deems savings for this measure, PSE should use an algorithm for calculating energy

[33] Washington Low-Income Weatherization Manual.

[34] Calculated for the measure "CFL Screw-In Lamps" using the PSE participant database for single-family and manufactured homes.

[35] The Residential Lighting Calculator can be downloaded from the RTF's Website: http://www.nwcouncil.org/energy/rtf/measures/measure.asp?id=141. Version 2 provided the most recent version at the time of our review.

[36] Regional Technical Forum's Planning, Tracking, and Reporting System can be found at: http://ptr.nwcouncil.org/

[37] http://www.bpa.gov/energy/n/emerging_technology/DHP.cfm

savings for ductless heat pumps, and should consider the methodology provided in the Pennsylvania TRM.[38]

For thermostats, a wide range in savings occurs within the literature, from 0% to 12% of heating energy consumption.[39] Given PSE's program has an educational component, savings are more likely to be realized; however, the process evaluation found mixed responses on persistence of thermostat settings. Currently, PSE should use the most recently approved RTF savings value of 348 kWh rather than the PTR value until further, low-income specific data become available. In particular, PSE could conduct a billing analysis or energy education study to determine savings and persistence for this measure.

Water Heating Measures

PSE's program includes three water heating measures: water heater replacement; energy-efficient showerheads; and pipe insulation. Table 27 compares current savings values used by PSE to suggested savings values.

Table 27. Current and Recommended Energy Savings Values for Water Heating Measures*

Measure	Current PSE Savings **				Cadmus Recommended Savings **			
	SF/MH (kWh)	SF/MH (therms)	MF (kWh)	MF (therms)	SF/MH (kWh)	SF/MH (therms)	MF (kWh)	MF (therms)
Water Heater Replacement	131	N/A	131	N/A	105	N/A	105	N/A
Showerhead	175	8	114	5.1	426	18.7	299	13.1
Pipe Insulation	20	0.9	20	0.9	20	0.9	20	0.9

* SF = single-family; MH = manufactured homes; MF = multifamily.
** Natural gas (therm) savings are for homes with natural gas water heaters.

We recommend that current saving values for water heater replacement and pipe insulation continue to be used, but a different savings algorithm should apply for energy-efficient showerheads.

For electric water heater replacement, PSE uses the RTF value, which assumes the water heater is replaced upon failure, and not an early replacement measure. Agencies confirmed they were only replacing water heaters that have failed. For this measure, the baseline water heater meets the 2004 federal energy code, and Cadmus recommends continuing to use this baseline. However, Cadmus suggests changing the gallons of hot water used per day from 64.3 to 52.9, and tank temperature setting from 135°F to 126.5°F. The 64.3 gpd assumption is a national average,[40] based on a 2.6 person household.[41] Average households from PSE's low-income program survey have

[38] Pennsylvania Public Utilities Commission. Technical Reference Manual: June 2011. State of Pennsylvania Act 129 Energy Efficiency and Conservation Program & Act 213 Alternative Energy Portfolio Standards. http://www.puc.state.pa.us/electric/Act129/TRM.aspx

[39] See the literature review presented within the RTF thermostat v2 calculator on the "Input Assumptions" worksheet.

[40] http://www1.eere.energy.gov/buildings/appliance_standards/pdfs/htgp_rfi_25815.pdf

[41] Residential Energy Consumption Survey (RECS) 2005, Table US1. Total Energy Consumption, Expenditures, and Intensities, 2005 Part 2: Household Characteristics.

2.3 residents, resulting in decreased water used per day. Tank temperature settings of 126.5°F derive from a California Public Utility Commission (CPUC) evaluation report, based on metered data.[42]

For energy-efficient showerheads, PSE calculated savings, with the majority of inputs based on RTF assumptions and sources, account for distributions of homes with more than one showerhead. Additionally PSE calculated separate savings values for single-family and multifamily homes. Based upon the two studies, Cadmus suggests using a higher baseline flow of 2.8 gpm.

Enbridge Gas Distribution, Inc. conducted the first study in 2010.[43] The Ohio TRM referenced this study as the source for baseline flow used in determining energy savings. Iowa Energy Wise Program produced the second study, which measured showerhead flow rates in low-income homes, with an average flow of 2.8 gpm.[44] This calculation change served as the main driver behind increased energy savings for this measure. As the baseline flow provides an important variable in determining energy savings, Cadmus recommends PSE conduct its own measurements to further refine this variable. In addition, the number of people per home has been adjusted, based on participant survey data. The result is an increase in energy savings to 426 kWh for single family and 299 kWh for multifamily. This is within the range of values seen in the literature, where the maximum energy savings seen was 518 kWh per the Michigan Measure Database.[45]

For pipe insulation, PSE uses the RTF value for 3 feet of insulation. Cadmus has conducted a literature review and engineering review for pipe insulation, which found maximum energy savings of 48 kWh per year. The literature review found only three of nine sources had deemed savings less than 48 kWh, and these deemed savings values ranged from 33 kWh to 45 kWh. As much uncertainty exists regarding energy savings for this measure, Cadmus recommends continuing to use the RTF value.

Appliances

For refrigerator replacement, PSE currently uses energy savings from a study conducted in California. Table 28 compares the current PSE savings value with the suggested value. Our suggested value is based upon a different baseline assumption.

[42] CPUC Residential Retrofit—High Impact Measure Evaluation Report Draft. Dec. 7, 2009. Pg 76. Average temperature setpoints for two utilities.

[43] Enbridge Gas Distribution Inc., April 2010; "Demand Side Management 2009 DSM Draft Annual Report", p77-78. Calculated with the average flow rate of units between 2 and 2.5GPM of 2.45GPM, average flow rate of units greater than 2.5GPM of 3.07, and 33% of all units between 2 and 2.5%, 67% of units over 2.5GPM; (2.45*0.33)+(3.07*0.67) = 2.87GPM

[44] The Cadmus Group. Iowa 2010 Energy Wise Program. An evaluation report prepared for Iowa Utility Association. March 2011.

[45] Morgan Marketing Partners. Michigan Energy Measures Database. http://www.michigan.gov/mpsc/0,4639,7-159-52495_55129---,00.html

Table 28. Current and Recommended Energy Savings Values for Refrigerator Replacement

Measure	Current PSE Savings (kWh)	Cadmus Recommended Savings (kWh)
Refrigerator Replacement	755	811

Cadmus recently contributed to a Washington State study to update energy savings for low-income measures of the statewide Weatherization Assistance Program Evaluation.[46] This evaluation considered a variety of sources, as summarized in Appendix E. Sources included: the RTF; metering studies conducted in Utah; Washington State data on Savings to Investment Ratio (SIR) thresholds; and other state TRMs. Though Cadmus recommends aligning with the Washington State methodology, its methodology included all refrigerator configurations; a more effective methodology would adjust the energy-efficient refrigerator based solely upon top-mount refrigerators with no added features, per the Low-Income Weatherization Manual, resulting in increased energy savings, compared to PSE's method.

Ventilation

For ENERGY STAR mechanical ventilation (i.e., whole house fans), PSE cited correspondence with Panasonic as the basis for energy savings. As a retrofit measure, a whole house fan replaces a bathroom fan and the whole house fan is generally set on a timer to meet ventilation requirements. Table 29 compares the current PSE savings value with the value suggested for this measure.

Table 29. Current and Recommended Energy Savings Values for Whole House Fans

Measure	Current PSE Savings (kWh)	Cadmus Recommended Savings (kWh)
ENERGY STAR Mechanical Ventilation	128	0

PSE's method assumed both the baseline bathroom fan and whole house fan operated 8 hours per day. Though an appropriate assumption for new construction homes, it raises questions as this is a retrofit measure. For the retrofit case, the baseline would be a bathroom fan, operated by occupants (as opposed to an automated timer), with a reasonable assumption of running for an hour or less per day. Changing baseline operating hours from 8 to 1 results in increased energy use. Therefore, Cadmus suggests this measure be assigned zero savings, and be treated as a health and safety measure.

Plug Load

Cadmus recommends PSE continue to use the provisional RTF savings value for smart strips. The RTF will revisit this measure during 2012, updating the provisional value after reviewing data from more recent studies. Studies prior to 2009 showed variability in energy savings depending on types of smart strips installed (occupancy sensor, load sensor, or timer) and types

[46] Kunkle, R. and Schueler, V. Washington State University Extension Energy Program Evaluation Report for FY2010. WSUEEP11-025. May 2011. Can be downloaded from http://www.commerce.wa.gov/DesktopModules/CTEDPublications/CTEDPublicationsView.aspx?tabID=0&ItemID=9840&MId=870&wversion=Staging

of equipment (office or entertainment) plugged into the smart strip.[47] Cadmus recommends PSE monitor the RTF's progress with this measure, and consider collecting additional information if new deemed savings values become dependent on the smart strip type and equipment type.

[47] Ecos Consulting. Plug Loads: Proposal for Provisional Deeming of Smart Strips. Presentation to the Regional Technical Forum on April 7, 2009. Presentation can be downloaded from: http://www.nwcouncil.org/energy/rtf/meetings/2009/04/

APPENDIX A. PAYMENT ANALYSIS CALCULATIONS

This appendix outlines formulae used to calculate various metrics in the payment analysis. For all formulae presented below:

Arrangement Metrics

Where:

= the amount in dollars that an outside party paid on behalf of customer, i, in period, t.

Where:

= 1 if customer, i, received a non-zero amount of arrangements and 0 otherwise.

Payment and Billing Metrics

Where:

= 1 if a newly incurred charge to customer, i, in billing period, t, is not paid in full and 0 otherwise.

Where:

= the amount in dollars that customer, i, paid in period, t.

Disconnect Metrics

Where:

= 1 if a customer had a reconnect in billing period, t, is and 0 otherwise.

Arrearage Metrics

Where:

= the amount in dollars that customer, i, owed PSE in period, t.

Where:

= is the discount rate faced by PSE (8.1%).

APPENDIX B. ECONOMIC ANALYSIS ASSUMPTIONS

Economic impacts analysis modeling assumptions are outlined below. PSE provided Cadmus with expenditure data by revenue source (electric and gas tariff collections, electric and gas Attorney General funds, and shareholder contributions), and future energy rates for analysis:

- ***Model Regions:*** The gas and electric models cover different regions according to the counties listed on PSE's Website.
- ***State-level Analysis:*** Ratepayer costs and participant energy savings are assigned to sectors and households in the same proportions as when models run separately. Direct costs and savings will not accrue outside of PSE territory; so household demand and commercial/industrial load shares are not updated to reflect the larger region.
- ***Agency spending*** is allocated to administration (15%, as noted by PSE in its expenditure sheet), and weatherization spending (the remaining 85%). Of weatherization funds, 60% was assigned to labor, and 40% to materials, based on agency interviews.
- ***Program Funding Sources***: Tariff collections are charged to ratepayers. Attorney General funds are not charged to anyone as these funds flow into PSE territory from out of state. Shareholder and evaluation expenses are charged to PSE, and are assigned to the electric and gas models in proportion to tariff funds flowing into these programs. Each of the electric and gas models is assigned half of Cadmus evaluation expenses.
- ***Tariff collections*** are assigned across the residential, commercial, and industrial sectors in proportion to average 2009–2010 shares of total electric/gas load;[48] residential household income groups pay in proportion to total residential electricity/gas expenditures; commercial and industrial ratepayers pay in proportion to total electricity/gas loads; industries not in the Cadmus load table are not modeled as ratepayers, but can still be impacted when the I/O model runs.
- ***Program eligibility*** is based on federally established poverty guidelines, which rely on an income threshold corresponding to the number of people living in a home. Cadmus used the 2009 program eligibility guidelines, converting these to 2010 dollars using the Consumer Price Index. Participants in the phone survey reported an average of 2.31 people typically living in each home over the past year. The average program eligibility income threshold for households with this average occupancy is $32,095. Cadmus assigned energy savings in the models to the four household income groups whose annual earnings ranges contain or are below this threshold: less than $10,000; between $10,000 and $15,000; between $15,000 and $25,000; and between $25,000 and $35,000. As with tariff collections, household energy savings are assigned in proportion to each income group's share of total residential spending on that type of energy. The results are robust to assigning energy savings only to lower income groups or expanding the range of income groups receiving savings; the induced effects are the only impacts differing across the methods, but these small changes do not affect qualitative results.

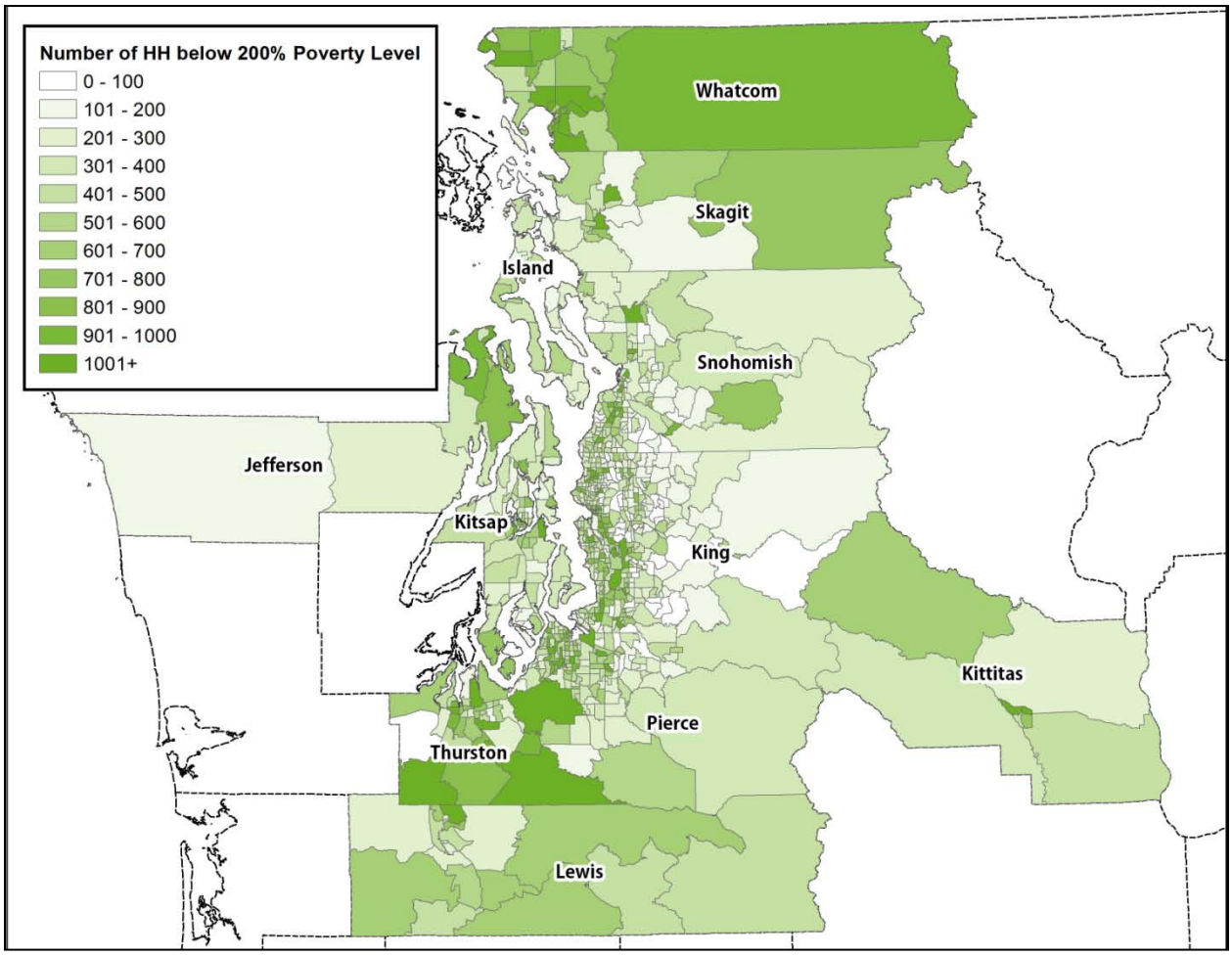
[48] The load distribution for each sector derives from the PSE 2010 Conservation Potentials Assessment, performed by Cadmus.

