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Memorandum

To: **Lauren Gage (Bonneville Power Administration)**

From: **Bill Provencher, Jenny Hampton (Navigant)**

Copy: **Andrew Miller, Summer Goodwin (Bonneville Power Administration); Matt Babbits, Larry Blaufus, and Debbie DePetris (Clark Public Utilities District); Jane Pater Salmon (Navigant)**

Date: **October 202015**

Re: **Clark Public Utilities Home Energy Reports Program Evaluation Final Report**

This report presents Navigant's evaluation of the Clark Public Utilities District's (PUD's) Home Energy Reports (HER) program and includes the following sections:

I. **Executive Summary.** Includes a short description of the Clark PUD HER program and a summary of the evaluation's key findings.
II. **Introduction.** Includes a detailed description of the Clark PUD HER program and a summary of the evaluation objectives.
III. **Verification of Randomized Control Trial.** Describes the analysis Navigant conducted to confirm the assumption that the HER is implemented as a randomized control trial, as well as the verification results.
IV. **Program Impacts.** Describes the data used in the impact analysis, the impact evaluation methodology, and the evaluation results.
V. **Estimating Joint Savings with EE Programs.** Describes Navigant's estimates of joint savings between the HER programs and other EE programs offered by Clark PUD.
VI. **Key Findings and Recommendations.** Summarizes the key findings and associated recommendations.

I. Executive Summary

This executive summary includes a short description of the Clark PUD HER program and a summary of the evaluation's key findings.

Program Description

Clark PUD's HER program generates energy savings by providing residential customers with sets of information about their specific energy use and related energy conservation suggestions and tips. The

program sends Home Energy Reports that give customers various types of information, including: a) how their recent energy use compares to their energy use in the past; b) tips on how to reduce energy consumption, some of which are tailored to the customer's circumstances; and c) information on how their energy use compares to that of neighbors with similar homes. In other studies, this type of information has stimulated customers to reduce their energy use, creating average energy savings in the 1% to 2% range, depending on local energy use patterns.

Clark PUD implemented the HER program in September 2012. This report presents the impact analysis for the first two years of the program. Year 1 covers the period September 2012-August 2013, and Year 2 covers the period September 2013-August 2014.

Key Findings

Table 1 presents the impact evaluation results. Key findings include:

1. Navigant verified that the assignment of customers to the treatment and control groups is consistent with a randomized controlled trial (RCT).
2. Table 1 summarizes the program savings. On average, participants reduced their electricity usage by 1.90% in Year 1 and 2.23% in Year 2. The weighted average savings across the two years is 2.07% per customer. Total savings before subtracting joint savings with other energy efficiency programs, referred to as the "uplift adjustment," are 8,115 MWh in Year 1, 9,497 in Year 2, and 17,623 for the two-year program period. Annualized savings are the average of the two-year program savings. By comparison, the percent savings estimates provided to Clark PUD by Opower are 1.76% for Year 1, 2.20% for Year 2, and 1.98% for the two year program period. Total estimated savings provided by Opower are 7,591 MWh in Program Year 1, 8,783 MWh in Program Year 2, and 16,375 combined for the first two program years.[1]
3. After subtracting out joint savings with other energy efficiency programs, program savings during the first 24 months of the program are 17,201 MWh.

[1] The lower estimated savings by Opower is mostly due to fewer participant days in their estimate.

Table 1. Program Electric Savings†

Type of Statistic	Year 1	Year 2	Total Savings for Two-Year Program Period	Annualized Savings for Two-Year Program Period
Number of Participants	20,482			
Sample Size, Controls	20,543			
Total Savings prior to uplift adjustment (MWh)	8,115	9,497	17,623	8,812
(Standard errors in parentheses)	(617)	(825)	(1,305)	(653)
Savings per customer (kWh)	396	464	860	430
(Standard errors in parentheses)	(30)	(40)	(65)	(33)
Percent savings	1.90%	2.23%	2.07%	2.07%
(Standard errors in parentheses)	(0.14%)	(0.19%)	(0.15%)	(0.15%)
Total savings uplift in other programs (MWh)	217	205	422	211
Total savings after accounting for uplift (MWh)	**7,898**	**9,292**	**17,201**	**8,601**

†Year 1 covers the period September 2012 to August 2013; Year 2 covers the period September 2013-August 2014.
Source: Navigant analysis

II. Introduction

This section includes a detailed description of the Clark PUD HER program and a summary of the evaluation objectives.