- ***Cost-sharing:*** The model assumes weatherization costs are covered in full by PSE's reported expenditures, as it is unlikely participants paid some costs of weatherizing their homes.
- ***Impact Horizon:*** For this analysis, impacts are considered only for 30 years post-installation, the length of PSE's future rate forecast series. This means insulation, for instance, is modeled as having a measure life of 30 years instead of 45 years.
- ***Discount rate***: PSE provided 8.1% as the utility cost of capital. This discount rate was used for the present values of participant savings and utility revenue loss. Alternate results using the prevailing mortgage rate (4%) as the participant savings discount rate are provided in Appendix G.
- ***Revenue Loss:*** PSE is assigned revenue loss according to energy savings received by participants. The future energy rates from PSE's "Rates for Future PC Test" sheet include an adder, which accounts for lost marginal revenues due to DSM programs.

APPENDIX C. ADDITIONAL TERRITORY MAPS

Map Appendix

Figure 37. Number of Households Below 200% of the Poverty Level per Census Tract*



*Census tracts in the counties served by PSE showing total number of households below 200% of the poverty level. In this and all subsequent maps, darker color is associated with a region that should be considered to have higher need.

Figure 38. Number of Households with Children per Census Tract

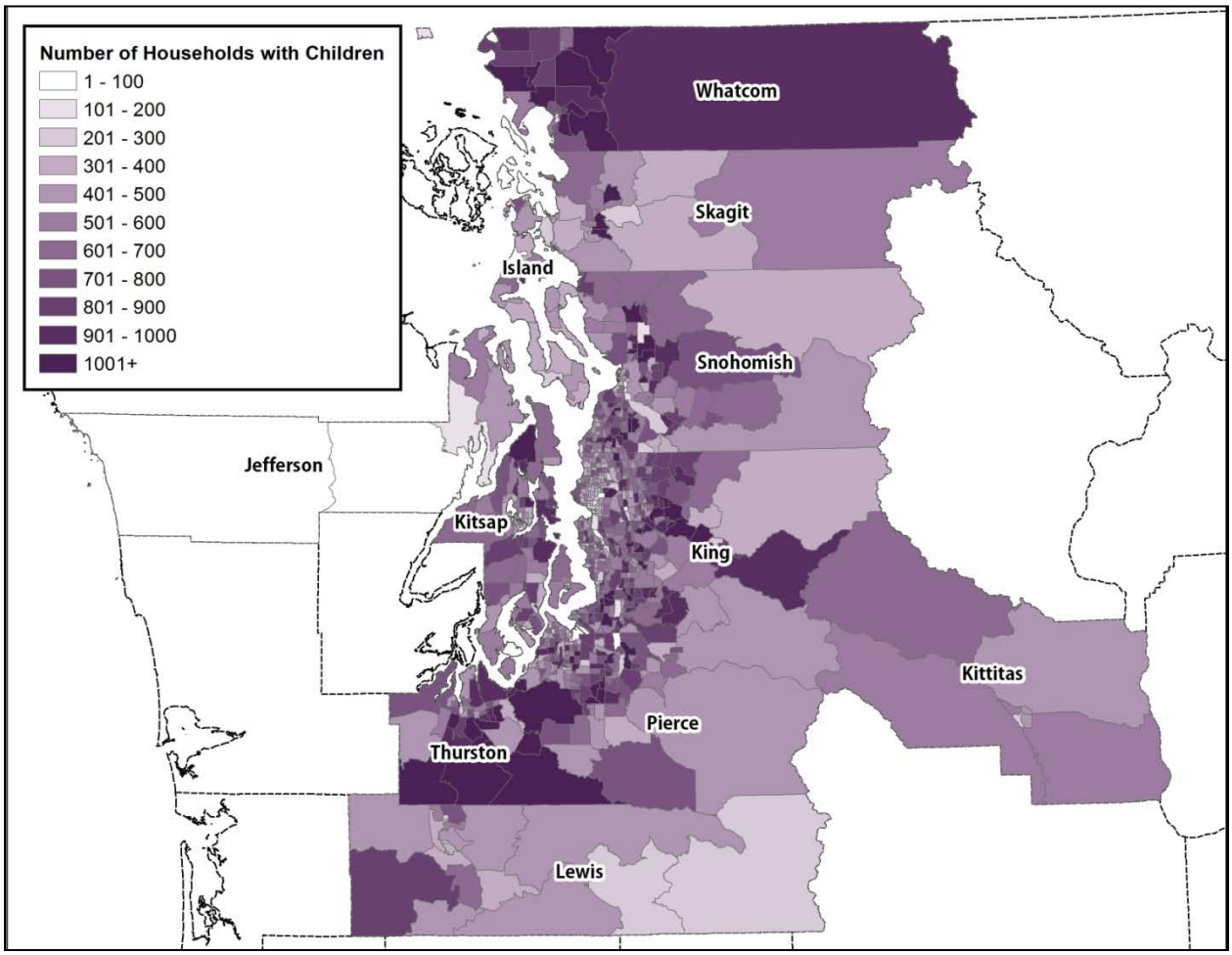


Figure 39. Number of People over the Age of 65 per Census Tract

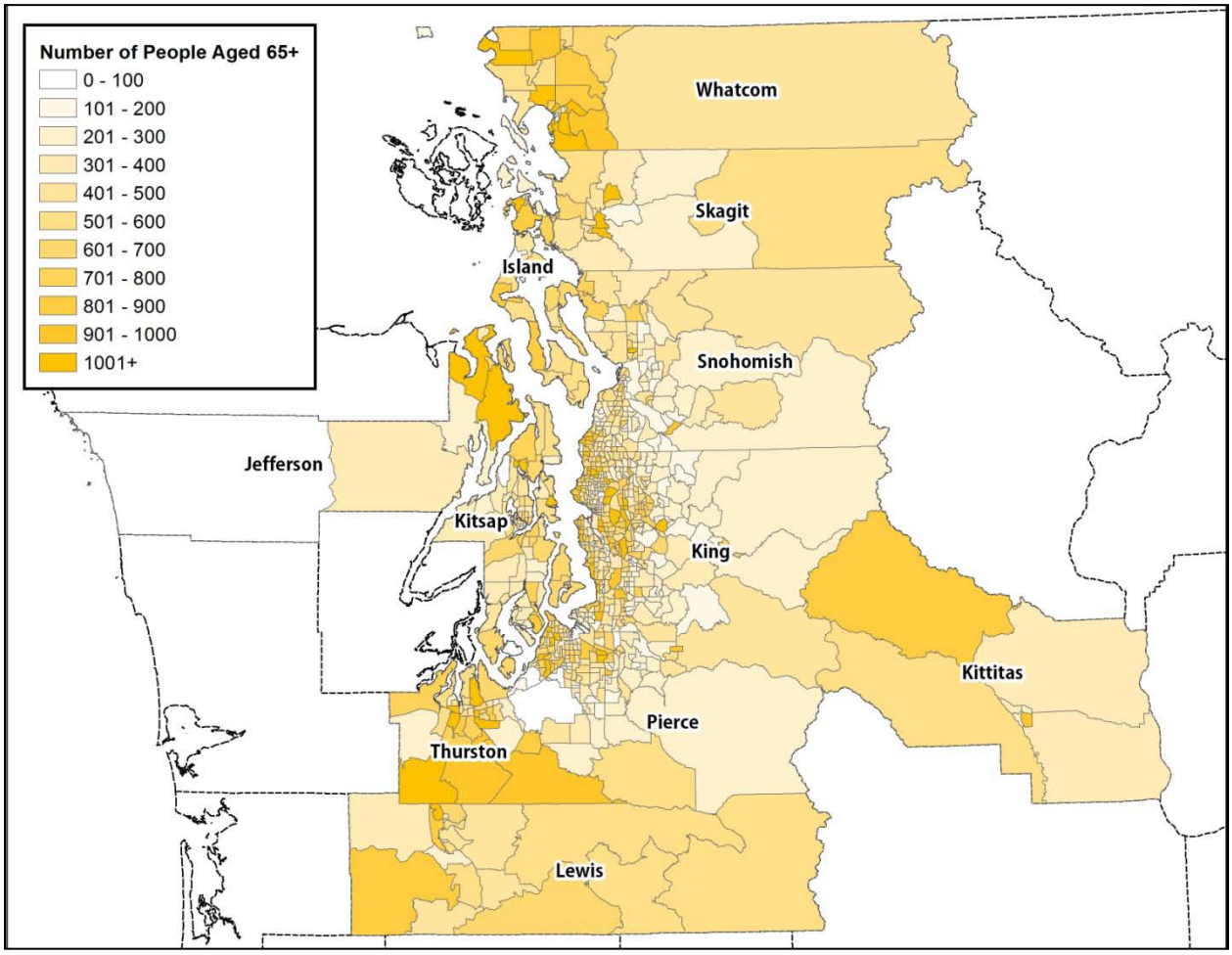


Figure 40. Number of People with a Disability per Census Tract

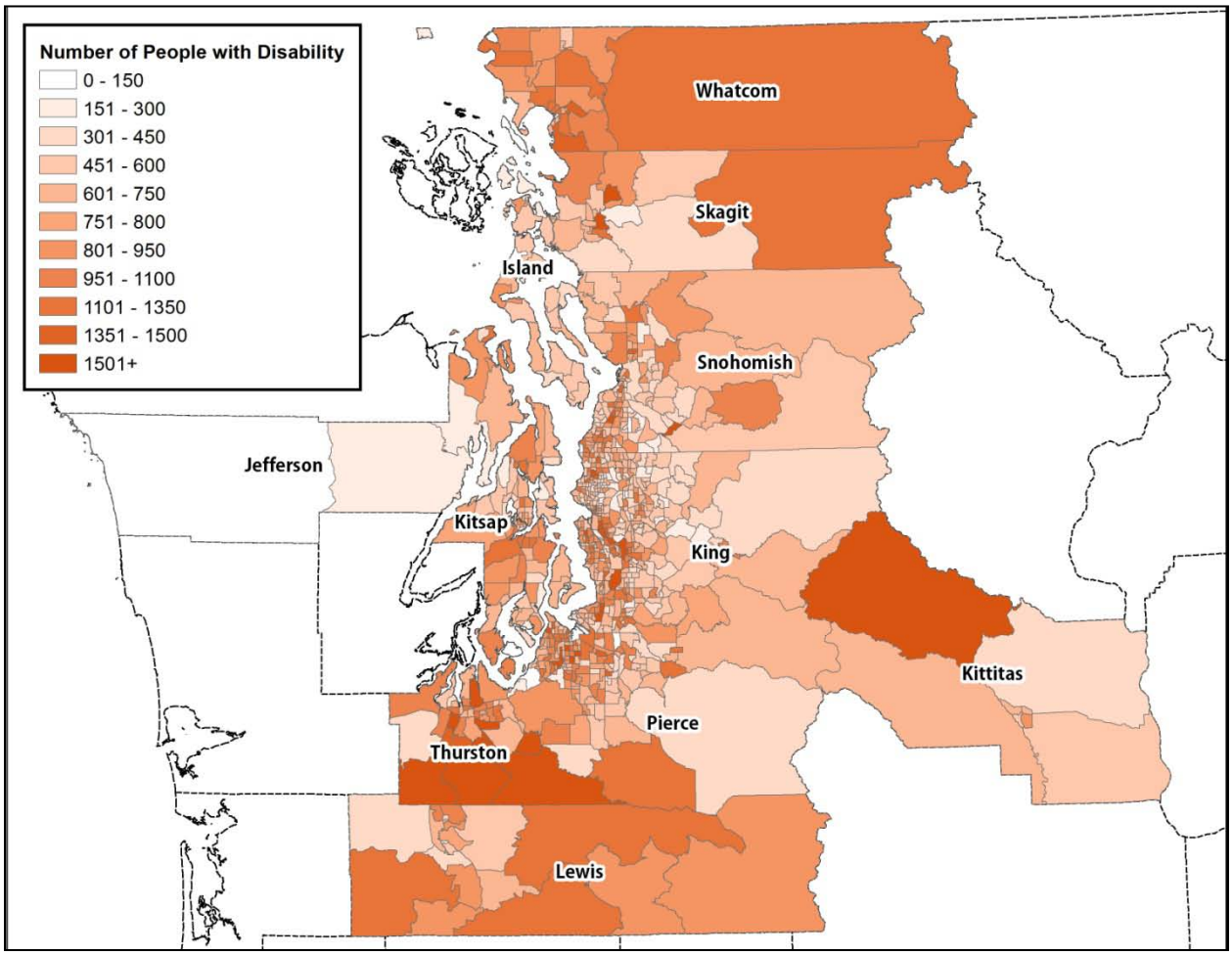
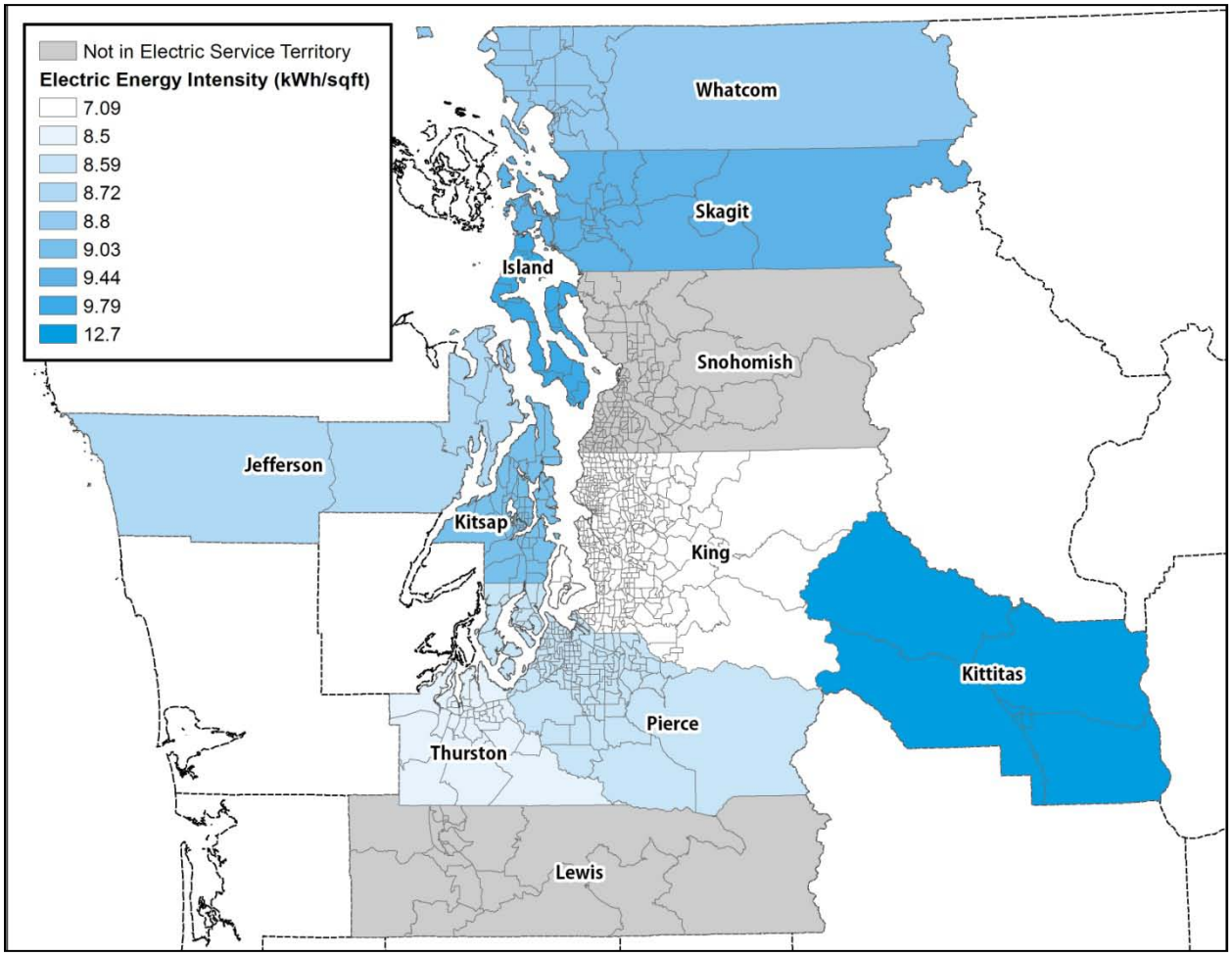


Figure 41. Average Electric Energy Intensity per County*



*The average electrical energy intensity (kWh/sqft) as derived from a billing analysis and house square footage from Zillow.com.

Figure 42. Number of Historical Participants per Census Tract

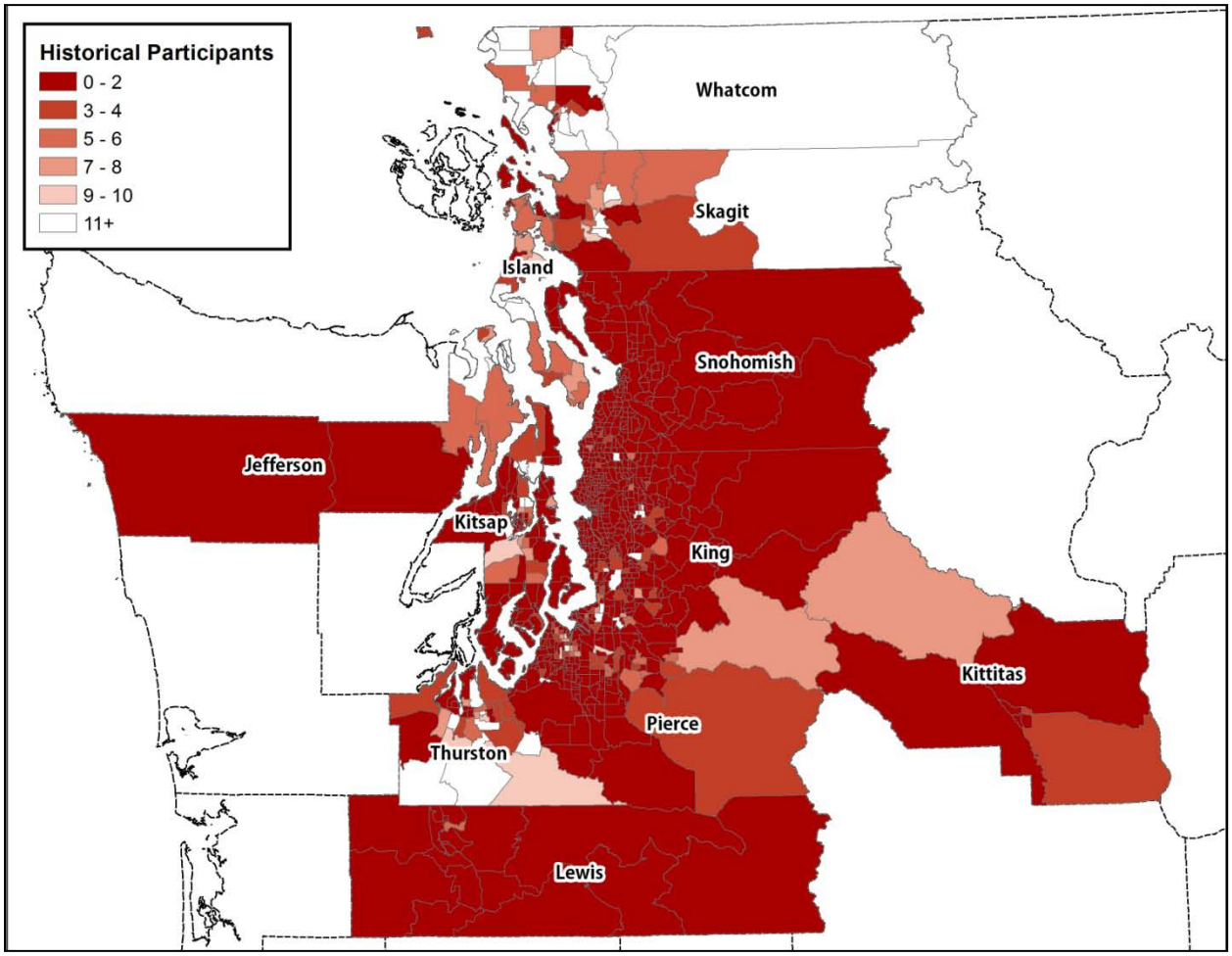
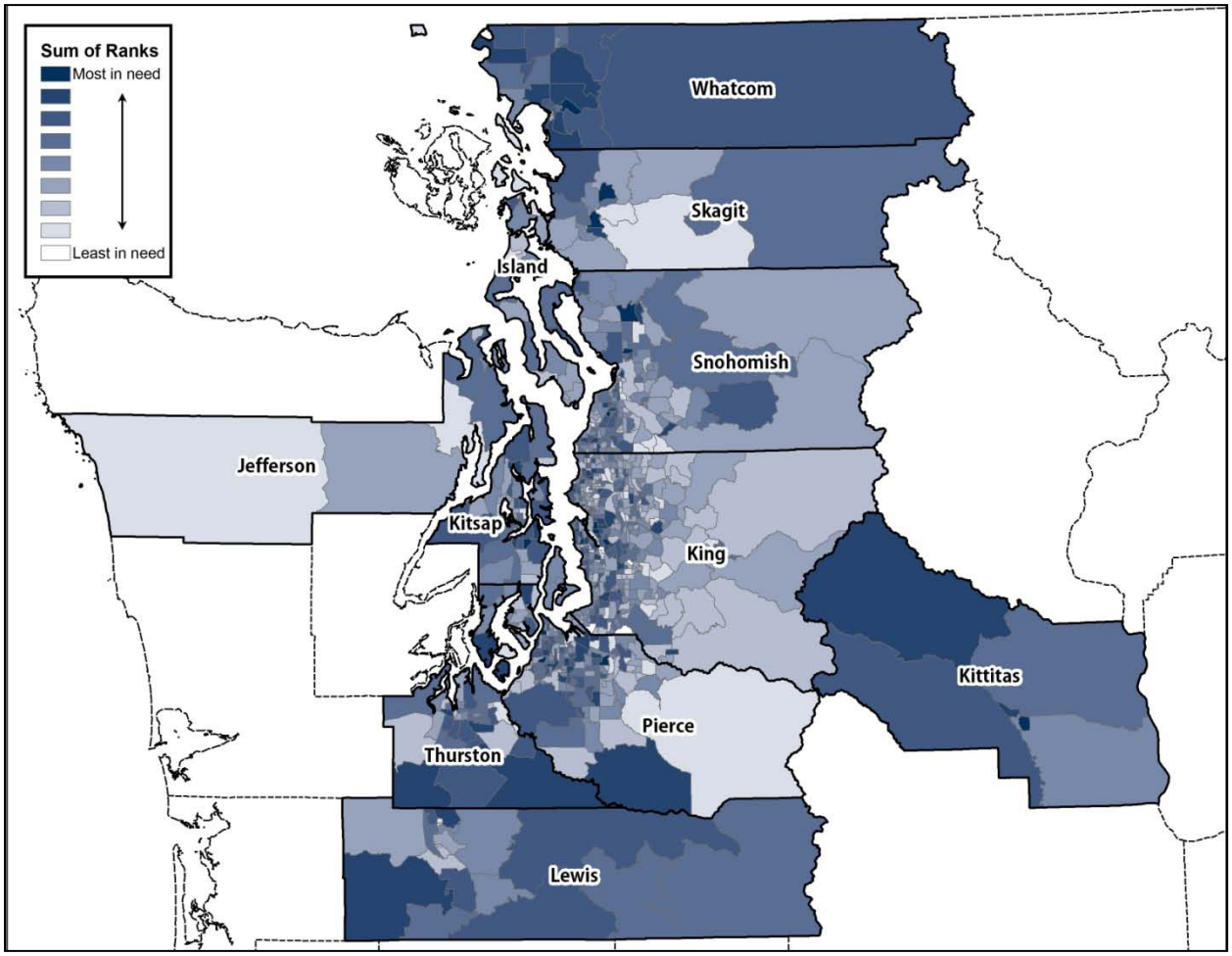
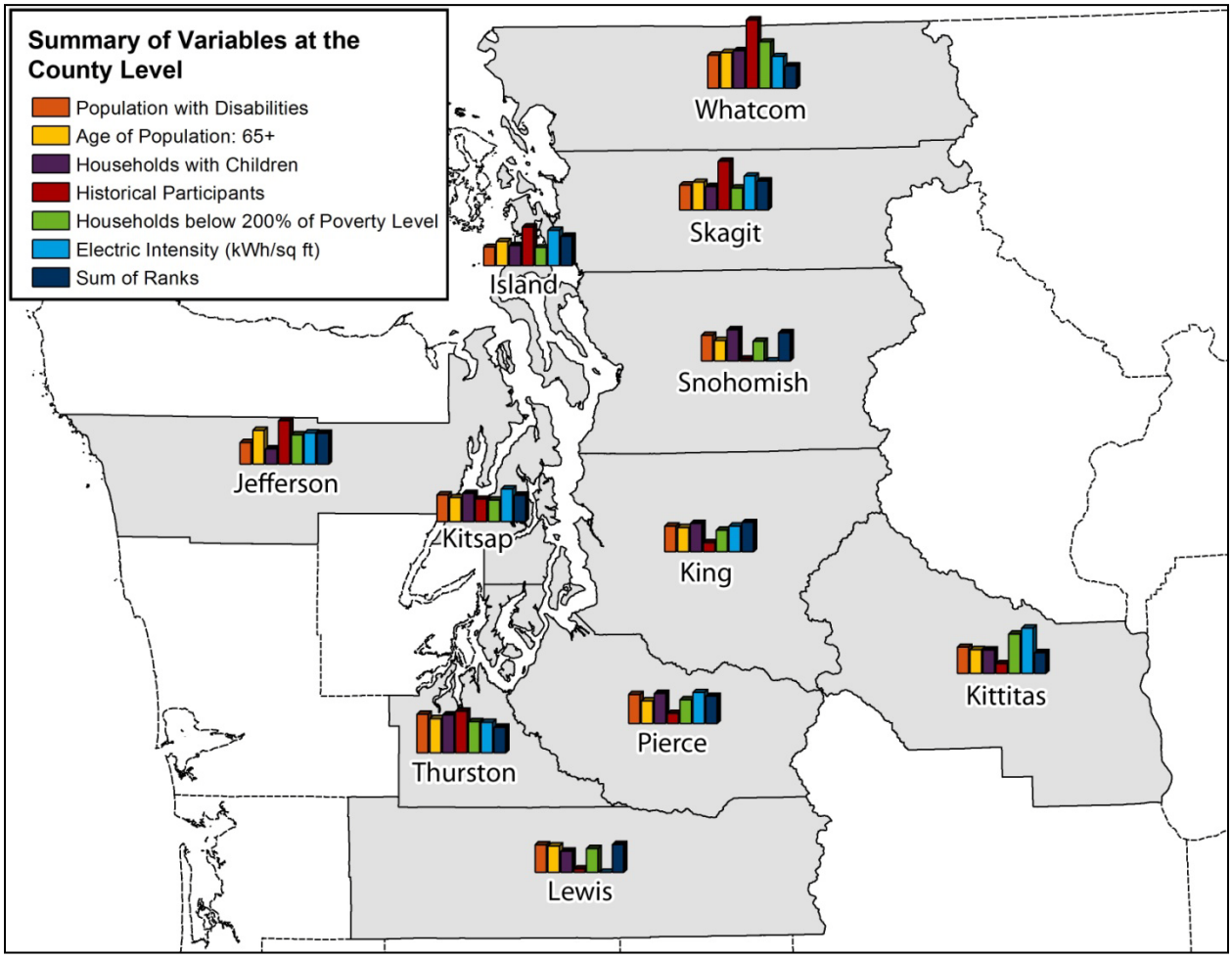


Figure 43. Sum of the Ranks of the Six Metrics*



*Census tracts were ranked from one to 860 for each variable category, where one always corresponds to those most in need (e.g., most households below 200% poverty level, fewest historical participants, highest electrical energy intensity). This map represents the sum of six ranks for each census tract with equal weighting. Dark blue tracts had the lowest sums and, consequently, these tracts represent regions with the highest need.

Figure 44. Normalized Bar Graph Summary at the County Level*



*An alternative representation of the six metrics and the sum of the six ranks at the county level. The column heights represent raw data values; a taller bar corresponds to a higher number of the given variable. As such, tall bars correspond to those most in need, excepting historical participants and sum of ranks, where the shortest bars represent the most-in-need counties.