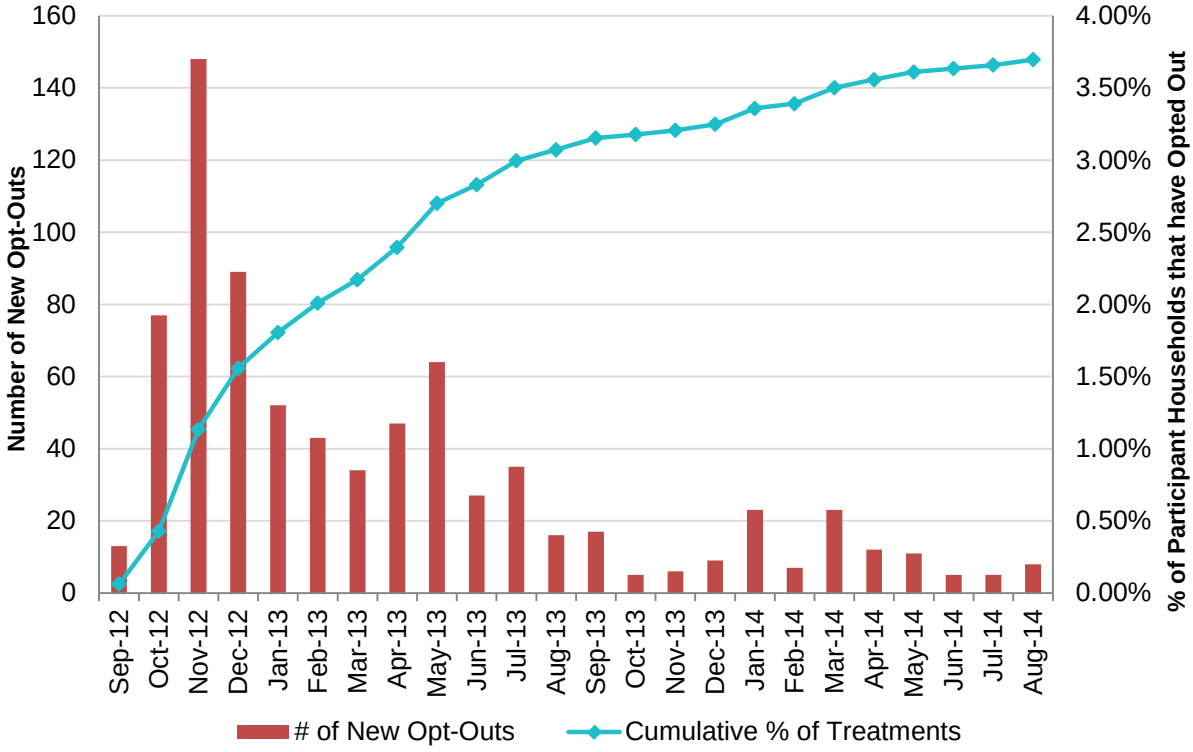
Program Description

Clark PUD's Home Energy Reporting (HER) program generates energy savings by providing residential customers with information about their specific energy use and related energy conservation suggestions and tips. The information is provided in the form of home energy reports that illustrate: a) how customers' recent energy use compares to their energy use in the past; b) tips on how the customers can reduce energy consumption, some of which are tailored to each customer's unique circumstances; and c) information on how the customers' energy use compares to that of neighbors with similar homes. In other studies, this type of information has stimulated customers to reduce their energy use, creating average energy savings in the 1% to 2% range, depending on local energy use patterns.

An important feature of the program is that it is a randomized controlled trial (RCT). Eligible customers are randomly assigned to a participant group and a control group for the purpose of estimating changes in energy use due to the program.

The HER program was launched in September 2012. The initial deployment of the program involved 20,995 participants and 20,995 control customers.[2] There are two sources of decay in program participation over time. The first is customers who opt out of the program. Figure 1 shows the monthly number of participants choosing to opt out of the program, and the cumulative percentage of opt-outs, since the start of the program. Over the first two years of the program, 3.70% of participants chose to opt out of the program. The second source of decay is customers who move from the residence. Figure 2 shows the cumulative percentage of move-outs over the course of the program for both participants and controls. The rate of program customer loss due to move outs is about 0.5% per month, and is virtually the same for participants and controls. Over the two years of the program covered by this evaluation, move-outs account for 12.07% of participant accounts and 12.07% of control accounts shed from the program.

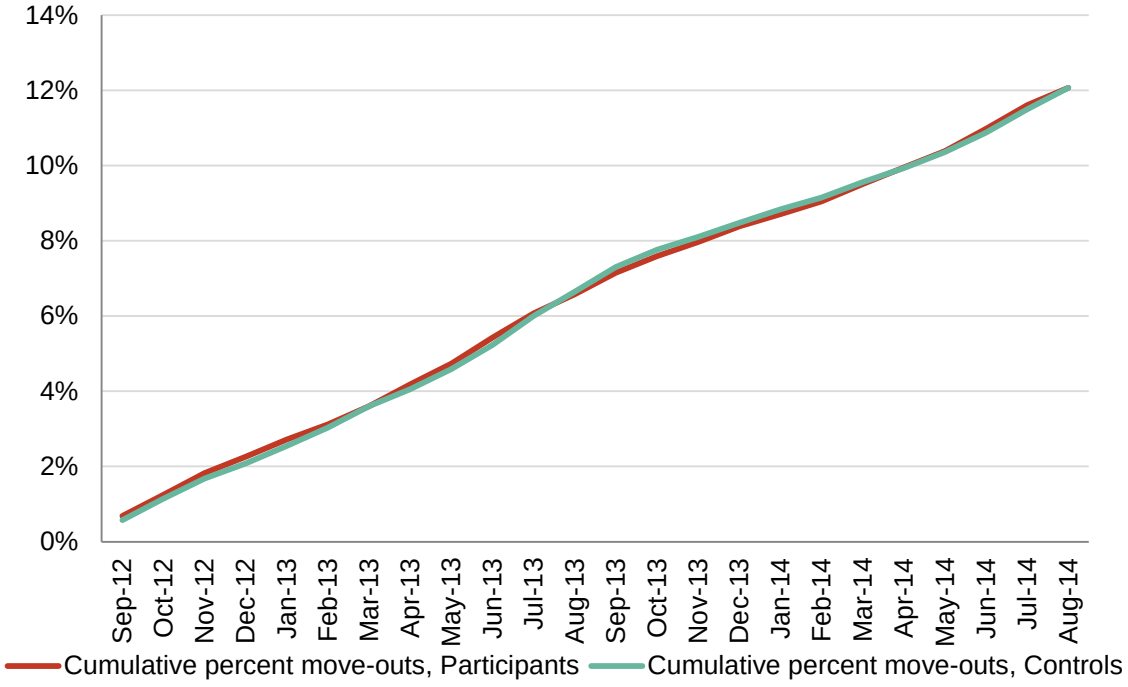
Figure 1. Customers Opting Out of the HER Program, September 2012-August 2014



Source: Navigant analysis of program tracking data

[2] The Data Used in the Impact Analysis section of this memo discusses the reasons why the number of participants used to estimate aggregate savings is smaller than the full participant count listed here.

Figure 2: Cumulative Percentage of Move-Outs, September 2012-August 2014



Source: Navigant analysis of program tracking data

Evaluation Objectives

The primary objectives of the analysis in this report are the following:

1. Compare energy use by treatment and control customers in the pre-treatment year to verify that the allocation of customers across the groups is consistent with a randomized controlled trial (RCT).
2. Estimate program impacts in Years 1 and 2 of the program and over the two year program period.
3. Evaluate the effect of the HER program on the uptake by households of other energy efficiency (EE) programs offered by the utility, and estimate the joint savings for the HER program and these other programs (that is, provide an estimate of double-counted savings).

To achieve these objectives, Navigant employed an approach that is consistent with the methodology described in the SEE Action report,[3] relying on statistical analysis appropriate for RCTs. This evaluation has three primary components:

1. **Verification of Randomized Control Trial.** Checking the assignment of customers to the treatment and control groups for consistency with an RCT;
2. **Program Impacts.** Regression analysis to quantify program savings;

[3] Todd, A., E. Stuart, S.Schiller, and C. Goldman. *Evaluation, Measurement, and Verification (EM&V) of Residential Behavior-Based Energy Efficiency Programs: Issues and Recommendations.* Lawrence Berkeley National Laboratory. May 2012. Available at: http://behavioranalytics.lbl.gov/

3. **Estimating Joint Savings with EE Programs.** Quantification of joint savings from participation in other EE programs.