Figure 45. Sum of Ranks with the Top 50 Highest Need Census Tracts

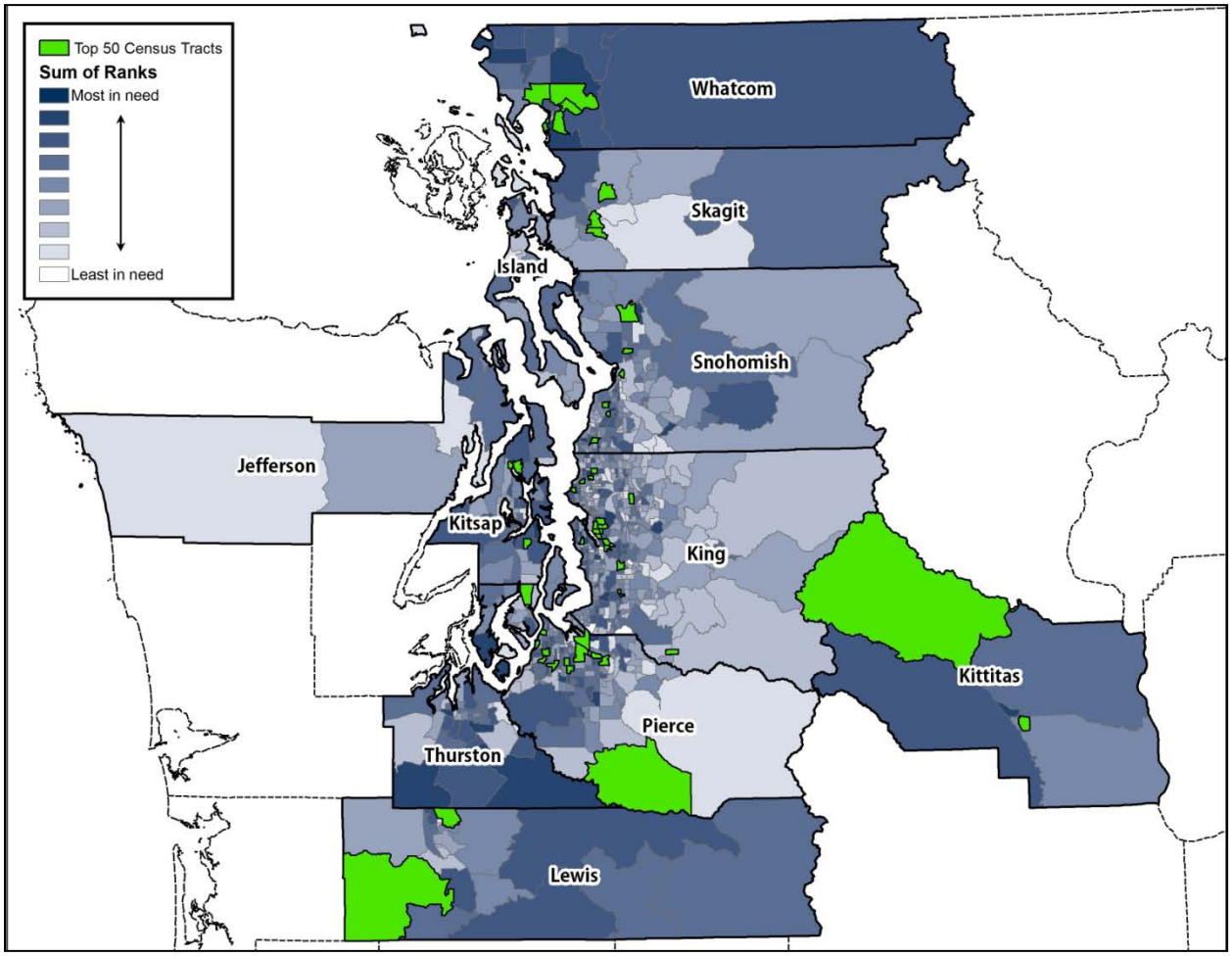
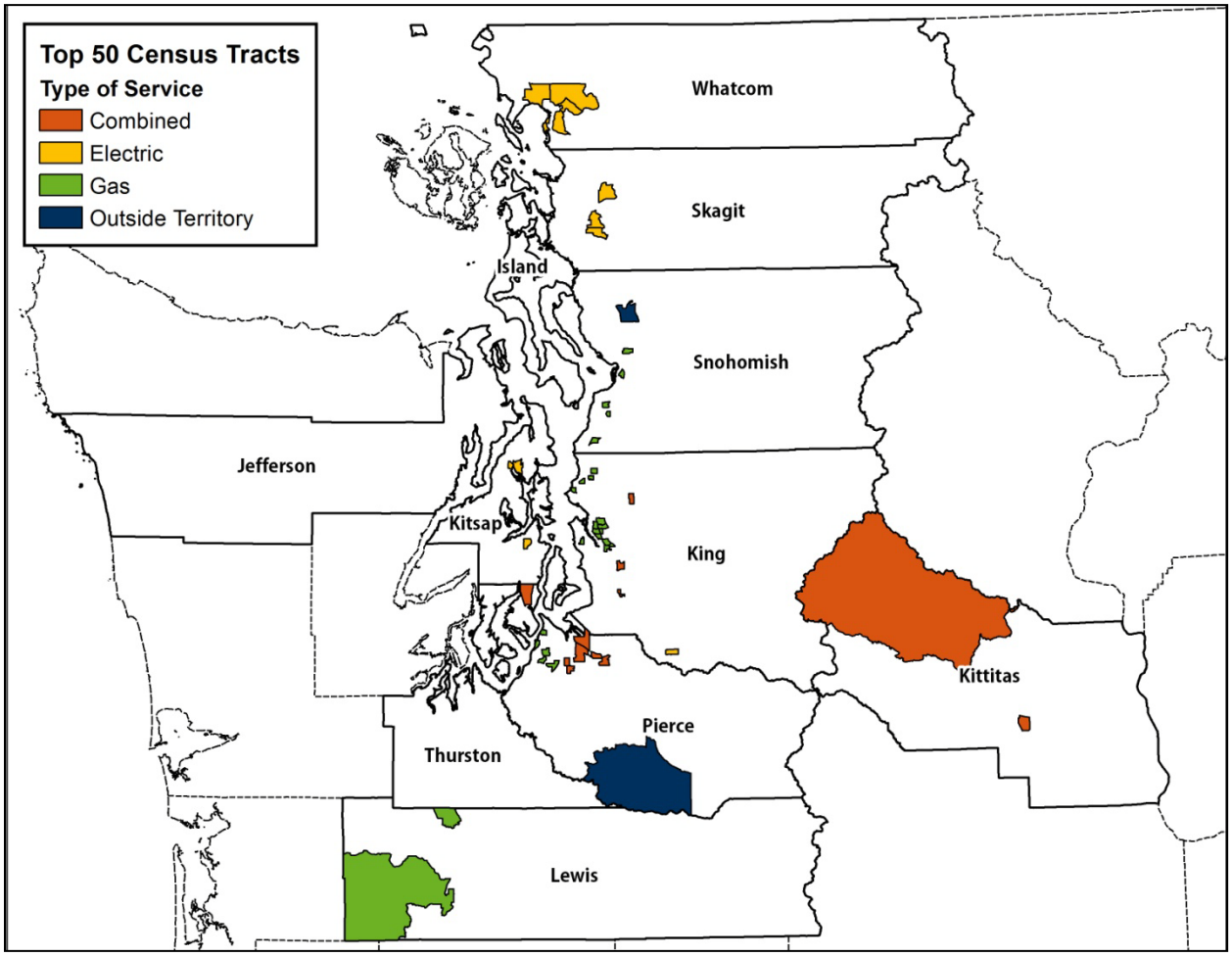


Figure 46. Service Type Provided by PSE for the Top 50 Census Tracts



APPENDIX D. SUMMARY OF STATE TECHNICAL REFERENCE MANUAL REVIEW

Ten TRMs were selected for examination of low-income residential savings. Four TRMs containing low-income specific savings for measures within PSE's program were: Connecticut, Massachusetts, Ohio, and Vermont. Six TRMs contained no low-income specific savings for measures within the PSE Low-Income Weatherization program. Table 30 summarizes TRM review findings.

Table 30: Summary of the TRM Review Findings*

TRM	Includes LI measures	LI Savings are the Same as Residential	LI Savings are Different from Residential	Measures Included only as LI
Connecticut (2008)	Yes	CFL/fixtures, duct sealing, ductless HPs, showerheads, ceiling/wall insulation	-	Duct insulation, pipe insulation, refrigerator replacement, windows
Connecticut (2011)	Yes	Ceiling/wall insulation	CFLs, showerheads	Refrigerator removal
Massachusetts	Yes	-	-	Refrigerator replacement
Ohio	Yes	-	-	Refrigerator replacement
Vermont	Yes	Pipe insulation, showerheads, CFLs (SF)	Light fixtures, refrigerator replacement	CFLs (MF), showerheads
Pennsylvania	Yes, but no PSE overlap	-	-	-
NW RTF	Yes, but no PSE overlap**	-	-	-
Hawaii	No	-	-	-
Maine	No	-	-	-
NEEP Mid-Atlantic	No	-	-	-
New York	No	-	-	-
Wisconsin	No	-	-	-
California DEER	No	-	-	-

*LI = low-income, SF = single family, MF = multifamily

**Though the RTF's Planning, Tracking, and Reporting System (PTR) contains some low-income measures, the measures in PSE's program only had standard residential savings; low-income specific savings values were not available.

Many measures had no comparable non-low-income residential measures with which to compare savings methodology and values (the column titled "Measures Included only as LI"). When non-low-income values were present, savings were often the same (the column titled "LI Savings are the Same as Residential"). The Connecticut TRM and Vermont TRM both had measures where savings differed from comparable non-low-income measures (the column titled "LI Savings are Different from Residential").

One of the main differences between low-income and non-low-income savings in all TRMs was the assumption that low-income appliances were replaced before the end of their useful life. Baseline energy use, therefore, was an average of two values over the new appliance's useful life: the existing unit's energy consumption; and the federal standard.

Table 30 highlights measure savings for the low-income segment often did not differentiate from residential savings. The most commonly found measure with low-income specific savings was refrigerator replacement. Other measures with low-income specific savings included CFLs and showerheads.

APPENDIX E. MEASURE-LEVEL SAVINGS REVIEW DETAILS

This appendix overviews variables reviewed and adjusted for each measure as well as detailed methodologies, resources, and suggestions for each measure.

Variables Reviewed and Adjusted by Measure

Table 31 lists variables considered for adjustment and variables recommended for adjustment. When a low-income specific value could not be found for a variable, the single-family or multifamily value was used, as appropriate. Some variables were also adjusted to be specific to the program design, as discussed previously. Recommendations for further refinement are discussed for each individual measure in following sections.

Table 31. Variables Considered for Adjustment and Variables Adjusted by Measure

Measure Category	Measure	Variables Considered for Adjustment	Variables Adjusted
Shell	Floor Insulation Attic insulation Wall Insulation Roof insulation Duct Insulation and Duct Sealing Structure Sealing Windows	• Type of heating equipment • Capacity of heating equipment • Efficiency of heating system • Conditioned square feet of home	• None
Lighting	CFLs, Light Socket Conversion, Fixtures LEDs	• Hours of use, • Watts of replaced lamp • Watts of new lamp • Number of lamps per fixture	• None
HVAC	Ductless Heat Pump Programmable Thermostat	• Baseline energy use for heating • Percent savings	• None
Water Heating	Water Heater Replacement	• Efficiency of replaced water heater • Gallons of water used per day • Temperature setting of the tank • Inflow water temperature	• Gallons of water used per day • Temperature setting of the tank
	Showerheads	• Flow of replaced showerhead • Flow of new showerhead • Showers per day • Minutes per shower • Temperature of shower • Inflow water temperature	• Flow of replaced showerhead • Showers per day (based upon people per household)
	Pipe Insulation	• Deemed savings	• None
Appliance	Refrigerator Replacement	• Energy use of replaced refrigerator • Energy use of new refrigerator	• Energy use of replaced refrigerator • Energy use of new refrigerator

Measure Category	Measure	Variables Considered for Adjustment	Variables Adjusted
Ventilation	Whole House Fans	• Watts of replaced fan • Watts of new fan • Hours of use	• Watts of replaced fan • Hours of use
Plug Load	Smart Strips	• Type of Smart Strip installed • Type of equipment plugged into the Smart Strip	• None

Shell Measures

Shell measures refer to all insulation and weatherization measures within PSE's program. This list specifically includes:

- Attic or ceiling insulation;
- Floor insulation;
- Wall insulation;
- Roof (tapered rigid board) insulation;
- Duct insulation;
- Duct sealing;
- Structure sealing; and
- Windows.

PSE uses RTF energy savings values for shell measures. The majority of these values were available through the RTF's standard calculator; however, some PSE estimates were developed through additional RTF model runs as a special request by PSE. The methodology for the additional measure calculations remained consistent with the approach used for other RTF shell measures. Table 32 highlights measures for which PSE requested additional model runs.

Table 32: Shell Measures*

Measure	Efficiency Level	Standard RTF Measure?
Attic Insulation	R-0 to R-38	Yes
	R-11 to R-38	No
	R-0 to R-19	Yes
	R-19 to R-38	Yes
	R-0 to R-49	Yes
	R-0 to R-30	Yes
	R-0 to R-33	No
	R-0 to R-22	No
	R-11 to R-33	No
Floor Insulation	R-0 to R-19	Yes
	R-0 to R-30	Yes
	R-11 to R-30	Yes
	R-0 to R-22	Yes
	R-11 to R-22	Yes

Measure	Efficiency Level	Standard RTF Measure?
Wall Insulation	R-0 to R-11 (or fill cavity)	Yes, except for Manufactured Homes
	R-0 to R-15	No
Tapered Rigid Board	R-5 to R-38	No
Duct Insulation	R-0 to R-11	Yes
Duct Sealing	N/A	Yes
Structure Sealing	Per 0.1 ACH reduction	Yes
Windows	Single-pane to Double-pane (U.30)	Yes
	Double-pane to Double-pane (U.30)	Yes
	Single-pane to Triple-pane (U.22)	Yes
	Double-pane to Triple-pane (U.22)	Yes

* Bold text highlights those measures with non-standard RTF savings estimates.

Cadmus recommends PSE continue using the RTF energy savings values for now, but consider collecting additional site data, allowing for updated RTF model runs for low-income specific PSE customers. In the meantime, PSE should use site-specific heating system types to estimate energy savings, using the RTF estimate specific to that heating type (rather than the current weighted average). The RTF's average energy savings values, weighted by heating system type, should not be used for low-income homes, as the distribution of heating systems assumed by the RTF differs greatly from the distribution found during PSE's low-income participant survey. Table 33 compares the distribution of heating systems used by the RTF to that reported in the participant survey.

Table 33: Comparison of Electric Heating System Distributions

Heating System Type	RTF Assumption	PSE Low-Income Program Participant Survey
Zonal	42%	14%
Electric Furnace	36%	77%
Electric Heat Pump	22%	9%

Seventy-seven percent of low-income customers participating in PSE's program had an electric furnace, compared with 36% of single-family homes in the RTF's distribution.

Additional site data could be collected, summarized, and provided to the RTF to update the model. specifically for low-income customers in PSE's territory. In particular, Cadmus recommends collecting the following variables:

- Capacity of heating system;
- Efficiency or age of heating system; and
- Conditioned square feet of home.

Though the RTF's model uses other variables, but these three provide the easiest means to collect and have the greatest impact on energy savings.

Equipment Measures

Table 34 overviews comparisons of current savings valued used by PSE with Cadmus' energy savings recommendations for each equipment measure.

Table 34. Current and Recommended Energy Savings Values by Equipment Measure

Measure	Current PSE Savings			Cadmus Recommended Savings		
	SF	MF	MH	SF	MF	MH
CFL	37 kWh	37 kWh	37 kWh	37 kWh	37 kWh	37 kWh
Light Socket Conversion	37 kWh	37 kWh	37 kWh	37 kWh	37 kWh	37 kWh
CFL Fixture	74 kWh	74 kWh	74 kWh	74 kWh	74 kWh	74 kWh
LED Lamps	34.1 kWh	34.1 kWh	34.1 kWh	34.1 kWh	34.1 kWh	34.1 kWh
Ductless Heat Pump	3,500 kWh	N/A	N/A	3,500 kWh	N/A	N/A
Programmable T-Stat	435.8 kWh	N/A	435.8 kWh	**348 kWh**	N/A	**348 kWh**
Water Heater Replacement	131 kWh	131 kWh	131 kWh	**105 kWh**	**105 kWh**	**105 kWh**
Showerhead	175 kWh or 8 therms	114 kWh or 5.1 therms	175 kWh or 8 therms	**426 kWh or 18.7 therms**	**299 kWh or 13.1 therms**	**426 kWh or 18.7 therms**
Pipe Insulation	20 kWh or 0.9 therms	20 kWh or 0.9 therms	20 kWh or 0.9 therms	20 kWh or 0.9 therms	20 kWh or 0.9 therms	20 kWh or 0.9 therms
Refrigerator Replacement	755 kWh	755 kWh	755 kWh	**811 kWh**	**811 kWh**	**811 kWh**
ENERGY STAR Mechanical Ventilation	128 kWh	128 kWh	128 kWh	**0 kWh**	**0 kWh**	**0 kWh**
Smart Strips	100 kWh	100 kWh	100 kWh	100 kWh	100 kWh	100 kWh

*SF = single family, MF = multifamily, MH = manufactured homes
**Red bold font indicates there was a change in savings.

Recommendations for each equipment measure follow in detail below.

Lighting Measures

PSE currently uses the RTF's method for calculating energy savings for lighting measures. All RTF assumptions remain the same, except for CFL operating hours per day, which were adjusted upward from 1.9 to 3.0, based on the Low-Income Weatherization Manual. This resulted in an increase in energy savings from 23 kWh to 37 kWh per CFL. Cadmus recommends PSE continue to use 37 kWh savings per CFL, and 74 kWh savings per fixture. Currently, no LEDs have been installed through the program. Savings for LEDs match RTF savings, and continue to use 1.9 hours of use per day. Table 35 summarizes lighting savings estimates and comparisons between PSE and Cadmus recommended values.

Table 35. Current and Recommended Energy Savings Values for Lighting Measures

Measure	Current PSE Savings (kWh)	Cadmus Recommended Savings (kWh)
CFL	37	37
Light Socket Conversion	37	37
CFL Fixture	74	74
LED Lamps	34.1	34.1

Collecting additional information will allow PSE to refine the energy savings calculation, as follows:

- **Lamp Wattages.** In interviews with stakeholders, several agencies reported installing 13-Watt, 15-Watt, or 20-Watt CFL lamps; however, agencies must replace incandescent lamps with CFL lamps of corresponding or higher lumens.[49] Additionally, some agency staff reported in interviews that customers' needs may result in higher CFL wattages replaced than CFL equivalents. If agencies record the wattage of replaced lamps and wattage of CFLs or LEDs, energy savings will be more accurate. If baseline wattage is not recorded, Cadmus suggests PSE track RTF calculator updates, as implementation of EISA will impact energy savings beginning in October 2012.
- **Number of Lamps per Fixture.** CFL fixture energy savings are based on an assumption that a fixture contains two lamps. Cadmus suggests PSE record the number of lamps in the fixture, as this impacts energy savings.
- **Hours of Use.** Hours of daily use provide another critical factor in estimating energy savings. This usage often is contingent upon room types where lamps are installed, with different usage assumptions attributed to different room types. Agencies must replace incandescent bulbs that typically operate for three hours of use or more per day.[50] While some agency staff reported following this guideline, other staff indicated replacements were driven by needs of clients, resulting in replacement of bulbs in sockets of potentially lower hours of use. On average, approximately six CFLs were installed per home,[51] according to the participant database provided by PSE, suggesting the lamps were likely installed in high-use areas. However some customers received more than 10 lamps; so hours of use probably are less than three hours (PSE's current assumption) for some lamps.

  The RTF Residential CFL Lighting calculator[52] includes a table of hours of use per room, which could be used to refine the energy savings estimate, if agencies record where lamps are installed; however, these hours of use are not low-income specific. If PSE seeks low-income specific hours of use per room, metering is recommended.
- **In-Service Rates.** Energy savings values are based on an assumed 4% removal rate (applied through the RTF algorithm), which value is specific to a direct install program. As PSE's program provides both direct install and leave behind CFLs, this may not be an appropriate removal rate. Cadmus recommends designing a survey or performing on-site verification to assess an overall program installation rate that takes into account both direct install and leave behind bulbs.

[49] Washington Low-Income Weatherization Manual: http://www.commerce.wa.gov/DesktopModules/CTEDPublications/CTEDPublicationsView.aspx?tabID=0&ItemID=10233&MId=870&wversion=Staging

[50] Washington Low-Income Weatherization Manual.

[51] Calculated for the measure "CFL Screw-In Lamps" using the PSE participant database for single-family and manufactured homes.

[52] The Residential Lighting Calculator can be downloaded from the RTF's website: http://www.nwcouncil.org/energy/rtf/measures/measure.asp?id=141. Version 2 was the most recent version at the time of our review.

Ductless Heat Pump

PSE currently uses the RTF provisional savings value of 3,500 kWh, based on an assumption that ductless heat pumps result in a 55% reduction in energy use. Much uncertainty exists concerning savings for ductless heat pumps, as it is a relatively new residential measure in the U.S., and insufficient research has been done for the RTF to deem savings for this measure. Currently, RTF savings have been provisionally deemed until further data become available. The Bonneville Power Administration, Northwest Energy Efficiency Alliance, and other electric utilities in the Northwest[53] currently are conducting studies to determine a more accurate savings value.

As an alternative to RTF savings, PSE could use an algorithm for calculating energy savings for ductless heat pumps from the Pennsylvania TRM.[54] This algorithm is based on system capacity and efficiency, and full load hours per year, which are weather dependent, and would have to be adjusted for PSE's territory.

Programmable Thermostat

The current PSE savings value for programmable thermostats has been based on the PTR value of 435.8 kWh. The RTF methodology assumes energy savings are 5% of baseline energy consumption for heating. The literature indicates a wide range in savings, from 0% to 12%.[55] Cadmus recommends PSE use the most recently approved RTF savings value of 348 kWh.

Electric Water Heaters

PSE currently uses the RTF savings value of 131 kWh for electric water heaters. Cadmus recommends adjusting some assumptions underlying this value. The energy savings equations for water heaters are shown in Equation 1 and Equation 2 (the same algorithms used by the RTF).

Equation 1: Electric Water Heating Annual Energy Savings

Equation 2: Heat Content of Water Drawn from the Water Heater

[53] http://www.bpa.gov/energy/n/emerging_technology/DHP.cfm

[54] Pennsylvania Public Utilities Commission. Technical Reference Manual: June 2011. State of Pennsylvania Act 129 Energy Efficiency and Conservation Program & Act 213 Alternative Energy Portfolio Standards. http://www.puc.state.pa.us/electric/Act129/TRM.aspx

[55] See the literature review presented within the RTF thermostat v2 calculator on the "Input Assumptions" worksheet.

As agencies only report replacing water heaters that must be replaced, this is not considered an early replacement measure. Cadmus suggests PSE continue to use the 2004 Federal energy code as the baseline efficiency. Other RTF assumptions are based on DOE standard test conditions, specified in the Water Heater Analysis Model (WHAM).[56] These include gallons per day, temperature setpoints on tanks, and incoming water temperatures. Cadmus recommends adjusting these values to reflect data gathered from site visits or surveys for different studies, as cited in Table 36.

Table 36. Water Heater Energy Savings Calculation Recommendations

Variable	RTF Input*	Cadmus Recommended Input	Source for Cadmus Recommendation
EF_{base}	0.921	0.921	2004 Federal Standard for a 45 gal tank
EF_{eff}	0.950	0.950	PSE Program Requirement
RE	0.98	0.98	Recovery efficiency for electric water heater
P_{on} (Btu/hr)	15,354	15,354	Input power for residential-sized water heaters
$HVAC_{int}$	-0.09795	-0.09795	RTF Domestic Hot Water Calculator FY10v2_1
# people	64.3 gal/day	2.3	Participant Survey
Gal / people-day		23	Averaged from various sources: NY TRM, ACEEE, OH TRM, EPA, and others.
T_{tank} (°F)	135.0	126.5	CPUC Residential Retrofit - High Impact Measure Evaluation Report Draft. Dec. 7, 2009. Pg 76. Average temperature set points for two utilities.
T_{in} (°F)	58.0	58.0	RTF DHW Calculator

*The RTF inputs align with the DOE Standard Test Procedure for residential water heaters. However, using these values provides a higher savings than 131 kWh. As values within the RTF calculator were hardcoded, Cadmus could not replicate their calculation.

The recommended inputs reduce annual energy savings from 131 kWh to 105 kWh, primarily driven by adjusting gallons of hot water used per day from 64.3 to 52.9, and tank temperature settings from 135°F to 126.5°F. The 64.3 gpd assumption is a national average, based on a 2.6 person household.[57] The average household size from PSE's low-income program survey is 2.3 people, resulting in decreased water use per day. The tank temperature setting of 126.5°F derives from a CPUC evaluation report, and is based on metered data.[58]

Showerheads

For energy-efficient showerheads, PSE calculated savings, with the majority of inputs based on RTF assumptions and sources. PSE calculated separate savings values for single-family and multifamily homes. PSE also accounted for distributions of homes with more than one showerhead, as shown in Table 37.

[56] Residential Water Heaters Technical Support Document for the January 17, 2001, Final Rule APPENDIX D-2. WATER HEATER ANALYSIS MODEL (WHAM) http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/D-2.pdf

[57] Residential Energy Consumption Survey (RECS) 2005, Table US1. Total Energy Consumption, Expenditures, and Intensities, 2005 Part 2: Household Characteristics

[58] CPUC Residential Retrofit - High Impact Measure Evaluation Report Draft. Dec. 7, 2009. Pg 76. Average temperature setpoints for two utilities.

Table 37: Distribution of Homes by Segment with One and Two Showerheads

Segment	% Homes with One Showerhead	% Homes with Two Showerheads
SF, MH	90%	10%
MF	70%	30%

Energy savings are calculated using Equation 3, and then weighted for distributions of homes with more than one showerhead. After determining Btu savings, this can be converted to kWh by dividing by 3,413, or to therms by multiplying by 100,000.

Equation 3: Energy-Efficient Showerhead Energy Savings Calculation

Table 38 compares PSE's single-family assumptions with values recommended.

Table 38. Showerhead Energy Savings Calculation Recommendations for Single-Family

Variable	PSE Input SF Primary Showerhead	Cadmus Input SF Primary Showerhead	PSE Input SF Secondary Showerhead	Cadmus Input SF Secondary Showerhead
GPM_{base}	2.2	2.8	2.2	2.8
GPM_{low}	1.8	1.8	1.8	1.8
# people	2.51	2.3	2.51	2.3
Min/shower	7.84	7.84	7.84	7.84
Showers/day-person	0.55	0.55	0.28	0.28
Days per year	350	350	350	350
Tshower (°F)	104	104	104	104
Tin (°F)	53.0	53.0	53.0	53.0
RE	0.98	Electric: 0.98 Gas: 0.75	0.98	Electric: 0.98 Gas: 0.75
Wastewater energy savings (kWh/gal)	0.002	0.002	0.002	0.002

Table 39 compares PSE's multifamily assumptions with values recommended.

Table 39. Showerhead Energy Savings Calculation Recommendations for Multifamily

Variable	PSE Input SF Primary Showerhead	Cadmus Input SF Primary Showerhead	PSE Input SF Secondary Showerhead	Cadmus Input SF Secondary Showerhead
GPM_{base}	2.2	2.8	2.2	2.8
GPM_{low}	1.8	1.8	1.8	1.8
# people	1.8	1.8	1.8	1.8
Min/shower	7.84	7.84	7.84	7.84
Showers/day-person	0.55	0.55	0.28	0.28
Days per year	350	350	350	350
Tshower (°F)	104	104	104	104
Tin (°F)	53.0	53.0	53.0	53.0
RE	0.98	Electric: 0.98 Gas: 0.75	0.98	Electric: 0.98 Gas: 0.75
Wastewater energy savings (kWh/gal)	0.002	0.002	0.002	0.002

Upon review, Cadmus suggests using a higher baseline flow of 2.8 gpm, based on two studies. The first was conducted by Enbridge Gas Distribution, Inc., in 2010.[59] This study was referenced in the Ohio TRM as the source for the baseline flow used in determining energy savings. The second study derives from the Iowa Energy Wise Program, where showerhead flow rates were measured in low-income homes, and the average flow was 2.8 gpm.[60] This change to the calculation was the main driver behind the increase in energy savings for this measure. As baseline flow provides an important variable in determining energy savings, Cadmus recommends PSE conduct its own measurements to further refine this variable. In addition, Cadmus adjusted the number of people per home to 2.3, based on participant survey data. The resulting savings using the Cadmus recommended inputs are compared to PSE's current savings values in Table 40.

Table 40. Comparison of Current and Recommended Annual Energy Savings for Showerheads

Segment	PSE Savings (kWh)	Cadmus Recommended Savings (kWh)	PSE Savings (therms)	Cadmus Recommended Savings (therms)
SF, MH	175	426	8.0	18.7
MF	114	299	5.1	13.1

[59] Enbridge Gas Distribution Inc., April 2010; "Demand Side Management 2009 DSM Draft Annual Report", p77-78. Calculated with the average flow rate of units between 2 and 2.5GPM of 2.45GPM, average flow rate of units greater than 2.5GPM of 3.07, and 33% of all units between 2 and 2.5%, 67% of units over 2.5GPM; (2.45*0.33)+(3.07*0.67) = 2.87GPM

[60] The Cadmus Group. Iowa 2010 Energy Wise Program. An evaluation report prepared for Iowa Utility Association. March 2011.

Pipe Insulation

For pipe insulation, PSE uses the RTF value for 3 feet of insulation. Cadmus conducted a literature review and engineering review for pipe insulation as part of an evaluation for EmPOWER Maryland.[61] The engineering review found maximum energy savings of 48 kWh per year. The literature review found only four of 10 sources had deemed savings less than 48 kWh, and these deemed savings values ranged from 20 kWh to 45 kWh, as shown in Table 41.

Table 41. Published Pipe Insulation Values within Maximum Calculated Value

Pipe Insulation Savings Source	Annual Energy Savings (kWh)
Arkansas Deemed Savings	44.00
Michigan Deemed Savings Database R 2	45.00
Vermont TRM	33.00
Northwest Regional Technical Forum	20.00

As much uncertainty exists in energy savings for this measure, Cadmus recommends continuing to use the RTF value.

Refrigerator Replacement

For refrigerator replacement, PSE currently uses energy savings from a study conducted in California. A variety of sources were considered for this evaluation, as summarized in Table 42.

Table 42. Overview of Energy Savings for Refrigerator Replacement

Source	Savings (kWh)	Notes	Reference
PSE	755	From a CA study	
Massachusetts TRM	1,122		Massachusetts Technical Reference Manual: 2011 Program Year. Can be downloaded from: http://www.ma-eeac.org/docs/MA%20TRM_2011%20PLAN%20VERSION.PDF
National Grid Billing Analysis	473	This billing analysis was done after the report that MA referenced in the TRM	The Cadmus Group. Energy*Wise* 2008 Program Evaluation for National Grid. May 2010.
Utah Low-Income Evaluation	1,034 all 416 top mount	Savings based on metering for at least 72 hours. Total sample size was 80 Sample for top mount refrigerators was 19	Cadmus evaluation for PacifiCorp conducted in 2010. Data is not public.

[61] The Cadmus Group, Inc. EmPOWER Maryland 2011 Engineering Review: Residential Retrofits. Presented to Baltimore Gas & Electric, Potomac Electric Power Company, Delmarva Power & Light, Southern Maryland Electric Cooperative, and Potomac Edison. October 2011.

Source	Savings (kWh)	Notes	Reference
Connecticut 2008 TRM	786		UI and CL&P Program Savings Documentation for 2008 Program Year. Can be downloaded from: http://www.ctsavesenergy.com/files/Final%202008%20Program%20Savings%20Document.pdf
Ohio TRM	976		State of Ohio 2010 Energy Efficiency Technical Reference Manual. Can be downloaded from: http://amppartners.org/pdf/TRM_Appendix_E_2011.pdf
WSU Analysis	793	All refrigerator types	Kunkle, R. and Schueler, V. Washington State University Extension Energy Program Evaluation Report for FY2010. WSUEEP11-025. May 2011. Can be downloaded from: http://www.commerce.wa.gov/DesktopModules/CTEDPublications/CTEDPublicationsView.aspx?tabID=0&ItemID=9840&MId=870&wversion=Staging
WSU Methodology	811	Top mount refrigerators only What Cadmus recommends	

Table 42 shows a wide range in energy savings assumptions for refrigerator replacements. Cadmus recently contributed to a study for Washington State to update energy savings for low-income measures of the statewide Weatherization Assistance Program Evaluation.[62] This methodology takes the Savings to Investment Ratio (SIR) into account. However, its methodology included all refrigerator configurations, and Cadmus recommends adjusting the energy-efficient refrigerator to be based solely on top-mount refrigerators, with no added features, per the Low-Income Weatherization Manual. Cadmus further recommends aligning with the Washington State methodology, with a resulting increase in energy savings from 755 kWh to 811 kWh.