The following sections describe these components in more detail.

III. Verification of Randomized Control Trial

This section describes the analysis Navigant conducted to confirm the assumption that the HER is implemented as an RCT, as well as the results of the RCT analysis.

Verification Methodology

The impact analysis is predicated on the assumption that the HER program is an RCT. Therefore, a necessary step in the analysis is to check that the data is indeed consistent with an RCT. The check conducted by Navigant involved comparing the monthly energy consumption of the treatment and control samples during the 12 months before the start of the program (September 2011-August 2012). The underlying logic of the analysis is that if the allocation of households across the two groups is truly random, then they should have the same distribution of energy consumption for each of the 12 months before the start of the program.

The analysis tests the hypothesis that there is no difference between the two groups for the particular features of the distribution, except due to random chance. It is not possible to test whether an entire *distribution* of energy consumption is the same across two groups. Instead, the analysis pertains to particular features of the distribution, such as the mean of the distribution, the median, the 1st quartile (the 25th percentile), and so forth. In statistical parlance, these features are called "moments" of the distribution. For this evaluation, Navigant compared the two groups on the following features of their energy use distributions for each of the 12 months before the start of the program:

- First quartile (25th percentile) of energy use;
- Second quartile (50th percentile, i.e., median) of energy use;
- Third quartile (75th percentile) of energy use;
- Mean energy use.

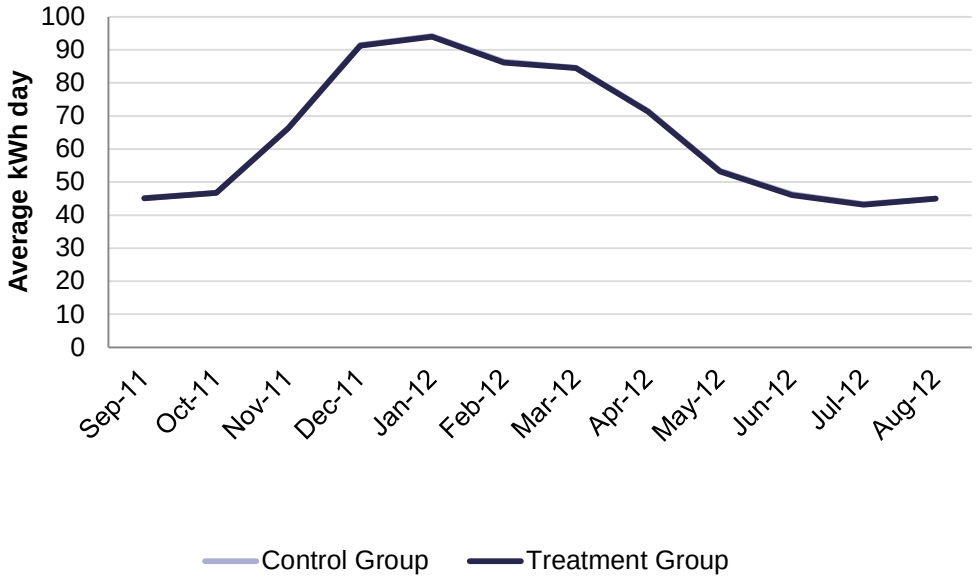
Navigant focused on a comparison of the distribution of *energy use* by treatment and control households in the pre-program year, rather than the distribution of households across zip codes or demographic variables, for two reasons. First, this is the data typically available. Second, the estimate of program energy savings is based on the assumption that control households are "just like" treatment households in their energy use except for the effect of the HER program. This is the variable of greatest concern when it comes to non-random assignment of households between the treatment and control groups.

Verification Results

Figure 3 presents the average daily energy use for treatment and control households for the 12 months prior to the start of the HER program, and Figure 4 presents the average *difference* in daily energy use between the two groups for the same period. The difference between the two groups is relatively small –no greater than 0.3 kWh/day, or, in percentage terms, no greater than 0.6% --and not statistically significant in any of the 12 months examined. The conclusion that the two groups are the

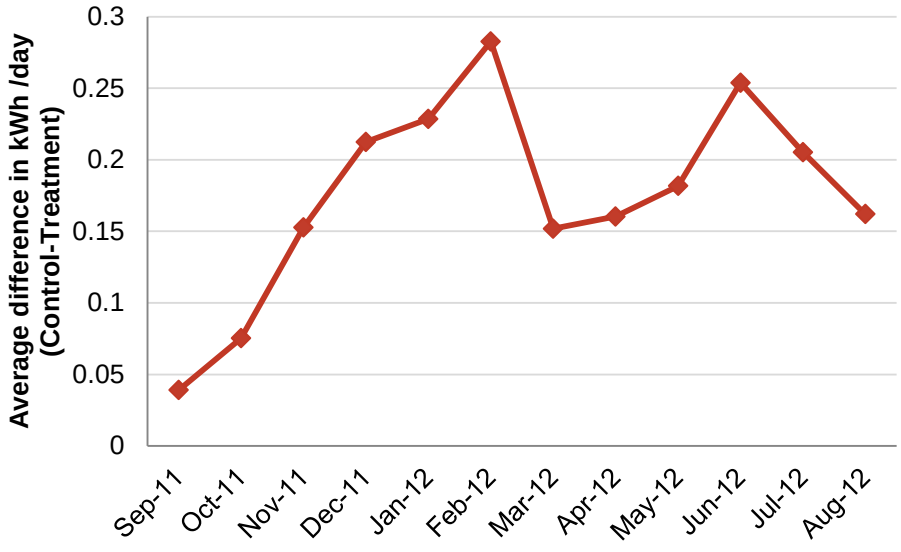
same except for small random error is supported by comparisons of their 25th, 50th, and 75th percentiles of energy use across the 12 months, as shown in Figure 5.

Figure 3. Average Daily Energy Use by Treatment and Control Customers in the 12 Months Prior to HER Program Implementation, by Month



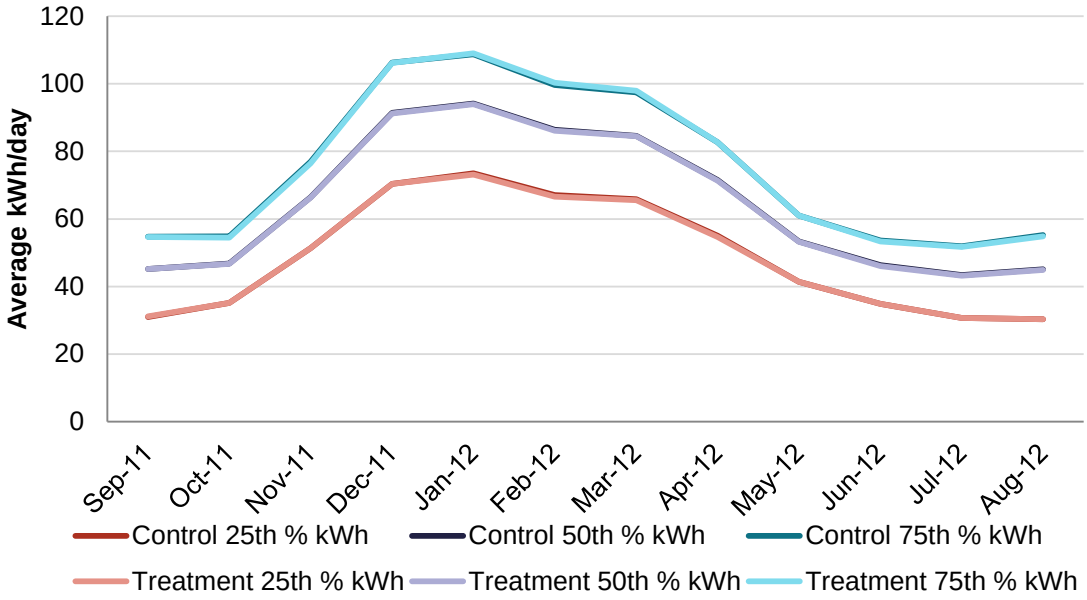
Source: Navigant analysis of treatment and control customer billing data

Figure 4. Difference in Average Daily Energy Use by Treatment and Control Customers in the 12 Months Prior to Program Implementation, by Month



Source: Navigant analysis of treatment and control customer billing data

Figure 5. Quartiles of Energy Use by Treatment and Control Customers in the 12 Months Prior to Program Implementation, by Month



Source: Navigant analysis of treatment and control customer billing data

IV. Program Impacts

This section describes the data used in the impact analysis, the impact evaluation methodology, and the evaluation results.

Data Used in the Impact Analysis

In preparation for the impact analysis, Navigant cleaned the data provided by the HER program implementer, Opower. The initial dataset indicated records for 20,995 participants and 20,995 controls. Navigant reached the count of verified customers used in the analysis—20,482 participants and 20,543 controls—as follows:

- Removed non-random "test" participants (2 participants);
- Removed participants with no "first generation date" indicating a report was sent, and remove controls with a similar indication (511 participants, 452 controls).

In addition, Navigant removed the following observations:

- Observations that occurred after a customer's inactive date (the date an account closes, usually because the customer moves);
- Observations with less than 20 days or more than 40 days in the billing cycle. These observations were removed because long and short bills can be an indication of an issue in the recording of energy use;
- Observations outside of the evaluation period, including the twelve month pre-program period and the post-program period;

- Outliers, defined as observations with average daily usage at least ten times larger or ten times smaller than the median usage.

The removal of these observations further reduced the total number of participants and controls used in the analysis. The final clean dataset used for the analysis contained 20,047 participants and 20,114 controls (98% of the verified participants and control customers).

Impact Evaluation Methodology

Navigant estimated program impacts using two approaches applied to monthly billing data: linear fixed effects regression (LFER) analysis, and a post-only regression (POR) analysis with lagged controls. Navigant runs both models as a robustness check. Although the two models are structurally different, both generate unbiased estimates of program savings in the context of an RCT. The two models were each run for each of the two program years.

The LFER model combines both cross-sectional and time series data in a panel dataset. The regression essentially compares pre- and post-program billing data for participants and controls to identify the effect of the program. The customer-specific constant term ("fixed effect") is a key feature of the LFER analysis and captures all customer-specific effects on energy usage that do not change over time, including those that are unobservable. The fixed effect represents an attempt to control for any small systematic differences between the participant and control customers that might occur due to chance. Specifically, Navigant estimated the following regression model:

Equation 1. LFER Model

$$ADU_{kt} = \alpha_{0k} + \alpha_1 Post_t + \alpha_2 Participant_k \cdot Post_t + \varepsilon_{kt} \,,$$

where,

ADU_{kt}	= The average daily energy use in kWh for customer *k* for a monthly bill ending in month *t*. This is the dependent variable in the model.
$Post_t$	= A binary variable indicating whether month *t* is in the post-program period (taking a value of 1) or in the pre-program period (taking a value of 0).
$Participant_k$	= A binary variable indicating whether customer *k* is in the participant group (taking a value of 1) or in the control group (taking a value of 0).
α_{0k}	= The customer-specific fixed effect (constant term) for customer *k*. The fixed effect controls for all customer-specific effects on energy usage that do not change over time.
α_1, α_2	= Regression parameters corresponding to the explanatory variables.
ε_{kt}	= The error term for customer *k* and bill *t*.

The parameter α_2 indicates average daily savings. Program savings are the product of the average daily savings estimate and the number of participant-days in the post-period.[4]

[4] Savings accrue for participants with active accounts.

As with the LFER model, the POR model combines both cross-sectional and time series data in a panel dataset, and the dependent variable remains ADU_{kt} , but the model applies only to the post-program period, with lagged energy use for the same calendar month of the pre-program period replacing the customer-specific fixed effect as a control for any small systematic differences between the participant and control customers. The underlying logic is that systematic differences between participants and controls will be reflected in differences in their past energy use, which is highly correlated with their current energy use. Average daily energy use in the model is given by the following equation.

Equation 2. POR Model

$$ADU_{kt} = \beta_{1t} Month_t + \beta_{2t} ADUlag_{kt} * Month_t + \beta_3 Participant_k + \varepsilon_{kt} ,$$

where ADU_{kt}, $Participant_k$, and ε_{kt} are defined as in the LFER model, $Month_t$ is a 0/1 dummy variable for month *t*, and $ADUlag_{kt}$ is customer *k*'s energy use in the same calendar month of the pre-program year as the calendar month of month *t*. The use of interaction terms $Month_t * ADClag_{kt}$ allows the effect of lagged energy use on current energy use to vary by calendar month. Estimated parameters β_{1t} and β_{2t} are specific to each month of the post-program period.