Whole House Fans

For ENERGY STAR mechanical ventilation, also called whole house fans, PSE cites correspondence with Panasonic as the basis for the energy savings. Table 43 compares current PSE inputs with inputs Cadmus suggested for this measure.

[62] Kunkle, R. and Schueler, V. Washington State University Extension Energy Program Evaluation Report for FY2010. WSUEEP11-025. May 2011. Can be downloaded from http://www.commerce.wa.gov/DesktopModules/CTEDPublications/CTEDPublicationsView.aspx?tabID=0&ItemID=9840&MId=870&wversion=Staging

Table 43. Current and Recommended Variable Inputs for Whole House Fans

Variable	PSE Current Inputs		Cadmus Recommended
	Whole House Fan	Baseline (ENERGY STAR Bathroom Fan)	Baseline (Bathroom Fan)
CFM/Watt	1.4	6	1.1
CFM	80	80	80
Watts	57	13	71
Hours of Operation	8	8	1
kWh Consumed	167	39	26
Energy Savings	128		0*

*Energy usage increases by 13 kWh using the Cadmus Recommended Baseline, therefore we recommend assigning zero savings.

PSE's method assumes both the baseline bathroom fan and whole house fan operate 8 hours per day. This is an appropriate assumption for new construction homes meeting ventilation requirements; however, this is a retrofit measure. For retrofits, the baseline is a bathroom fan, operated by the occupants (as opposed to a timer), and a reasonable assumption would be the fan runs an hour or less per day. Additionally, Cadmus assumed the retrofit baseline case was less efficient than an ENERGY STAR-rated bathroom fan; thus, the baseline CFM/Watt decreased by 20%. These adjustments resulted in an increase in energy use; therefore, Cadmus suggests this measure be assigned zero savings, and be treated as a health and safety measure.

Smart Strips

PSE currently uses the provisional RTF savings value of 100 kWh, based on a literature review which found savings varied between 38 and 114 kWh per year. Cadmus recently assisted in an engineering review for smart strips for a northeastern utility, calculating average savings of 128 kWh, based on appliance standby power consumption. Based on RTF's literature review and Cadmus' engineering review, PSE should continue to use the provisional RTF savings value for smart strips. Cadmus recommends PSE monitor the RTF's progress with this measure. Current studies are looking at savings from smart strips, and the RTF will be updating the provisional value once these studies have been completed. New savings values will potentially depend on types of smart strips installed (occupancy sensors, load sensors, or timers) and types of equipment (office or entertainment) plugged into the smart strips. PSE may consider collecting additional information if new deemed savings values depend on types of smart strip and types of equipment.

APPENDIX F. PARTICIPANT PHONE SURVEY INSTRUMENT

See attached PDF file.

APPENDIX G. ALTERNATIVE ECONOMIC IMPACT RESULTS

Table 44. Inputs for the Electric and Gas Economic Impact Models

Category	Event Description	Electric	Gas
Program Spending	Agency administrative costs	$932,307	$304,676
	Agency weatherization costs*	$5,283,071	$1,726,495
	Evaluation expenses	$75,059	$75,059
	CTED auditors	$73,950	$28,050
	Utility administrative costs	$486,828	$160,438
Program Costs	Costs to ratepayers: tariff collections	$4,903,960	$1,379,326
	Costs to PSE: shareholder funds and evaluation expenses	$548,860	$206,019
Energy Savings for Participants	Program participants' avoided energy costs	$9,364,700	$762,675
Revenue Loss for PSE	Value of energy payments avoided by program participants before they are recovered in normal rate adjustments	$6,183,444	$487,871

* Analysis assumes costs are allocated between labor (60%) and materials (40%).

Table 45. Electric Economic Impacts Summary for PSE Territory

Impact Type	Employment	Labor Income	Total Value Added	Output
Direct Effect	5.9	$8,843	-$3,464,492	-$2,377,424
Indirect Effect	6	$356,912	$633,747	$1,023,846
Induced Effect*	68.4	$3,692,578	$5,671,235	$8,822,874
Total Effect	80.3	$4,058,334	$2,840,490	$7,469,295

Table 46. Gas Economic Impacts Summary for PSE Territory

Impact Type	Employment	Labor Income	Total Value Added	Output
Direct Effect	7.8	$580,735	$786,715	$1,070,209
Indirect Effect	3.2	$192,191	$333,695	$518,467
Induced Effect*	4.9	$266,133	$408,497	$625,201
Total Effect	16.0	$1,039,059	$1,528,907	$2,213,876

Table 47. Top 10 Industries by Employment Increase Induced by Electric Measures in PSE Territory

IMPLAN Sector	Description	Total Employment	Total Labor Income	Total Value Added	Total Output*
354	Office	30.1	$1,867,437	$3,344,641	$3,344,641
34	Construction	19.8	$1,288,805	$1,548,119	$1,548,119
319	Commercial other	13.3	$1,061,687	$2,052,034	$2,052,034

IMPLAN Sector	Description	Total Employment	Total Labor Income	Total Value Added	Total Output*
394	Ambulatory health care	6.3	$467,522	$504,711	$504,711
320	Dry goods retail	5.4	$196,749	$285,804	$285,804
413	Food services and drinking places	4.2	$89,597	$135,493	$135,493
427	Government and non NAICs	3.7	$280,461	$360,676	$360,676
398	Nursing and residential care	2.7	$97,261	$111,046	$111,046
399	Social assistance	2.5	$70,406	$71,470	$71,470
397	Hospitals	2.3	$183,788	$199,651	$199,651

Table 48. Top 10 Industries by Employment Increase Induced by Gas Measures in PSE Territory

IMPLAN Sector	Description	Total Employment	Total Labor Income	Total Value Added	Total Output
34	Construction	6.6	$428,247	$513,927	$1,043,420
354	Office	5.6	$349,955	$630,369	$861,859
319	Commercial other	3.4	$276,494	$536,605	$818,400
320	Dry goods retail	0.6	$22,334	$32,374	$49,083
427	Government and non NAICs	0.5	$40,033	$50,669	$61,749
394	Ambulatory health care	0.4	$32,912	$35,457	$54,597
398	Nursing and residential care	0.2	$6,735	$7,673	$10,960
399	Social assistance	0.2	$5,144	$5,236	$7,686
153	Nonmetal mineral products	0.1	$5,216	$8,805	$21,777
335	Truck transportation	0.1	$6,384	$7,541	$13,233

Table 49. Comparison of Economic Impacts for Electric Utilities

Consultant	State	Region of Analysis	Years	Ratepayers	Program Type	Output Effect / Costs	Output Effect / Savings	Output Effect per Participant
KEMA/PA	WI	state	2001-2009	Residential	Residential Portfolio	89%	11%	n/a
Cadmus	WA	state	2003-2005	Residential	Low-Income Weatherization	n/a	n/a	$1,470
Cadmus	ID	state	2007-2009	Residential	Low-Income Weatherization	24%	19%	$556
Cadmus	WA	PSE territory	2009-2010	Residential, Commercial, and Industrial	Low-Income Weatherization	109%	80%	$5,826

Table 50. Non-Energy Benefits for Tier 2 Cost-Effectiveness Testing

Non-Energy Benefit	Gas	Electric
Economic Impact	$6,962	$5,826

APPENDIX H. MARKET ASSESSMENT TARGETED CENSUS TRACT ZIP CODES

The tables below provide ZIP code information corresponding to the top 50 census tracts identified through the market assessment. In particular, the ZIP+4s in Table 51 are specific to the complete non-participant sample, while Table 52 provides these details only for those non-participants identified as high-use customers within the top 50 census tracts identified.

Table 51. Top 50 Census Tracts Detail for Complete Non-Participant Sample

TOP 50 Census Tracts	RANKING	ZIP + 4
53061052901	1	982709201, 982704023, 982703315, 982703373, 982703434, 982706217, 982706210, 982706208, 982703851, 982703510, 982702913, 982706205
53053060905	2	984061124, 984061125, 984061407, 984061901
53053073401	3	983724829, 983724621, 983724507, 983725110, 983723955, 983723332, 983724650, 983724036, 983723344, 983724003, 983723958, 983723328, 983723949, 983723347, 983724162, 983724018, 983723960, 983723434, 983726405, 983723924, 983723919, 983723951, 983723921, 983723336, 983723938, 983723417, 983723331
53033010000	4	981081819, 981082185, 981446614, 981082184, 981081618, 981082171, 981446808, 981446522, 981446320, 981081531, 981086103, 981445158, 981446404, 981445923, 981081554, 981082113, 981445908, 981446517, 981445853, 981446426, 981082148, 981445812, 981081435, 981081518, 981081684, 981081683, 981445918, 981081421, 981445731, 981445927, 981446507, 981445156, 981445905, 981445829, 981446402, 981446405, 981445933, 981445735, 981446515, 981445726, 981446325, 981445250, 981446436, 981446607, 981446508, 981446708
53037975402	5	989268779, 989268927, 989268923, 989269652
53033011800	6	981185804, 981185933, 981184710, 981185810, 981184723, 981185742, 981184618, 981185513, 981184128, 981184251, 981184601, 981184734, 981184133, 981184429, 981185713, 981184720, 981184638, 981184747, 981184433, 981185732, 981185712, 981184904, 981184639, 981184649, 981185703, 981185736, 981185824, 981184635, 981185411, 981185529, 981185514, 981184713, 981184406, 981184420, 981184402, 981186004, 981185901, 981185956, 981185420
53033010400	7	981182204, 981082051, 981083033, 981082348, 981183108, 981082904, 981082835, 981083078, 981082956, 981083067, 981082937, 981082118, 981082170, 981083006, 981082117, 981082315, 981082362, 981082938, 981082827, 981083135, 981082137, 981082136, 981083042, 981182629, 981083123, 981083046, 981082035, 981083066, 981182602, 981082837, 981182205, 981081872, 981083108, 981081862, 981082336, 981082908, 981082115, 981082836, 981082334, 981182207, 981081868, 981182625, 981081536
53061041807	8	982045685, 982045687, 982045612, 982047812, 982044860, 982045672, 982044850
53061053503	9	N/A
53033011400	10	981061869, 981062638, 981062208, 981263504, 981062604, 981062648, 981062607, 981061743, 981062328, 981061818, 981263939, 981263710, 981062627, 981062287, 981062383, 981061834, 981061738, 981061858

TOP 50 Census Tracts	RANKING	ZIP + 4
53057952300	11	982736002, 982738454, 982733513, 982735790, 982733505, 982733503, 982738640, 982733514, 982736605, 982735703, 982738623, 982735813, 982733678, 982738624, 982738618, 982733704, 982733640, 982738941, 982732756, 982733025, 982735842, 982738600, 982735867, 982735788, 982738632, 982733018, 982738616, 982738614, 982733051, 982738911, 982739188, 982739101, 982738631, 982733023, 982733511, 982739177, 982732636, 982732742, 982733019, 982733424, 982733006, 982733447, 982739178, 982732741, 982733024, 982733549, 982738980, 982733512, 982735840, 982733616, 982733002, 982739166, 982739434, 982733061
53035092400	12	983663950, 983665847, 983662201, 983662733, 983665733, 983665745, 983665801, 983665735, 983662697, 983665803, 983662730, 983661011, 983665844, 983663418, 983662774, 983665810, 983661735, 983662737, 983663821, 983665819, 983661704, 983665764, 983665843, 983662754, 983665850, 983663820
53057951500	13	982849322, 982841023, 982842124, 982841210, 982841130, 982841555, 982844340, 982848745, 982842001, 982841228, 982841120, 982841221, 982841382, 982844345, 982841172, 982844372, 982848680, 982841404, 982844363, 982841161, 982841559, 982848706, 982848082, 982841159, 982841332, 982841385, 982848731, 982841133, 982841216, 982849387, 982841312, 982848729, 982841262, 982844350, 982848311, 982842016, 982841206, 982849084, 982849615, 982848679, 982847640, 982841131, 982841668, 982847959, 982841403, 982841002, 982842005, 982841322, 982841246, 982848755, 982848733, 982841317, 982849327
53053072106	14	984992110, 984992106, 984992041, 984992042, 984992517, 984984833
53073000801	15	982264251, 982265608, 982268824, 982264340, 982269457, 982269499, 982264421, 982264321, 982268620, 982267803, 982269410, 982267847, 982268801, 982268892, 982268859, 982266612, 982265640, 982268873, 982268883, 982265614, 982265671, 982268895, 982261733, 982265635, 982264402, 982264231, 982264435, 982265633, 982265622
53053071804	16	984994717, 984994716, 984994734, 984998808, 984998341, 984993116, 984995082, 984995095, 984993872, 984998962, 984998959, 984999107, 984998961, 984993870
53053070900	17	984242236, 984243890, 984243823, 984243805, 984243826, 984242130, 984243878, 984242328, 984243874, 984242904, 984242330, 984243824, 984241526, 984242362, 984242338, 984243652, 984243827, 984243875, 984242359, 98424, 984243051
53033000200	18	981254316, 981254114, 981557246, 981254231, 981254120, 981254121, 981254249, 981254333, 981254306, 981253902, 981254338, 981253429, 981253907
53033011000	19	981183765, 981083734, 981083765, 981083781, 981083779, 981083735, 981083124, 981083783, 981183501, 981184031, 981083170, 981083774, 981083902, 981083744, 981083785, 981083643, 981083915, 981083793, 981183226, 981083723, 981184036, 981083764, 981184045, 981083780, 981184107, 981183709, 981083729, 981083726, 981083169, 981083938, 981083715, 981183504, 981184110, 981183227, 981083655, 981183208, 981083789, 981184040, 981083130, 981186456, 981083787, 981184011, 981183503, 981183507, 981183706, 981183527, 981083904, 981083634, 981083926, 981083717, 981083714, 981083917, 981083633, 981083624, 981083658, 981083702, 981186404, 981184060, 981083925, 981083125, 981184024, 981183207, 981083622, 981083618
53041971500	20	985969408, 985969445, 985969464, 985969496