Impact Evaluation Results

Navigant estimated the LFER and POR models for both Year 1 of the HER program (September 2012-August 2013) and Year 2 (September 2013-August 2014). Parameter estimates for the two models are presented in the report appendix (Section VII). As shown in Table 2, The LFER and POR models generate very similar results for program savings in both years. Navigant uses POR results for reporting total program savings because the standard errors tend to be slightly lower, though in this analysis the standard errors for the LFER and POR models were nearly identical.

The estimate of total program savings for a program year was obtained by multiplying the savings per day per household by the number of participant days in the program. The number of participant days in Year 2 of the program was calculated as follows for each customer:

- For customers in the program for the full program year, 365 days;
- For customers with a specified inactive date, the number of days from the start of the program year up to the inactive date.

The total program savings for Year 1 was similarly calculated, except that the calculated number of program days for a customer was based on the report first-generated date.

Two-year program savings before subtracting out joint savings with other EE programs (see Section V), are 17,623 MWh. Annualized saving are the annual average of the two-year program savings.

Table 2. Clark PUD HER Program Savings, by Year and Model†

Type of Statistic	Year 1		Year 2		Total Savings for Two-Year Program Period		Annualized Savings for Two-Year Program Period	
	POR Model	LFER Model	POR Model	LFER Model	POR Model	LFER Model	POR Model	LFER Model
Initial number of Participants/Controls	20,995 / 20,995							
Eligible sample size†, Participants/Controls	20,482 / 20,543							
Percent Savings	1.90%	1.89%	2.23%	2.17%	2.07%	2.02%	2.07%	2.02%
(Standard errors in parentheses)	(0.14%)	(0.14%)	(0.19%)	(0.19%)	(0.15%)	(0.15%)	(0.15%)	(0.15%)
kWh Savings per Customer	396	394	464	451	860	840	430	420
(Standard errors in parentheses)	(30)	(30)	(40)	(40)	(65)	(65)	(33)	(33)
Total savings before subtraction of EE joint savings	8,115	8,061	9,497	9,231	17,623	17,196	8,812	8,598
(Standard errors in parentheses)	(617)	(617)	(825)	(824)	(1,305)	(1,293)	(653)	(647)

†*First generation date recorded, indicating (for participants) that a report was sent.*
Source: Navigant analysis of treatment and control customer billing data

V. Estimating Joint Savings with EE Programs

Joint savings refer to the outcome that two programs generate different total savings together than the sum of their savings if implemented in isolation. For instance, suppose the HER program drives customers into EE program X; these customers save more energy than they would in the absence of program X. In calculating portfolio savings, joint savings should be counted in one program or the other, but not both. This issue is in play when savings are separately estimated for the two programs.

This section describes Navigant's estimates of joint savings between the HER programs and other EE programs offered by Clark PUD, including programs with available tracking data and the upstream lighting program, which does not have tracking data.

Joint Savings with Other EE Programs with Tracking Data

For EE programs with tracking data, Navigant used a simple difference estimator to estimate uplift in Clark PUD's EE programs over the two years of the evaluation period. This method uses differences between the participant and control groups in EE program rates of participation to calculate the uplift in EE program participation due to the HER program. The basic logic is that because the HER program is an RCT, differences between the treatment and control groups in EE program participation rates are due to the HER program.

If participation rates in other EE programs are the same for HER participants and controls, the savings estimates from the regression analysis are already net of savings from the other programs, as this indicates the HER program had no effect on participation in the other EE programs. If the HER program increases or decreases participation in an EE program, the measured savings for the HER program must be adjusted to account for this interaction with other programs, because the interaction is not explicitly addressed in the regression analysis for the HER program. In particular, if the HER program increases participation in an EE program, the net increase in savings in the EE program is effectively counted twice, once in each program, and needs to be subtracted from one program or the other. If, on the other hand, the HER program generates a net reduction in the rate of participation in other programs—as might happen, for instance, if the HER program encourages behaviors or actions that reduce the value to customers of participating in the EE program—then the full savings due to the HER program is partially "masked" in the regression analysis by the higher rate of EE program participation by the control customers, and the EE program savings associated with the differential rate of participation must be *added* to the estimate of HER program savings.

Table 3 and Table 4 present the program-by-program calculation of joint savings for the EE programs for which data were available. As indicated in the tables, Navigant made these calculations for over 20 EE programs with tracking data. Overall, joint savings were 217 MWh for Year 1 (2.7% of estimated HER program savings) and 205 MWh (2.2% of estimated HER program savings) for Year 2. As shown in the tables, at the individual program level the estimates of double counting generally are not statistically significant at the 90% confidence level. This is especially true for those programs where the point estimate indicates negative participation uplift; for none of these programs is the effect statistically significant.

Table 3. Estimated Joint Savings with other EE Programs, Year 1

Program	Median program savings (annual kWh per participant)	Rate of participation, HER participants (%)	Rate of participation, HER controls (%)	Difference in rate of participation	Change in program participation due to HER program	Statistically significant at the 90% confidence level?	Estimated Joint Savings(kWh)
AIR SEALING REBATE	1,294	0.04%	0.03%	0.01%	2	No	**2,610**
CEEP DHP INCENTIVE - MATCH	3,816	0.12%	0.10%	0.01%	3	No	**11,686**
CEEP WEATHERIZATION - MATCH	2,451	0.09%	0.10%	0.00%	-1	No	**-2,305**
DUCTLESS HEAT PUMP REBATE	3,816	0.67%	0.54%	0.13%	26	Yes	**100,474**
ELECTRIC CLOTHES WASHER	238	1.16%	1.16%	-0.01%	-1	No	**-307**
FREEZER REBATE	58	0.18%	0.14%	0.04%	9	No	**527**
GAS CLOTHES WASHER REBATE	159	0.16%	0.09%	0.07%	14	Yes	**2,234**
HP COMM & CONTROL REBATE	1,256	0.10%	0.07%	0.03%	6	No	**7,588**
MFG DUCT SEAL REBATE	1,284	0.71%	0.60%	0.10%	21	No	**27,437**
MFG FLOOR INSUL REBATE	1,011	0.01%	0.00%	0.00%	1	No	**1,014**
PROPANE CLOTHES WASHER REBATE	159	0.01%	0.00%	0.00%	1	No	**159**
REFRIGERATOR REBATE	47	1.15%	1.08%	0.08%	16	No	**736**
SF ATTIC INSUL REBATE	1,171	0.17%	0.09%	0.08%	16	Yes	**18,804**
SF DUCT SEALING REBATE	1,144	0.08%	0.10%	-0.02%	-4	No	**-4,505**
SF FLOOR INSUL REBATE	2,944	0.10%	0.08%	0.02%	5	No	**14,859**
SF HEAT PUMP REBATE	1,440	0.37%	0.33%	0.04%	9	No	**13,246**
SF WALL INSUL REBATE	1,669	0.02%	0.01%	0.00%	1	No	**1,684**
SF WINDOW & DOOR REBATE	3,528	0.21%	0.18%	0.03%	6	No	**21,554**

Source: Navigant analysis of program tracking data

Table 4. Estimated Joint Savings with other EE Programs, Year 2

Program	Median program savings (annual kWh per participant)	Rate of participation, HER participants (%)	Rate of participation, HER controls (%)	Difference in rate of participation	Change in program participation due to HER program	Statistically significant at the 90% confidence level?	Estimated Joint Savings (kWh)
AIR SEALING REBATE	2,462	0.059%	0.024%	0.034%	7	Yes	**17,269**
DUCTLESS HEAT PUMP	3,816	0.439%	0.312%	0.128%	26	Yes	**99,941**
ELECTRIC CLOTHES WASHER REBATE	238	0.976%	1.047%	-0.070%	-14	No	**-3,418**
FREEZER REBATE	58	0.137%	0.136%	0.000%	0	No	**5**
GAS CLOTHES WASHER REBATE	159	0.156%	0.131%	0.025%	5	No	**808**
HEAT PUMP WATER HEATER REBATE	960	0.054%	0.063%	-0.010%	-2	No	**-1,883**
HP COMM & CONTROL REBATE	1,256	0.171%	0.083%	0.088%	18	Yes	**22,671**
LOW INCOME PROGRAM	1,246	0.039%	0.058%	-0.019%	-4	No	**-4,940**
MFG DUCT SEAL REBATE	1,284	0.171%	0.180%	-0.009%	-2	No	**-2,427**
MFG FLOOR INSUL REBATE	0	0.000%	0.010%	-0.010%	-2	No	**0**
MFG HEAT PUMP REBATE	4,676	0.005%	0.005%	0.000%	0	No	**14**
MFG WINDOW & DOOR REBATE	2,082	0.005%	0.000%	0.005%	1	No	**2,082**
PROPANE CLOTHES WASHER REBATE	159	0.010%	0.005%	0.005%	1	No	**159**
REFRIGERATOR REBATE	47	0.752%	0.745%	0.007%	1	No	**68**
SF ATTIC INSUL REBATE	1,172	0.107%	0.049%	0.059%	12	Yes	**14,095**
SF DUCT SEALING REBATE	1,144	0.117%	0.083%	0.034%	7	No	**8,066**
SF FLOOR INSUL REBATE	2,915	0.098%	0.054%	0.044%	9	No	**26,328**
SF HEAT PUMP REBATE	1,440	0.352%	0.321%	0.030%	6	No	**8,922**
SF WALL INSUL REBATE	400	0.034%	0.010%	0.024%	5	Yes	**2,002**
SF WINDOW & DOOR REBATE	3,605	0.166%	0.146%	0.020%	4	No	**14,743**

Source: Navigant analysis of program tracking data

Savings after Subtracting Out Joint Savings with Other EE Programs with Tracking Data

Table 5 presents HER program savings for the POR model (the model that is the basis of reported savings) after subtracting out these joint savings with other EE programs. Total net savings for the first two years of the program are 17,201 MWh.

Table 5. Net Program Savings and Uplift of Savings in Other EE programs (MWh)

Type of Statistic	Year 1	Year 2	Total Savings for Two-Year Program Period	Annualized Savings for Two-Year Program Period
Total Savings including Joint Savings	8,115	9,497	17,623	8,812
Savings Uplift in other EE programs	217	205	422	211
Savings Net of Joint Savings	**7,898**	**9,292**	**17,201**	**8,601**

Source: Navigant analysis of treatment and control customer billing data and program tracking data

Joint Savings with the Upstream Lighting Program

The Clark PUD is a participating partner in the Simple Steps program that provides discounted CFL bulbs and low-flow showerheads to customers throughout BPA's territory. Clark PUD customers have access to these discounted measures through local retailers. As with most upstream programs, partnering retailers do not collect household information when customers make their purchase in the store. The Simple Steps program tracking data only includes the count of measures sold at each retail location. BPA calculates program savings using an RTF-approved value for each bulb sold.[5]

The unavailability of household-level tracking data for the program hampers the ability to account for joint savings with Clark PUD's Simple Steps program. Previous studies based on survey research provide some guidance regarding accounting for joint savings between the Opower HER program and upstream lighting programs (ULPs).[6] An evaluation of joint savings between Puget Sound Energy's Opower HER program and its upstream lighting program concluded that average annual joint savings per household in the second year of the program was 1.59 kWh. A study of the issue for Pacific Power's Opower HER program found no statistical difference between treatment and control households in the number of CFL's installed after 18 months. Navigant enlisted these previous studies along with primary analysis to determine how to account for joint savings between the HER program and the Simple Steps program.

Based on this analysis, Navigant recommends against reducing the estimated savings from the Clark PUD HER program due to the presence of the Simple Steps program. Importantly, joint savings can be either positive or negative depending on competing effects. An "installation effect", in which treatment households install more CFLs, causes positive joint savings. A "behavioral effect", in which treatment customers use their lights less, causes negative joint savings. Because it is not clear which of these effects dominates, and that in any case joint savings are likely very small relative to both the savings estimated for each of the two programs and the precision of the estimates, the appropriate

[5] Source: Navigant interview with Clark PUD program staff.
[6] "Puget Sound Energy's Home Energy Reports: 2012 Impact Evaluation". March 2013. Prepared by KEMA, Inc.; "Washington Home Energy Reporting Program: 18-month Evaluation Report". June 18, 2014. Prepared by Navigant Consulting, Inc., for Pacific Power.

neutral conclusion is that joint savings between the HER program and the Simple Steps program are zero. Section VII includes further theoretical discussion on the topic of accounting for joint savings between behavioral programs and upstream lighting programs.

VI. Key Findings and Recommendations

This section summarizes the key findings and associated recommendations.

Finding #1. The treatment and control groups had similar usage prior to the start of the program. Therefore Navigant employed a statistical method appropriate for use with RCTs to quantify the energy savings for the program.