TOP 50 Census Tracts	RANKING	ZIP + 4
53033025801	21	980554219, 980554277, 980555058, 980555303, 980555300, 980554529, 980553359, 980554210, 980555206, 980555785, 980554275, 980555862, 980555770, 980555106, 980555302, 980555911, 980555031, 980554507, 980555308, 980557401, 980555026, 980557173, 980555119, 980555933, 980554520, 980553324, 980554278, 980555111, 980554205, 980554357, 980555071, 980555917, 980555904, 980555908, 980555221, 980554255, 980555466, 980554360, 980555267, 980555228, 980555915, 980553360, 980555015, 980555960, 980555092, 980555726, 980555134, 980553309, 980555605, 980555965, 980555254, 980553364, 980555231
53053073403	22	983714233, 983715167, 983714137, 983713812, 983715279, 983714132, 983714144, 983716546, 983713921, 983715350, 983715291, 983715219, 983714004, 983713992, 983714227, 983713967, 983715086, 983713860, 983713827, 983714010, 983714358, 983714218, 983714006, 983715139, 983714104, 983714255, 983714083, 983713454, 983714070, 983714069, 983714305, 983715133, 983722933, 983725008, 983714026, 983714053, 983715259, 983715218, 983714808, 983714117, 983722925, 983713882, 983715242, 983715265, 983725004, 983714224, 983713801, 983723048, 983712302, 983715129, 983715292, 983715113, 983714141, 983715294, 983714012, 983714319, 983713824, 983713419, 983714027, 983714251, 983715189, 983713933, 983714248, 983723063, 983713437, 983713576, 983712303, 983722928, 983713429, 983713411, 983713844, 983713438, 983714050, 983713422, 983714065
53033011900	23	981782100, 981782340, 981782538, 981782849, 981783053, 981782866, 981782264, 981782829, 981782158, 981782851, 981782406, 981782253, 981782436, 981782822, 981782358, 981782228, 981185820, 981782150, 981782416, 981185834, 981185835, 981782310, 981782117, 981782334, 981782110, 981782415, 981782262, 981782808, 981782314, 981782261, 981782229, 981782411, 981782435, 981782855, 981782330, 981782835, 981782320, 981782456, 981185906, 981782443, 981782418, 981782611
53073000200	24	982261214, 982258508, 982269229, 982488916, 982258454, 982268311, 982269173, 982261747, 982269056, 982267394, 982251117, 982267233, 982269008, 982251121, 982258529, 982251576, 982258403, 982269635, 982269055, 982269230, 982251139, 982267619, 982258528, 982258512, 982258448, 982488930, 982251115, 982256975, 982258410, 982261232, 982269236, 982269109, 982251103, 982258523, 982258531, 982269006, 982251113, 982488921
53033010100	25	981181452, 981181101, 981181116, 981181105, 981181307, 981447103, 981181319, 981447123, 981081602, 981181232, 981181352, 981181138, 981446829, 981181543, 981447104, 981181109, 981081608, 981181107, 981181302, 981181112, 981181325, 981181214, 981181462
53033001200	26	981338512, 981256308, 981257502, 981256429
53053071602	27	984458086, 984456408, 984458082, 984453917, 984458067, 984453911, 984445512, 984453910, 984458080, 984455530, 984457727, 984458060, 984454018, 984458085, 984453109, 984457728, 984452090, 984446542
53057952400	28	982748753, 982745133, 982748720, 982746198, 982734929, 982749411, 982743030, 982743017, 982746122, 982744609, 982744429, 982748406, 982744723, 982744649, 982744026, 982744037, 982734310, 982748714, 982744426, 982748994, 982748620, 982744433, 982748711, 982745141, 982745124, 982744016, 982745156, 982748938, 982748604, 982745122, 982744619, 982745316, 982746015, 982734955, 982749438, 982744734, 982744621, 982748606, 982746110, 982744612, 982745125, 982744775, 982748992, 982749108, 982744551, 982744428, 982744774, 982734946, 982748995, 982745118, 982748996, 982734937, 982734932, 982748429, 982744747, 982734940, 982745313, 982744617, 982744008, 982748988, 982745012, 982744403, 982734925, 982734311, 982744705, 982744713, 982734933
53053071000	29	984432248, 984044160, 984432729, 984432703, 984432708, 984432212, 984432530

TOP 50 Census Tracts	RANKING	ZIP + 4
53061040200	30	982015202, 982011919, 982011939, 982011233, 982011944, 982011903, 982011907, 982011918, 982011938, 982011238, 982011239
53033003200	31	981264218, 981072401, 981176107, 981072566, 981074117, 981175827, 981072552, 981175828, 981176119
53061051400	32	980367511, 980367506, 980367517, 980367505, 980366328, 980366319
53033001700	33	981033132, 981339213, 981172110, 981172008, 981173301, 981173036, 981173130, 981774901, 981172011, 981339133, 981173127, 981172201, 981339118
53033022801	34	980073221, 980051023
53073000900	35	982256058
53073000100	36	982268100, 982267731, 982267946, 982267710, 982265505, 982268087, 982268712, 982265615, 982261201, 982267132, 982267145, 982268745, 982267858, 982267719
53061041903	37	982041448, 982041444, 982041492, 982041561
53033029503	38	N/A
53041970400	39	985313448, 985315317, 985315437, 985314428, 985315333, 985315038, 985314420, 985315530, 985315529, 985313357, 985315009, 985315010, 985314753, 985315507, 985315331, 985314921, 985315448, 985313420, 985315441, 985315449
53073001100	40	982255815, 982257723, 982257715, 982256617, 982257820, 982256128, 982256125
53053063400	41	984086005, 984085228, 984085424, 984042046, 984446451, 984085310, 984446250, 984085221, 984042092, 984041059, 984041030, 984446454, 984446465, 984452188, 984087106, 984085217, 984041018, 984085419, 984085413, 984446215, 984042091, 984446208, 984085307, 984085314, 984041063, 984085220, 984452208, 984085308, 984087102, 984452224, 984085422
53037975100	42	989221327, 989221023, 989221152, 989221144, 989221256, 989221143, 989229639, 989221037, 989221402, 989221025, 989221026, 989221255, 989229647, 989221208, 989229672, 989221253, 989221020, 989221049, 989221138, 989221215, 989221006, 989221050, 989229761, 989221419, 989221031, 989221061, 989221234, 989221015, 989229603, 989221363, 989221320, 989221206, 989221212, 989221301, 989221141, 989221400, 989221233, 989221083, 989221306, 989221007, 989221139, 989221229, 989221142, 989221041, 989221376, 989221364, 989221370, 989221302, 989229401, 989221254, 989221117, 989221236, 989221055, 989221033, 989229702, 989221004, 989221304, 989229631, 989221252, 989221118, 989221221, 989229745, 989221140, 989221334, 989221128
53053072306	43	984666645, 984672224, 984666611, 984664928, 984674799, 984672201, 984672110, 984091201, 984674937
53033010300	44	981181916, 981182714, 981186125, 981181706, 981181871, 981186130, 981182842, 981182637, 981182420, 981181930, 981186126, 981182638, 981182260, 981182608, 981181701, 981182258, 981181857, 981182215, 981181724, 981182007, 981182408, 981181725
53033009500	45	981443746, 981443709, 981444915, 981446852, 981446019, 981446121, 981443700, 981444713, 981444910, 981443825, 981445553, 981443941, 981444616, 981446122, 981447015, 981446110, 981443879, 981445527, 981443915, 981443939, 981443917

TOP 50 Census Tracts	RANKING	ZIP + 4
53035090500	46	983706207, 983708771, 983707322, 983706320, 983708331, 983708733, 983708595, 983707433, 983709034, 983709705, 983709219, 983709169, 983708783, 983708577, 983708302, 983708721, 983709170, 983708486, 983708773, 983708759, 983707048, 983708757, 983708538, 983707131, 983709163, 983707468, 983709033, 983709160, 983708256, 983706202, 983708729, 983709081, 983709162, 983707363, 983708528, 983707130, 983709164, 983709043, 983708402, 983707565, 983707567, 983707564, 983708475, 983708718, 983708779
53053072309	47	984662918, 984662530, 984662121
53053073200	48	N/A
53053072505	49	983329748, 983328051, 983327900, 983328649, 983328740, 983328819, 983329120, 983327807
53033031400	50	980223783, 980222265, 980223711, 980222704, 980222642, 980223307, 980223319, 980228490, 980223338, 980222422, 980222331, 980222814, 980228311, 980222427, 980222733, 980223526, 980223411, 980222809, 980228647, 980222423, 980226458, 980222200, 980222256, 980223302, 980223328, 980222257, 980223510, 980223331, 980228651, 980223339, 980222825, 980229289, 980222210, 980222631, 980223445, 980222641, 980223614, 980223340, 980222724, 980223329, 980223727, 980222627, 980223717

Table 52. Top 50 Census Tracts Detail for Only High-Use Non-Participants

TOP 50 Census Tracts	RANKING	ZIP + 4 (>10 kWh/sqft only)
53061052901	1	N/A
53053060905	2	N/A
53053073401	3	983723951, 983723955, 983723921, 983723336, 983723938, 983723417, 983723331
53033010000	4	N/A
53037975402	5	989268923, 989269652
53033011800	6	N/A
53033010400	7	N/A
53061041807	8	N/A
53061053503	9	N/A
53033011400	10	N/A
53057952300	11	982739177, 982732636, 982732742, 982733019, 982733424, 982733006, 982733447, 982739178, 982732741, 982733024, 982733549, 982738980, 982733512, 982735840, 982733616, 982733002, 982739166, 982739434, 982733061
53035092400	12	983662737, 983663821, 983665819, 983661704, 983665764, 983665843, 983662754, 983665850, 983663820
53057951500	13	982848311, 982842016, 982844345, 982841206, 982849084, 982849615, 982848679, 982847640, 982841131, 982841668, 982847959, 982841403, 982841404, 982841002, 982842005, 982841322, 982841246, 982848755, 982848733, 982841317, 982849327
53053072106	14	N/A

TOP 50 Census Tracts	RANKING	ZIP + 4 (>10 kWh/sqft only)
53073000801	15	982264402, 982264231, 982264435, 982265633, 982265622
53053071804	16	N/A
53053070900	17	N/A
53033000200	18	N/A
53033011000	19	N/A
53041971500	20	N/A
53033025801	21	980553309, 980555111, 980555605, 980555965, 980555254, 980555267, 980553364
53053073403	22	983714319, 983713824, 983713419, 983714027, 983714251, 983715189, 983713933, 983714248, 983723063, 983713437, 983713576, 983712303, 983722928, 983713429, 983713411, 983713844, 983713438, 983714050, 983713422, 983714065
53033011900	23	N/A
53073000200	24	982251113, 982269236, 982258512, 982488921
53033010100	25	N/A
53033001200	26	N/A
53053071602	27	N/A
53057952400	28	982749108, 982744551, 982748604, 982744428, 982744774, 982734946, 982748995, 982748994, 982745118, 982748996, 982734937, 982734932, 982748429, 982744747, 982734940, 982745313, 982744617, 982744008, 982744016, 982748988, 982745012, 982744403, 982734925, 982734311, 982744705, 982744713, 982734933
53053071000	29	N/A
53061040200	30	N/A
53033003200	31	N/A
53061051400	32	N/A
53033001700	33	N/A
53033022801	34	N/A
53073000900	35	N/A
53073000100	36	982267719
53061041903	37	N/A
53033029503	38	N/A
53041970400	39	N/A
53073001100	40	N/A
53053063400	41	N/A

TOP 50 Census Tracts	RANKING	ZIP + 4 (>10 kWh/sqft only)
53037975100	42	989221031, 989221061, 989221025, 989221234, 989221015, 989229603, 989221363, 989221320, 989221206, 989221212, 989221144, 989221301, 989221141, 989221400, 989221233, 989221083, 989221306, 989221007, 989221139, 989221229, 989221142, 989221041, 989221376, 989221364, 989221370, 989221302, 989229401, 989221254, 989221117, 989221419, 989221236, 989221055, 989221033, 989229702, 989221004, 989221304, 989229631, 989221252, 989221118, 989221221, 989229745, 989221140, 989221334, 989221128
53053072306	43	N/A
53033010300	44	N/A
53033009500	45	N/A
53035090500	46	983707564, 983708475, 983708718, 983708779
53053072309	47	N/A
53053073200	48	N/A
53053072505	49	N/A
53033031400	50	980226458, 980222200, 980222256, 980223302, 980223328, 980222257, 980223510, 980223331, 980228651, 980223339, 980222825, 980229289, 980222210, 980222631, 980223445, 980222641, 980223614, 980223340, 980222724, 980223329, 980223727, 980222627, 980223717

Evaluation Report Response

Program: Low Income Wx

Program Manager: Sandra Sieg

Study Report Name: PSE 2012 LIW Evaluation Report

Report Date: 4/16/2012

Evaluation Analyst: Bobette Wilhelm

Date ERR Provided to Program Manager: 4/23/2012

Date of Program Manager Response: 5/7/2012

Please describe in detail, action plans to address the evaluation study's key findings and recommendations.

Overview:
The PSE 2012 LIW Evaluations Report captures four assessments performed by Cadmus:

- Non-Energy Related Benefits
- Market Evaluation
- Process Evaluation; and,
- Savings Review

The report highlights program challenges and provides some solutions. The focus of this ERR is on a list of actions PSE may take to address those challenges, with particular focus on the results of the process evaluation.

Action Plan:

Non-Energy Related Benefits (NEBs)

The Evaluation recommended that PSE apply NEBs data to its cost effectiveness tests on a incremental basis

PSE Action 1: PSE may apply the results of this analysis to determine the program impact to the TRC Electric and Gas programs. The earliest PSE would do so would be Fall 2012 in preparation for 2013 production. PSE will follow the guidance of the analysis by adding quantified benefits on an incremental basis. (Those easily quantified added first, with those more difficult to quantify added last.)

Market Evaluation

The market evaluation highlighted areas in the PSE service territory where the program has had little reach and where high energy users reside.

PSE Action 1: PSE will take this information into account and will share it with agencies when needed. PSE has launched a working group to identify ways to optimize PSE program delivery. The "hot spots" listed in the market evaluation may provide PSE and its partnering agencies guidance on where the LIW program can target its efforts.

Process Evaluation

For the process evaluation piece, the Cadmus study highlighted potential program problems (listed below) and recommended solutions (listed below). For each problem and recommended solution, PSE has identified actions it will take in response. At the end of this ERR is a table summarizing all PSE actions that will be taken in response to the Cadmus study.

Problem 1:

Single Family homes are often turned down for the program because they have too many health and safety issues that require significant repairs before weatherization measures can be installed. With limited funding for these measures, agencies often are often unable to incorporate weatherization measures resulting in missed opportunity.

Study Recommendation 1:

PSE has already started addressing this issues. Increasing PSE's health and safety and repairs budget provided a positive change for the program, from both utility and agency staff perspectives. This appeared to reflect PSE's goals in better serving its low-income customers from a total-benefits standpoint, while helping agencies weatherize more homes that would have been turned away under standard funding sources.

Continue to fund health and safety.

PSE Action 1:

PSE will retain its policy that:

For those funds that must meet a cost-effectiveness standard, up to 30 percent may be applied to energy-related repairs that are necessary to effect the installation of other cost-effective measures while maintaining overall program cost-effectiveness.

Completion Date: Ongoing

Problem 2:

Despite state implementation protocols, variations appeared between agencies—and potentially agency staff—regarding installation procedures (e.g., CFLs, energy-efficient showerheads). Variations also appeared in types of measures offered through the agencies (e.g., refrigerator replacement).

- This lack of standardization presents two potential impacts.

- First, deviation from direct installation of CFLs or other low-cost measures calls into question the application of deemed savings estimates that assume direct installation.
- Second, due to agency policies, cost-effective, high-savings measures, such as refrigerator replacements, are not being considered for installation in some cases. This prevents an opportunity to achieve cost-effective energy savings, as it is unlikely these savings will be achieved through other energy programs.

Study Recommendation 2:

a. Work with stakeholders to standardize delivery.

   Standardizing specific measure offerings (e.g., refrigerator replacements) and installation protocols (e.g., direct install CFLs)

b. PSE should work with directly with agencies, and potentially with Commerce and the Energy Project, to determine barriers to changing certain delivery aspects discussed in the program findings.

c. For some measures, such as refrigerator replacements, PSE should make it clear to agencies that their customers can use our free replacement program.

d. For other measures, such as energy-efficient showerheads affecting domestic water heating, increased client and agency education may prove beneficial.

   Cadmus evaluation research has found variations in satisfaction surrounding different types or brands of energy-efficient showerheads offered through programs.

   A specific brand of showerhead used by agencies may be associated with lower customer satisfaction. Working with agencies to identify high-quality brands could address this barrier.