Finding #2. Program savings rose from 1.90% of energy use in the first year to 2.23% in the second year. The weighted average savings across the two years is 2.07%. By comparison, the percent savings estimates provided to Clark PUD by Opower are 1.76% for Year 1, 2.20% for Year 2, and 1.98% for the two year program period. Total program savings before subtracting joint savings are 8,115 MWh in Year 1, 9,497 in Year 2, and 17,623 for the two-year program period. Opower's estimates of total program savings are about 7% lower: 7,591 MWh in Program Year 1, 8,783 in Program Year 2, and 16,375 combined for the first two program years.

Table 6 summarizes the program savings.

Recommendation #1. In planning for program savings for the current program cohort, Clark should expect savings to remain about the same as in Year 2 or increase slightly.

Recommendation #2. If Clark PUD is considering expansion of the program, and the expansion will involve customers whose energy use is different than the energy use of the current HER program participants, Navigant recommends additional analysis to examine savings potential using the new population's energy use distribution. This will allow Clark PUD and BPA to gain an understanding of expected savings if the program is expanded to different populations.

Table 6. Program Electric Savings†

Type of Statistic	Year 1	Year 2	Total Savings for Two-Year Program Period	Annualized Savings for Two-Year Program Period
Number of Participants			20,482	
Sample Size, Controls			20,543	
Total Savings prior to uplift adjustment (MWh)	8,115	9,497	17,623	8,812
(Standard errors in parentheses)	(617)	(825)	(1,305)	(653)
Savings per customer (kWh)	396	464	860	430
(Standard errors in parentheses)	(30)	(40)	(65)	(33)
Percent savings	1.90%	2.23%	2.07%	2.07%
(Standard errors in parentheses)	(0.14%)	(0.19%)	(0.15%)	(0.15%)
Total savings uplift in other programs (MWh)	217	205	422	211
Total savings after accounting for uplift (MWh)	**7,898**	**9,292**	**17,201**	**8,601**

†Year 1 covers the period September 2012 to August 2013; Year 2 covers the period September 2013-August 2014.
Source: Navigant analysis of treatment and control customer billing data

VII. Appendix

Table 7. LFER Parameter Estimates, Years 1 and 2

Variable	Year 1		Year 2	
	Coefficient	t-statistic	Coefficient	t-statistic
Post	-0.762	-12.10	-0.854	-9.81
Post * Participant	-1.184	-13.06	-1.390	-11.21

Source: Navigant analysis of treatment and control customer billing data

Table 8. PPR Parameter Estimates, Year 1

Variable	Year 1	
	Coefficient	t-statistic
Participant	-1.192	-13.14
ADClag*September 2012	0.808	96.08
ADClag*October 2012	0.850	144.83
ADClag*November 2012	0.729	159.75
ADClag*December 2012	0.699	167.84
ADClag*January 2013	0.941	185.45
ADClag*February 2013	0.933	182.32
ADClag*March 2013	0.752	165.51
ADClag*April 2013	0.698	151.59
ADClag*May 2013	0.840	147.91
ADClag*June 2013	0.855	136.63
ADClag*July 2013	0.936	165.99
ADClag*August 2013	0.873	192.13
September 2012	6.302	17.84
October 2012	5.727	21.96
November 2012	11.177	38.84
December 2012	14.350	40.25
January 2013	10.306	23.05
February 2013	9.247	22.30
March 2013	12.057	33.42
April 2013	12.204	39.52
May 2013	5.749	20.08
June 2013	5.776	21.04
July 2013	4.070	17.61
August 2013	4.972	25.78

Source: Navigant analysis of treatment and control customer billing data

Table 9. PPR Parameter Estimates, Year 2

Variable	Year 2	
	Coefficient	t-statistic
Participant	-1.430	-11.52
ADClag*September 2013	0.850	152.02
ADClag*October 2013	0.809	125.01
ADClag*November 2013	0.737	131.92
ADClag*December 2013	0.958	161.82
ADClag*January 2014	0.891	159.02
ADClag*February 2014	0.925	149.03
ADClag*March 2014	0.711	130.44
ADClag*April 2014	0.686	129.69
ADClag*May 2014	0.812	120.95
ADClag*June 2014	0.823	118.08
ADClag*July 2014	0.891	136.76
ADClag*August 2014	0.902	157.94
September 2013	6.274	26.11
October 2013	12.717	43.90
November 2013	13.286	37.40
December 2013	9.228	18.01
January 2014	11.309	22.71
February 2014	14.788	29.11
March 2014	14.713	33.65
April 2014	12.242	34.23
May 2014	7.098	20.74
June 2014	4.102	13.31
July 2014	5.403	20.12
August 2014	6.193	25.15

Source: Navigant analysis of treatment and control customer billing data

Theoretical background on joint savings with upstream lighting programs

In considering the joint savings of a behavioral program and an upstream lighting program, there are two issues to consider:

1. What is the effect of the behavioral program on the installation of bulbs purchased through the upstream lighting program? **We refer to this as the "installation effect**".

2. What is the effect of the behavioral program on the amount of lighting used (energy use per bulb per year)? **We refer to this as the "behavioral effect".** This issue is not considered in the well-regarded SEE Action report (see footnote 2) or, to the best of our knowledge, in any previous studies.

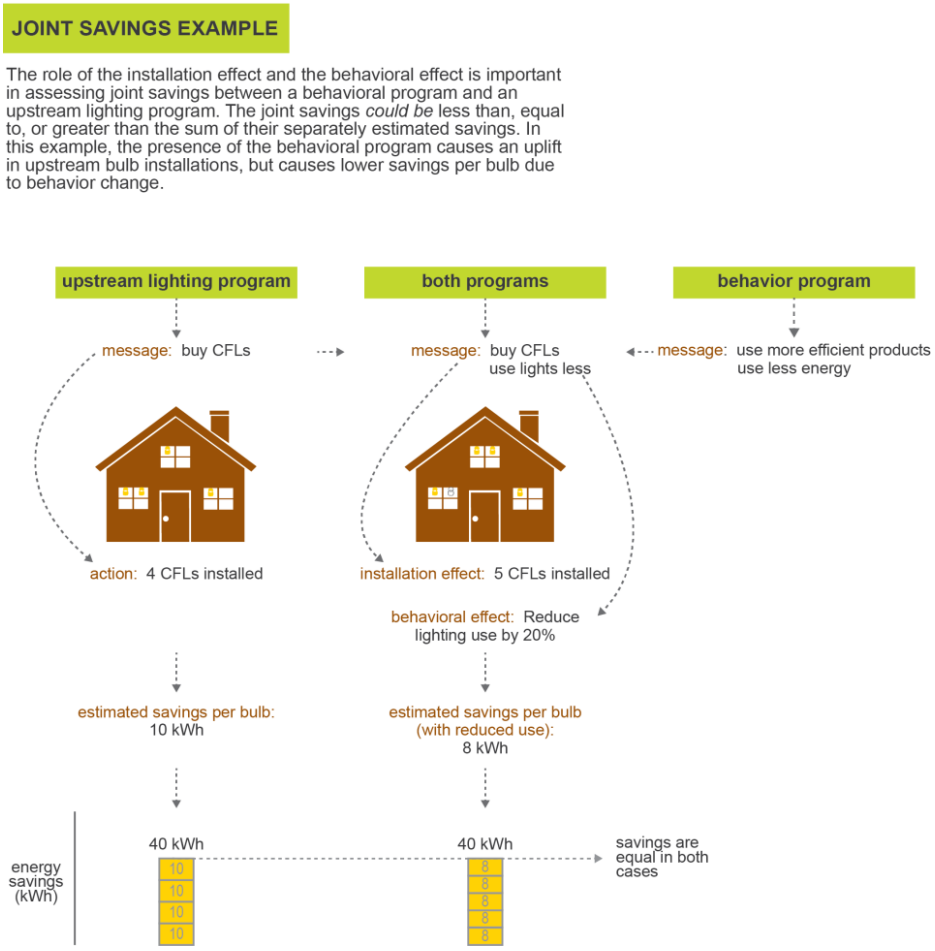
The role of the installation effect in assessing joint savings between a behavioral program and a ULP is obvious, though in practice it presents challenges. In particular, the issue goes beyond simply estimating the differential purchase of EE lighting by treatment and control customers in the behavioral program, which is difficult enough. It also requires estimating the actual installation of bulbs, and, most challenging of all, estimating the net installation of EE bulbs due to the ULP.

The role of the behavioral effect in estimating joint savings has been overlooked in previous studies, yet it is critical. If the behavioral program reduces the amount of time a bulb is used, the joint savings of the behavioral program and the ULP can be *less* than the sum of their separately estimated savings.

A simple example makes this case. Suppose the average net purchase of CFLs through the ULP is four bulbs per year for control customers and five bulbs per year for treatment customers, and suppose the savings per bulb for both control and treatment customers is 10 kilowatt-hours (kWh). Control customers save 40 kWh per year and treatment customers save 50 kWh per year. The joint savings of the ULP and behavioral programs is 10 kWh, due to the installation effect.

Yet, the behavioral program also intends to cause treatment customers to use their lights less. This behavioral effect reduces the combined savings across the two programs, as it reduces the effect of the ULP program for treatment customers. Pursuing this example, suppose the behavioral program causes treatment customers to reduce their lighting use by 20%. Then, all else being equal, for treatment customers the savings due to the ULP falls from 10 kWh to 8 kWh per bulb per year, with annual savings per customer of 40 kWh. In this example, joint savings are zero, *even though treatment customers purchased more bulbs through the ULP.* The presence of the behavioral program causes an uplift in ULP bulbs but lower savings per bulb. If the objective is to generate an unbiased estimate of joint savings, it would be a mistake to reduce the estimate of savings for the behavioral program based solely on an evaluation of the installation effect, without considering the behavioral effect. After considering the behavioral effect, it is clear that joint savings can be positive, negative, or zero. Figure 6 demonstrates this example.

Figure 6. Joint Savings with an Upstream Lighting Program



Source: Navigant

Empirical evidence concerning joint savings with upstream lighting programs

For empirical evidence of the installation effect and the behavioral effect, Navigant looked to two evaluations conducted in the Northwest:

1. The first is a study of the Puget Sound Energy (PSE) program conducted over several years.[7]
2. The second study was completed by Navigant for Pacific Power's Opower HER program. [8]

[7] "Puget Sound Energy's Home Energy Reports: 2012 Impact Evaluation". March 2013. Prepared by KEMA, Inc.
[8] "Washington Home Energy Reporting Program: 18-month Evaluation Report". June 18, 2014. Prepared by Navigant Consulting, Inc., for Pacific Power.

Installation Effect. Both of the aforementioned evaluations shed light on the installation effect:

a. ***PSE study findings.*** The PSE study team surveyed Opower HER program treatment and control customers about their purchases of ULP bulbs over the previous year. As reported in Table 5-6 in the report, the study estimates that, after two years in the HER program, the average difference between HER program treatment and control customers in average annual energy savings attributable to the ULP is 1.59 kWh.[9] This estimate is not statistically significant at the 90% confidence level.

b. ***Pacific Power study findings.*** The evaluation of Pacific Power's Opower HER program took a different approach to explore this issue. Navigant conducted a telephone survey of HER program treatment and control customers in which interviewers asked respondents to report the number of installed CFLs in the room in which they were located while responding to the survey. This approach addressed a concern about respondent recall and interviewer bias associated with the standard approach of asking customers about their EE bulb purchases over the previous year. Analysis of this Pacific Power survey data found no statistically significant difference between treatment and control customers in the number of CFLs installed in any room in the home, and in the average home overall.

Navigant concludes that the uplift in the purchase of ULP bulbs caused by the HER program (i.e., the installation effect) is likely small, on the order of less than one CFL after two years.

Behavioral Effect. The telephone survey conducted for the Pacific Power study also sheds light on the behavioral effect. Customers were surveyed in the evening, and asked to walk through their homes counting the number of lights turned on. Results revealed that treatment customers had about 15% fewer lights turned on than control customers, a statistically significant difference at the 90% level. Assuming six program bulbs per customer—the number of program bulbs purchased (and assumed installed) in the PSE report—the behavioral effect is a source of *negative* joint savings of about 0.9 bulbs.

Putting together the limited empirical evidence on the installation and behavioral effects, there is a good chance that the joint energy savings between the Clark PUD HER program and the Simple Steps program is virtually zero.[10]

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[9] The report is not clear about whether estimates are based on differences in the number of EE bulbs/fixtures purchased overall, or the difference in the number of EE bulbs/fixtures purchased at ULP retailers. Here Navigant assumes the latter, because the survey used in the analysis queries respondents about the location of their purchases.

[10] Importantly, the logic of this argument assumes that the estimate of program savings for the Simple Steps program is correct. In particular, it assumes that the estimate correctly accounts for the average use of bulbs in the home and the net impact of the Simple Steps program on the installation of EE bulbs.