   Regarding wage regulations that require plumbers for water-heating related installations, this may be a misconception of the particular agency that reported this concern, or it may be a genuine barrier to delivery; if the latter, it should be discussed with Commerce policy makers.

e. Work with stakeholders to standardize low-cost measure bundles for initial home inspections.

Regarding low-cost kit bundles, PSE did not appear to fund these measures directly. This could be a collaboration area between agencies and PSE. Standardizing delivery, so all customers receive low-cost measure bundles (including CFLs, aerators, etc.) upon initial inspection, would ensures even PSE customers not qualifying for full weatherization would receive some energy-savings benefits. If PSE covered partial kit costs for customers, agencies not currently offering them in this manner may be encouraged to do.

Study Recommendation 2:

PSE has formed a workgroup with agency representatives to identify opportunities to optimize LIW program delivery. Part of this effort has been to identify a list of "optimal" measures and to identify minimum requirements for those measures. This is a different approach to that of the past when PSE deferred to Commerce policies and

procedures for program delivery. In contrast, PSE is working directly with agencies to negotiate measures and minimum requirement, thus ensuring agency ownership and buy-in. The collaborative process will spot light requirements and PSE expectations, thus increasing program consistency during delivery. PSE will present these findings and proposed solutions to the workgroup and will address them throughout work group effort.

Completion Date: The workgroup effort is scheduled for completion at the close of 2012 with full implementation in the 2014-15 tariff cycle.

Problem 3:

WA State Prevailing Wage.

All agencies interviewed cited Washington's state prevailing wage laws as a concern, posing a barrier to delivering a wider range of measure installations (e.g., energy-efficient showerheads), and to delivering the same holistic program approach in a cost-effective manner. Wage rates were reported as making some measures too expensive to install.

Study Recommendation 3:

PSE should consider increasing funding because of these laws.

PSE Action 3:

Through the work group effort, PSE is addressing measure cost and program support costs to analyze a mechanism whereby agencies can pay for optimal measures without the need to leverage other State funding, thus eliminating the requirement for prevailing wage. With regard to this specific solution, this by default may result in increased funding for LIW. In this situation, agencies would retain the discretion to leverage other State/Federal funds with PSE and therefore pay prevailing wage.

Completion Date: The workgroup effort is scheduled for completion at the close of 2012 with full implementation in the 2014-15 tariff cycle.

Problem **4:**

DOE and Washington state protocols list high energy consumption as a factor allowed in participant prioritization, agencies have not been able to integrate this criterion.

Possible reasons for this barrier include a lack of access to PSE billing data

Study Recommendation 4:

a. Consider working with agencies to integrate high-energy consumption as prioritization criteria.

b. As high-consumption is a prioritization criterion approved under federal weatherization program and state guidelines, agencies do not appear to have the means to easily incorporate this into their targeting. Details of this arrangement would need to be discussed among stakeholders; however, PSE should be able to work with the agencies to either provide usage data or to actually calculate energy intensities (i.e., annual weather-normalized energy consumption per square foot), which agencies could then incorporate into their prioritization calculations.

c. By targeting customers with high-energy consumption, not only will these participants realize higher energy savings, but will be relieved of the disproportionate burden of their energy bills due to abnormally high usage. While calculating energy intensity controls for home size, other analyses can be performed to incorporate effects of other demographic indicators on high usage (e.g., number of people per household, household income, poverty level).

PSE Action 4:

PSE will take these recommendations into consideration in the same work group effort described above as a mechanism to optimize program delivery.

Completion Date: The workgroup effort is scheduled for completion at the close of 2012 with full implementation in the 2014-15 tariff cycle.

Problem 5:

Tribal Participation:

While PSE has offered some past programs within tribal lands, revisiting program delivery to these customers and overcoming previous delivery barriers will be important, as these areas represent significant opportunities to address both high-need customers and to achieve energy savings.

Study Recommendation 5:

a. Explore options for delivering weatherization to tribal areas within PSE's territory.

   PSE should work with program stakeholders as well as other utilities and regional entities to explore ways to overcome some past delivery barriers.

b. One approach would be working with the Bonneville Power Administration to leverage its contacts or experience in tribal outreach.

c. Another approach might involve soliciting assistance from tribal organizations or communities themselves. For example, Native American contractors may be available that PSE or agency staff could work with to deliver the program.

d. Another approach, recently utilized by a BC Hydro energy-education program, would be to contract with college-age Native Americans to work within the community to increase marketing, program awareness, and solicit participation.

e. Finally, PSE may want to consider the elimination of income eligibility requirements for tribal participants, particularly if verifying income eligibility has been difficult in previous program experience.

PSE Action 5:

PSE LIW staff has met internally with PSE staff in energy education and energy efficient communities to start a process to vet existing PSE relationships, including those outside of Customer Solutions (i.e., CRMs and Major Accounts) and to leverage those relationships. The group will continue to meet through 2012 to develop a strategy to build trust with this

community and to delivery energy efficiency to Tribes. The solutions listed above will be taken into consideration and may or may not be relevant to this PSE effort.

Completion Date: The internal group will leverage existing relationships in 2012 and agree to a strategy in 2013 with full implementation in the 2014-15 tariff cycle.

Problem 6:

Lower state and federal weatherization budgets, along with increased labor costs due to state wage requirements, potentially could change PSE's impacts associated with this program. Higher wage rates will result in PSE covering lower percentages of measure costs, while diminished state and federal funding will mean fewer opportunities for leveraging funding among program sponsors.

If all these funding scenarios materialize, there are likely two ways the program can go in the future, with neither option particularly desirable. Depending on agency production goals, the program may be restructured to focus on cheaper, easier-to-install measures or agencies could continue with comprehensive treatment, though seeking to complete fewer homes. In either case, associated savings relative to PSE funding may decrease.

Study Recommendation 6:

Work with all the key stake holders on a future solution. Discussing these issues with all stakeholder groups may reveal actions PSE can take to optimize the program, given a new delivery orientation. For example, increasing the proportion of clients with high energy intensity through better targeting may better achieve PSE objectives and meet energy-savings goals. PSE should be able to leverage the positive relationships they have cultivated with agencies to foster open conversations on this topic.

PSE Action 6:

The PSE work group effort to optimize program delivery directly addresses this problem and embraces the recommended solution via its commitment to a collaborative process with the agencies to target optimal measures and to quantify measure and program support costs.

Completion Date: The workgroup effort is scheduled for completion at the close of 2012 with full implementation in the 2014-15 tariff cycle.

Problem 7:

Agencies could not spend all of the PSE dollars they had because of other funding like ARRA

Study Recommendation 7:

a. PSE should continue working with agencies to identify potential, unspent funding, which can then be reallocated to agencies with greater potential for spending within a program year. As the Energy Project also works with agencies to track reasonable production estimates, this may offer a favorable opportunity for collaboration.

PSE Action 7:

PSE will continue to work with agencies to ensure budget spent out, paying particular attention to unspent funds that remain in the budget at the beginning of 4th quarter.

Completion Date: September/October 2012.

Communication

Communications between PSE and agencies appears very effective, as noted. All agencies interviewed cited PSE program staff as very responsive, helpful, and in-tune with agency needs and objectives.

PSE assuming a role in contracting directly with the agencies appears to have resulted in a understanding of the program and a desire for collaboration, regarding energy-saving objectives as well as in identifying participant and agency needs, and delivering a program seeking to aid underserved populations beyond just energy savings.

Study Recommendations:

Keep up the good work.

PSE Action 1:

Okay, will do.

Completion Date: Not Applicable

Program Tracking

Agency satisfaction with PSE's LIW Online System reporting tool indicates the system works well for both small and large agencies, and is not overly burdensome.

Study Recommendations

Consider collecting additional input assumptions for calculating more robust savings estimates. Since this isn't a burdensome tool, it might provide good information.

While the Savings Review section of report also offers this recommendation, the LIW Online System can track additional inputs to improve the deemed energy-saving estimates for PSE to calculating program savings. Additional information easily can be collected by agencies while on-site, with many appearing to be willing to provide PSE more data upon request. For example, determining types and efficiency levels of heating and cooling equipment will help refine savings assumptions for shell measures (e.g., insulation, infiltration controls, windows) installed by an agency.

PSE Action 1:

PSE will address these recommendations after the PSE Workgroup agrees on a program model for optimizing program delivery. Based on final program design, PSE will determine the appropriate mix of data to collect from agencies on a per unit basis.

Completion Date: Fall 2013

Quality Assurance and Control

Problem 1:

None: Problems or issues did not arise regarding PSE's monitoring efforts alongside Commerce. Agencies did not appear to find requirements excessively onerous, Commerce had no opinion on the issue, and PSE appeared to appreciate the opportunity for on-site, first-hand program experience.

Solution:

Between PSE's monitoring 15% of its completed weatherization projects, and Commerce monitoring 20% (as of 2009), sufficient quality assurance activities appear in place.

Keep doing the same thing you are doing.

PSE Action 2: Not applicable.

Participant Findings

When benchmarking awareness of utility contributions to other programs, PSE's participants ranked among higher levels of awareness of utility sponsorship (45%).

With nearly 80% (n = 12) of participants receiving program thermostats and setbacks reversing set-points to pre-project levels, increased education surrounding temperature settings may be required. These participants may need to better understand how to use these thermostats' programmable functionality to maintain temperatures at more reasonable levels during primetime occupancy. Alternatively, agencies may need to work more closely with participants to determine appropriate setback levels.

Problem 1:

A significant portion of PSE's participants (43%) reported using secondary heating sources, including 18% indicating use of electric room heaters. This impacts Savings.

Solution 1:

- Gather secondary heat source to assist in explaining or refining energy savings calculations.
- Work with agencies to increase education surrounding use of secondary heat sources.

  Due to the large number of participants still using secondary heat sources (particularly electric room heaters), PSE should consider ways to increase awareness to reduce use of potentially inefficient heating systems. A few actions might include working with agencies to highlight this issue, and including specific information about electric room heater usage in the energy-education curriculum.

PSE Action 1:

PSE will work with agencies to better educate customers on the use of secondary heat sources via the PSE Newsletter.

Completion Date: Summer/ Fall Newsletter 2012.

Problem 2:

Many customers reported changing thermostat set points after the agency left. These were for thermostat replacement or turn-down customers.

Solution 2:

a. Increase education surrounding thermostat setbacks to increase persistence.

b. The high number of participants resetting thermostat indicates a need for more education surrounding temperature settings.

c. While the survey did not probe to determine whether or not customers used programmable settings to increase temperature only for specific periods, or if increases were for constant, 24-hour temperature settings, participants apparently are not always satisfied with levels set by agency staff. PSE should convey this finding to contractors, and discuss methods for increasing emphasis on setting controls to allow for comfortable temperatures, while simultaneously taking advantage of programmable settings to reduce heating during lower occupation periods.

d. Additionally, a PSE-developed sticker or refrigerator magnet with energy-saving tips could emphasize the importance of thermostat setbacks, either in terms of operational information, or through dollar savings associated with average setbacks (e.g., 72 F to 68 F).

PSE Action 2

PSE will work with agencies to determine a strategy for addressing this issue (i.e., requiring that agencies complete in unit education on any unit where thermostats have been installed. However, in the current program the potential of this measure is limited only to electronic thermostats in SF dwellings. Otherwise installed thermostats is a SH or a TE repairs measure for which PSE does not take savings.

Completion Date: Low Priority—Although can be addressed along with secondary heating source education in the Summer/Fall Newsletter.

Participant Non-Energy Benefits

PSE participants reported a perceived value associated with each non-energy benefit asked about through the survey.

The percentage of PSE participants identifying these benefits were equal or higher, in many cases, than those of the other studies cited in comparison.

Though non-energy benefits PSE participants cited have been valued in various studies (some of which have been listed in the non-energy benefit literature review performed for this project), many of these exhibit a wide range of values, making it difficult to isolate a single, defensible value to use for claiming additional program benefits.

Recommendations

a. Consider exploring more detailed research in valuing some participant non-energy benefits.

While this study explores certain non-energy benefits in some depth (i.e., payments and economic impacts), if PSE is interested, opportunity exists to perform additional research to develop more robust values for some participant non-energy benefits. Such other benefits include: dollar savings attributed to improved health; reduced forced mobility; increased home property values; and others (see the literature review for a full list). This research would require analysis of additional data sources (e.g., assessor data, medical costs) as well as further in-depth participant interviews.

PSE Action 1:

PSE is not committing to additional research on Low Income NEBs at this time.

Energy-Saving Education

Problem1:

There are a few items provided in the LIW program which seem to be misused or not used by participating households.

Education apparently needs to be increased regarding: use of secondary heating sources (e.g., electric room heaters); thermostat programming and setback; and, potentially, energy-efficient showerheads (based on comments from an agency staffer).

Solution 1:

a. Focus energy education on actions resulting in high-energy savings.
b. Placing a greater emphasis on reducing heating set-points and reducing hot water use.
c. For areas of need, target energy education to increase awareness.
d. effective targeting may include developing PSE-specific materials, such as stickers or refrigerator magnets. Additionally, working with agencies to highlight areas for improvement could help address certain topics.

PSE Action 1:

In its workgroup effort to optimize program delivery, PSE will work with the agencies to address when and if education is required prior to and after measure installation. Insofar as timing, this issue will be addressed when PSE and the agencies define minimum requirements for measures and will consider incorporating education as a minimum requirement prior to reimbursement for the measures listed above--showerheads, in particular.

Completion Date: The workgroup effort is scheduled for completion at the close of 2012 with full implementation in the 2014-15 tariff cycle.

Date of Program Actions: Summary

PSE Action	Section	Problem #	Completion Date
Add NEBs data to the TRC cost effectiveness test for Low Income electric and gas programs	Non Energy Related Benefits (NEBs)	1	Fall 2012 at the earliest
Address Program Consistency via PSE Workgroup Effort	Process Evaluation: Program Delivery	2	12/2012 (workgroup) 1/2014 (implementation)
Analyze /Measure and Program Support Costs	Process Evaluation: Program Delivery	3	12/2012 (workgroup) 1/2014 (implementation)
Integrate high-energy consumption as prioritization criteria.	Process Evaluation: Program Delivery	4	12/2012 (workgroup) 1/2014 (implementation)
Tribal Participation	Process Evaluation: Program Delivery	5	2012 (ongoing, leverage existing relationships) 2013 (develop strategy) 1/2014 (full implementation)
Work with key stakeholders to optimize program	Process Evaluation: Program Delivery	6	12/2012 (workgroup) 1/2014 (implementation)
Work with agencies to identify potential, unspent funding,	Process Evaluation: Program Delivery	7	10-11/2012
Determine the appropriate mix of data to collect from agencies on a per unit basis	Process Evaluation: Program Tracking	1	Fall 2013
Work with agencies to better educate customers on the use of secondary heat sources	Process Evaluation: Participant	1	Fall 2012 (pse newsletter)

	Findings		
PSE will work with agencies to determine a strategy for addressing thermostat setback	Process Evaluation: Participant Findings	1	Low Priority but can address Fall 2012 (pse newsletter)
Consider incorporating education as a minimum requirement prior to reimbursement for showerheads in particular	Process Evaluation: Energy-Saving Education	1	12/2012 (workgroup) 1/2014 (implementation)

Savings Review

The savings review did provide some insight to LIW specific savings values, stopping short of providing actual savings values for LIW which are different from those claimed by our Single Family Weatherization Program (RTF). Because we rely on RTF savings values, we see no compelling reason for PSE to pursue additional investment in quantifying energy savings that are more specific to low income structures outside of the RTF. PSE will speak with the RTF about the possibility of completing LIW specific savings values, data required from regional utilities to facilitate these estimates, and we will work within the direction of the RTF in this matter.